Collocated Distance: A Fundamental Challenge for the Design of Hybrid Work Technologies

Melanie Duckert
IT University of Copenhagen, Copenhagen
mela@itu.dk

Louise Barkhuus
IT University of Copenhagen, Copenhagen
barkhuus@itu.dk

Pernille Bjørn
University of Copenhagen, Copenhagen
pernille.bjorn@di.ku.dk

ABSTRACT

After the pandemic, it is urgently important to explore the special challenges which arise with hybrid work. Through cross-case analyses of published papers, we propose *collocated distance* as a design challenge uniquely relevant for hybrid cooperative technologies. We identify and conceptualize collocated distance as a design challenge that arises in hybrid work situations, where at least three actors are mutually dependent in their work while being located within fewer contexts than the number of actors. Collocated distance reminds us that when designing hybrid technologies, we must not only focus on creating technologies that support the work across geographical locations but equally pay attention to the relations and possible disconnections which exist locally between collocated actors. When designing cooperative technologies supporting distributed work, often focus is on the boundaries *between* geographical contexts – however, in hybrid work, we must not forget to pay attention to the *collocated* boundaries within the same context.

CCS CONCEPTS

• **Human-centered computing** → Collaborative and social computing; Human computer interaction (HCI).

KEYWORDS

hybrid work, distributed work, cooperative work

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1 INTRODUCTION

Collaboration across geography is a core interest in CHI and CSCW research [33, 44]. The dedication to find ways to design technologies that allow for cooperative actors to be mutually dependent upon each other in a common field of work [93] despite being dispersed geographically, has received increased attention with the COVID-19 pandemic [81]. With the pandemic, we witnessed how the long-term research endeavor produced significantly important results in designing digital technologies allowing people across the globe to work from home. The infrastructures of working and teaching remotely during the pandemic included cooperative technologies such as Teams and Zoom [26]. These CSCW systems provide technology support for awareness [34, 47, 49, 52, 92] and/or coordination [40, 47] reducing the efforts of articulation work [22, 45, 97] for the distributed actors. The spatial opportunities and resources available, as well as the distance produced as part of the place-based activities, matter for how actors can cooperate through digital means [38, 51]. How we design and use technologies supporting cooperation across geography therefore shapes the potential of collaboration in important ways.

The pandemic introduced new ways of working, and as health restrictions are being lifted in most countries, several organizations are using the pandemic to reflect and rethink the nature of the workplace, including the use of cooperative technologies [105, 108]. Some employees are requesting to work remotely, while others want to return to the office. How work will be organized in the future is still being considered in many organizations. In this paper, we explore a particular type of cooperation emerging after the pandemic: The cooperative setup characterized by hybrid work. As a starting point, *we define hybrid work as situations where at least three actors are located at fewer geographical sites than the number of actors (but not all collocated), and all actors are mutually dependent in their work.* Hybrid work is then situations where at least one of the geographical sites includes multiple collocated people. We acknowledge that hybrid work in this definition is a large spectrum of different types of work. Our definition builds upon the assumption that even if one person is becoming remote in a large group of people, it impacts the type of collaboration that can take place. Similarly, if all but two people are distributed in a large cooperative remote setup, it also impacts the conditions for cooperative work. The research question guiding our work is: What are the characteristics of hybrid cooperative work that introduce unique design challenges to be met by cooperative technologies?

Hybrid work has multiple overlapping characteristics with distributed work, however, to fully understand which characteristics are unique for hybrid work, we decided to analyze previously published papers that provide detailed empirical cases of hybrid work. We collected papers published at CHI, CSCW, GROUP, ECSCW, and JCSCW, all top research venues that have included research pertaining to cooperative technologies and practices over the last decades. Our selected papers were then grouped into four domain areas: Healthcare, Performance, Office, and Non-Office work, each

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providing a number of papers that described rich empirical details on cases of hybrid work.

Based upon cross-case analysis of the selected papers, we make three contributions identifying the design challenges for hybrid work technologies: Firstly, supporting previous research [29, 35], we identified two core design challenges for hybrid work technologies, 1) the increased complexities involved in creating common ground in hybrid work settings, and 2) the increased complexities involved in balancing sub-group dynamics in hybrid work. Secondly, we identified a new design challenge that is uniquely relevant when designing hybrid work technologies compared to distributed work technologies. We label this challenge *collocated distance*. Collocated distance reminds us to not only focus our designs on mediating the geographical boundaries across sites, but also explore the collocated boundaries which exist in a hybrid setup and use these collocated boundaries as a design characteristic for hybrid technologies. Finally, we propose an analytical framework for hybrid work as a subset of distributed work and cooperative work, which we hope can help others continue the work of understanding the unique characteristic of hybrid work with the aim of designing hybrid work technologies.

The paper is structured as follows; First, we introduce prior work on cooperation and distributed work, while situating our research in the broader literature on computer supported cooperative work. Secondly, we introduce our strategies for selecting and analyzing the literature. Then we introduce the results of our analysis zooming in on the four selected empirical cases. Finally, we discuss and theorize the characteristics of hybrid work by visualizing hybrid work as a subset of both distributed work and cooperative work developing the concept of collocated distance.

2 FROM DISTRIBUTED WORK TO HYBRID WORK: DISCONTINUITIES AND SHARED MEANING

While in this paper, we generally refer to distributed work as situations where multiple people are working together while being geographically distributed, distributed work has been explored under different headings in the literature such as virtual teams [42], Far-flung teams [71], Global virtual teams [1], Virtual Learning teams [20], etc. It is therefore important that we start by clarifying the vocabulary – and make clear which dimensions are involved when we refer to distributed work.

Distributed work is cooperative work [93] and as such is defined by situations where at least two people are mutually dependent in their work and thus engage in cooperative work requiring articulation work. This means that distributed work situations take place within professional domains, and the activities which are involved are shaped by these domains, e.g., in terms of professional language and vocabulary [87]. What gets excluded by this definition is casual interactions or social interactions without a common field of work. Interdependence, domain, and professional language are all important aspects of distributed work. What makes distributed work as professional work interesting is that the dependencies shape and create cooperative engagement in important ways. It is the dependencies that require coordination [40] and it is the dependencies in work that requires actors to find and develop strategies for creating mutual awareness [47] as an approach to reduce the efforts of articulation work [92].

Distributed work is geographically distributed. Distance often refers to the geographical distance [82], while the discussion about how we define geographical distance and where the boundaries between collocation and distribution exist remains. Geographical distance matters, yet it is important to acknowledge that the perception of distance might in many cases be even more pertinent in shaping the collaboration [23]. Geographical distance can in the 'smallest' definition include actors being distributed across different floors – and there is work that shows that even a few meters [30] can create distance among collaborators. Geographical distance can also include actors which are in different countries and even on different continents. This type of work is often referred to as far-flung teams [70] or global virtual teams [58] and in some cases also specified by the domain such as 'software development' like global software development [54]. When the geographical distance is high, then additional aspects such as temporal, cultural, and geo-political concerns also enter the scene [14–16, 76]. Thus, while 'small scale' geographical distance matters, the larger geographical distance often includes additional dimensions that need to be taken into consideration when designing technologies to support such work. The complexities clearly arise when extending the geographical distance by introducing additional concerns, and when we design technologies for both distributed and hybrid work, it is crucial that we examine all the potential complexities of the specific setup. Distance is not just about 'the number of meters' but includes various dimensions or discontinues which can be pertinent.

Distributed work is characterized by various dimensions and discontinuities. Rather than considering complexities emerging in distributed work as a binary – where they either exist or do not exist – Mary Beth Watson-Manheim et al. focus on the organizational context and suggest conceptualizing these complexities in terms of dimensions [103]. They offer the following potential discontinuities/continuities which are important to consider for distributed work: Organizational affiliations, Work group membership, Physical locations, Temporal locations, Tasks, or Projects [103]. Their argument is that each example of a distributed work setting can have different discontinuities/continuities across these different dimensions. Focusing on work practices and coordinative actions, Charlotte Lee and Drew Paine [62] similarly propose a conceptualization for coordinative action suggesting the following dimensions: Synchronicity, Physical distribution, Scale, Numbers of Communities of Practices, Nascence, Planned permanence, and Turnover. They argue that each of these dimensions matters for the challenges of coordinative action. Following this way of thinking, we attempt to pay attention to the various types of dimensions or discontinuities that might arise in concrete situations of distributed work as critically important to consider, when designing cooperative technologies for such work.

The main challenge in distributed work is establishing a shared meaning context to develop and maintain common ground. One of the main challenges in cooperative work is establishing and maintaining a shared meaning context [18, 111]. A shared meaning context in distributed work is a conglomeration of pieces from the various contexts that collaborators bring with them into the distributed

work setting such as the professional context, the local context, and the distributed context [18]. Each context has assigned languages and practices, which need balancing during the cooperative engagements and can analytically be divided into the work practice level (work practices and professional language), the organizational level (norms and procedures), and the life world level (taken-for-granted assumptions) [18, 74–76]. Professional disciplines shape work in important ways as the work practices, policies, protocols, and procedures emerge out of long-term disciplinary endeavors [13, 41, 53, 99]. Disciplinary activities also create specific coordinative artefacts and stipulate how such artefacts are to be used in certain activities [8, 17, 91, 94]. While communication breakdowns often manifest within the cooperative practices, in many cases potential breakdowns are grounded at a different analytical level. The shared meaning context allows and supports actors involved in distributed work to develop common ground [29, 81] and share mutual knowledge [31]. What makes common ground difficult in distributed work is the challenges in establishing a shared meaning context, by which the grounding practices can be based – especially in situations of multiple interlinked discontinuities and where the geographical distance implicates a diverse set of additional complexities such as differences between the global north and the global south [15, 21, 74, 86]. Without a shared meaning context, the conditions to have a cooperative situation based on trust, commitment, and cultural sensitivity is challenged [96]. In addition, challenges related to technology use and technology readiness [75, 81], and whether such technologies support or constrain the distributed work [19], might arise.

We explore the characteristics of *hybrid work* as a subset of distributed work and where all the above considerations and challenges might be pertinent. Hybrid work is a special type of distributed work where at *least three people are geographically distributed on fewer sites than the number of participants and are mutually dependent in their work and thus engage in cooperative work requiring articulation work*. In this way, the geographical distribution is an important part of the definition and an important analytical lens for our examination. However, we are very aware that distance is more than geography, thus an important part of our analytical lens is to identify and bring into the analysis other discontinuities and dimensions which add to the complexity of the cases of hybrid work. Further, we will take a work practice perspective and focus our analysis on the discontinuities shaped by geography, time, national culture, organizational culture, work practices, professional disciplines, technologies, and languages. While each of these dimensions might not be relevant in all cases of hybrid work, we will explore whether they are available in the selected papers – and make them relevant for our analysis. Finally, using common ground and grounding activities as an analytical lens allows us to dive directly into the situations which often end in communication breakdowns, thus revealing the underlying assumptions and infrastructure which keeps collaboration afloat.

3 METHOD

In order to explore the characteristics of hybrid work with the aim of identifying the special design challenges to be met by cooperative technologies, we decided to search existing literature and identify previously published empirical cases on hybrid work arrangements, in human computer interaction and computer supported cooperative work. The purpose was to learn from past studies that might provide empirical data about hybrid work – without necessarily having a focus on the nature of hybrid work arrangements. When we began our literature search, we assumed that while the increased interest and focus on new forms of work – remote work and hybrid work – has been spurred by the COVID-19 pandemic, the organizational structure of working across geographical sites in different constellations is not new but has in fact been a research interest for decades. It would therefore be beneficial to investigate historic cases from the past to learn from previous work, before initiating new empirical studies and design new cooperative technologies facilitating hybrid work after the pandemic.

Interestingly, most research on geographically distributed work does not make a distinction between distributed work where all participants are geographically dispersed, and hybrid work situations. So, when searching for literature, we had to come up with a working definition that allowed us to identify and select cases. In this process, it became clear to us what distinguishes distributed work from hybrid work: The difference lies in when the number of geographical sites is fewer than the number of actors involved, and hybrid work has a minimum of three actors involved.

Our main methodological strategy for selecting papers was to look for papers that described empirical cases where at least three actors were involved in a common field of work while being geographically distributed across fewer geographical sites than the number of actors – and where the paper produced enough insights into the empirical data that we were able to explore the characteristics of hybrid work as emerging in the case.

An interesting part of the process of developing an appropriate definition for our literature search, was that it allowed us insights into the diverse nature of which empirical cases of hybrid work entails. To challenge our assumptions and pre-established understandings of hybrid work, we sought to identify cases that were different in nature (across different domains and types of work) to challenge and extend our definition of hybrid work beyond office work as part of our theorizing. However, since most of the cases of hybrid work in the literature were in an office environment, it was important for our method to also identify cases of hybrid work that did not take place in an office environment. From this perspective, we were excited to identify empirical cases outside of the office. These cases took place within different domains such as healthcare, performance, or different types of industrial settings. What makes these types of empirical cases interesting is that the work described includes physical artefacts, mobility, and activities that often are not present in office work. We now continue by describing in detail, how we searched and selected literature, as well as how we analyzed the data.

3.1 Data Collection

The identification of literature on hybrid work was inspired by a scoping study [2] where we iteratively identified relevant cases using the definition of hybrid work. In this process, we continuously became familiar with the scale, domains, topics, and diverse nature of cases – using these insights to iteratively search in new

ways. The iterative approach enabled us to produce an overview of prior literature while identifying certain categories which help us navigate the material.

Using EUSSET Digital Library (DL) and ACM Digital Library (DL), we searched for full papers. In the EUSSET DL we focused our search on ECSCW and JCSCW papers, while in the ACM DL we focused on publications from ACM CSCW, ACM CHI, and ACM GROUP conferences. We excluded workshops, posters, and position papers from our searches. The search terms we used included "hybrid", "tech" and "work", however, we extended the search to include papers using synonyms to hybrid such as "remote" and "virtual" to not miss relevant papers.

We used different search conditions in the two libraries; initially, the EUSSET DL gave 101 search results, and the searches across the ACM DL provided 7,389 papers. The first author skimmed through the titles of the ACM DL papers and discovered that many of the papers did not include hybrid cooperative work. To scope the ACM DL papers, we required the first search term (hybrid* OR remot*) to be mentioned in either the title or abstract of the paper. The search for papers mentioning virtual work was conducted separately as too many papers studied virtual reality technologies (VR) and focused on neither collaborative nor distributed work, therefore, either "work" or "team" had to be in the abstract too. This reduced our search results to 731 ACM DL papers. Combining the results from EUSSET DL and ACM DL the total number of papers after the initial searches was 832.

The first author then skimmed through the abstracts to determine whether the papers in fact provided empirical data on hybrid work cases. Surprisingly, it turned out that several of the papers were not focusing on hybrid cooperative work. Reading through the abstracts manually (in some cases also skimming the introduction and method section to confirm), papers that presented research with a focus on a work context supported by a hybrid/remote/virtual technology, were selected. During this stage, for example, papers focusing on a learning environment [12] or families [39, 106] were excluded. Further, it also turned out that there were papers that did not focus on cooperative hybrid work, but instead on hybrid combinations, e.g. of woodwork and carpentry [69]. The result of this sorting exclusion was a selection of 209 papers for detailed analysis, see Figure 1.

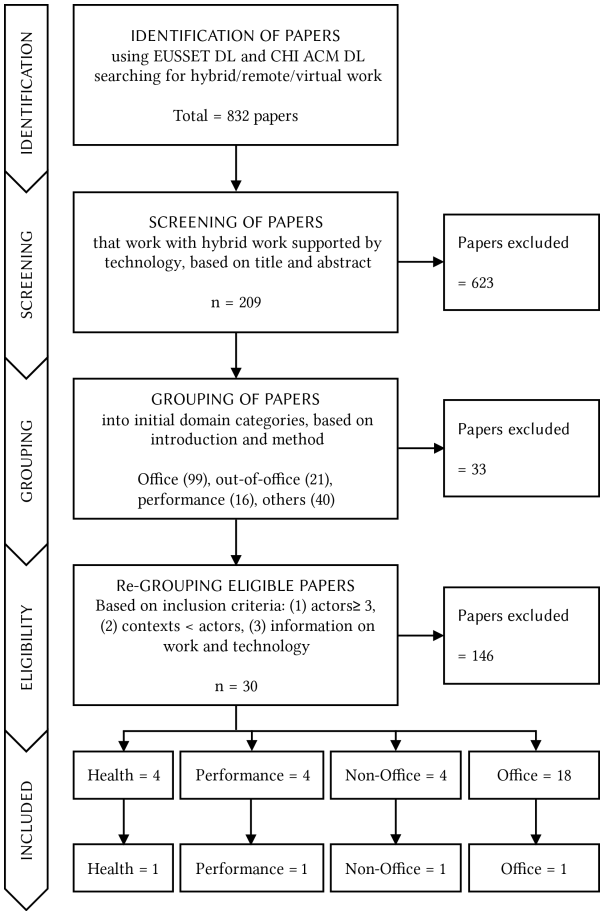

Figure 1: Literature selection process

3.2 Data Analysis

All 209 papers were downloaded and imported into Nvivo. Further, the first author created various spreadsheets for detailed analysis, note taking, and categorization. The classification work was done iteratively, where emergent categories were grouped and re-grouped. The purpose of the categorization was to identify what kind of papers had been published on hybrid work while also developing classifications for the domains and types of empirical cases. This selection process was based on the introduction and method sections of the papers. A few of the papers did not present enough information to place them into any kind of category or domain and did not provide data allowing for new analysis and were therefore removed. What was important to us at this stage was to have a diverse set of papers that presented different types of hybrid work from different domains. This meant that papers presenting empirical material and data from new types of settings went through extra scrutinizing to determine if they would extend our classifications of hybrid work. However, our selection criteria which said that the paper needed to have enough empirical data from a 'real-life' case sometimes meant that we had to leave papers behind, which otherwise had provided insights into an interesting domain [7, 43]. To get an overview of the content of the remaining papers, these were grouped into initial domain categories based on the introduction and method section. At this stage we had a total of 176 papers and the emergent categories of empirical cases were: Office work (99 papers); Out-of-office (21 papers); Performance (16 papers), and other (40 papers).

The diverse nature of the cases helped us to become more explicit in our definition of hybrid work and forced us to develop concrete ways to determine whether the cases were on hybrid work or something else such as individual work, distributed work, or independent system design. We also learned that laboratory studies did not provide much insight into the nature of hybrid work, since these often were done out of context and not in a real-life situation. In this iteration of the data analysis, we developed four criteria for the inclusion/exclusion of papers:

Table 1: Categorization of research papers studying Hybrid work build upon domains.

Domain	Reference	Method	Topic
Health (4)	Luk et al. (2008) [67]	Field study	Remote expertise sharing
	Mentis et al. (2020) [78]	Ethnographic study	Remote expertise in surgery
	Nardi et al. (1994) [80]	Field study	Coordination in surgical team
	Paoletti (2009) [83]	Ethnographic study	Emergency calls
Performance (4)	Baker et al. (1999) [5]	Case studies	Media production
	Bakhuus & Rossitto (2016) [10]	Case study	Theater
	Cai et al. (2021) [25]	Empirical study	Musicians
	Engström et al. (2010) [36]	Ethnographic study	Broadcasting of television
Non-Office (4)	Bayerl & Lauche (2010) [11]	Field study	Offshore oil production
	Luik et al. (2019) [66]	Empirical study	Virtual hubs
	Lukosch et al. (2015) [68]	Empirical study	AR in security domain
	Rae & Neustaedter (2017) [85]	Field study	Telepresence robots at CHI
Office: System focus (10)	Castellani et al. (2009) [27]	Field study	Trouble shooting
	Grønbæk et al. (2021) [46]	Qualitative study	Video-conference system
	Lee & Takayama (2011) [63]	Empirical study	Mobile remote presence
	McGregor et al. (2019) [77]	Ethnographic study	Chat use at work
	Misawa & Rekimoto (2015) [79]	Test study	Telepresence system
	Ruhleder & Jordan (1999, 2001) [88, 89]	Empirical study	Technology generated delays
	Tang & Isaacs (1992) [100]	Empirical study	Video conference rooms
	Tutt et al. (2007) [101]	Empirical study	Group-to-group collaboration
	Venolia et al. (2010) [102]	Ethnographic study	Telepresent co-worker
	Yamashita et al. (2011) [104]	Test study	Tabletop collaboration
Office: Collaboration focus (8)	Avram et al. (2009) [3]	Field study	Distributed software company
	Bjørn & Christensen (2011) [107]	Ethnographic study	Meetings in global engineering
	Doherty et al. (2012) [32]	Field study	Localization teamwork
	Huysman et al. (2003) [57]	Exploratory study	Virtual team communication
	Kipp et al. (2008) [59]	Project study	Collaborative working
	Mark et al. (1999) [73]	Empirical study	Virtually collocated teams
	Mark et al. (2003) [72]	Empirical study	Group-to-group collaboration
	Saatçi et al. (2020) [90]	Field study	Global software company

1. The empirical case must be a situation where at least three actors (actors ≥ 3) are involved in a common field of work
2. The empirical setting must include geographical distribution; however, the geographical sites must be fewer than the number of actors (if actors = 3 the geographical sites = 2)
3. The empirical case must include information about the technology used to facilitate the hybrid work situations (either an existing or new technology)
4. The paper must present sufficient empirical data and analysis of the cooperative work for us to be able to use it for our cross-case analysis.

Based on this, we removed papers that introduced system design without a clear connection to a hybrid work situation [4, 24, 55, 61, 65, 84, 95] and papers that turned out to focus on the individual person rather than the cooperative practice [6] such as a focus on distractions during remote meetings [64]. The result was 30 selected papers.

3.3 Data Sources

Through in-depth reading of the 30 selected papers, we categorized these papers into four main categories of hybrid work domains: Healthcare (4); Performance (4); Non-office work (4); and Office work (18). Office work was further divided into two sub-categories namely papers focusing on the system (10) and papers focusing on the cooperation (8). While some of the papers overlap in the domain categories – for example, papers working within the health domain can study work that took place in an office at a hospital – we grouped the papers based on their main research focus. The categories of domains were therefore not exclusive, but instead a strategy for us to analytically explore the diverse nature of hybrid work. The papers can be seen in Table 1.

3.4 Selected Empirical Cases

Based upon all the papers, we selected four papers with empirical cases for the detailed analysis, one from each of our classifications of hybrid work: Healthcare [83], Performance [36], Non-office work [11], and Office work [72]. When selecting the four papers, we aimed for significantly diverse empirical studies concerning scale, time sensitivity, professional work, technologies, and geography. Moreover, when there were several cases from a certain category, we selected the papers with the most detailed empirical descriptions.

Before presenting the results of our analysis, we will briefly present the context of the four selected empirical cases.

Emergency call: Our first selected case is Paoletti's [83] study of *Communication and Diagnostic Work in Medical Emergency Calls*. The context of the study is an emergency dispatch control room that received an emergency call from a factory reporting an injured person. The situation includes eight actors distributed over four geographical sites. The cooperative situation revolves around the situation where a caller reports an accident in a factory by calling the emergency call center and interacting with the operators. Two operators divide the tasks between them including tasks such as interviewing the caller, diagnosing the situation, and taking decisions. Later a second caller, who is also present at the factory, calls to report the same accident. It is the operator's role to coordinate the appropriate medical assistance to the patient. This coordination involves an ambulance and a helicopter with different medical providers onboard.

Ice hockey game: The second selected case is a study of live broadcasting of an ice hockey game by Engström et al. [36], titled *Temporal Hybridity: Mixing Live Video Footage with Instant Replay in Real Time*. The work situation involves 16 actors placed in four different geographical sites. Five actors with different professional backgrounds are placed in a bus outside the arena, three camera operators are inside the arena, and two commentators are in the arena studio. The focus in on the coordinative activities when mixing live and prerecorded images from the game, which need to be broadcasted to the audience. Thus, the cooperative work centers around decisions on what to broadcast, using which camera angles, supporting which kind of comments, and when to replay match activities.

Oil production: The third selected case is from the paper *Technology Effects in Distributed Team Coordination – High-Interdependency Tasks in Offshore Oil Production* by Bayerl and Lauche [11]. The data report a case where 78 actors were located on two geographical sites: Offshore and onshore. The 52 actors are onshore and professionally act as support engineers or take on managing roles. The 26 technicians are team leaders and engineers all located offshore. The main cooperative activities are to optimize the production and maintenance of the offshore installation. The cooperative focus is on how technology affected the distributed team coordination in these high-interdependent tasks within the offshore oil production domain.

Office work: The fourth selected case is by Mark et al. [72] and studies *Group-to-Group Distance Collaboration* within space mission design. The collaboration consisted of four distributed engineering teams with respectively 1, 9, 12, and 24 collocated actors. The purpose of the collaboration was to connect different professional expertise in working towards a shared goal for the research, and through this invent and develop new technologies within space-based scientific research. The focus is on the gap which exists in the "space between" the groups, and how this space is affected by the distance between the actors.

All the empirical cases reported in the selected papers were conducted at least ten years ago, and interestingly they are still relevant today despite the technological opportunities have evolved. Within the health domain category, current research is still addressing the challenges and advances of tele-triage [109]. Within performance, the increasing popularity of esports events has challenged the digital setup for live-streaming events [112] which also impact other sports disciplines. Current research also still explores the challenge of designing digital technologies to enable remote operation on offshore platforms [110], and in general the COVID-19 pandemic has increased the interest in remote and hybrid work technologies. All these studies demonstrate that the challenges in hybrid work persist and despite the technological opportunities are evolving, we are yet to fully understand the basic nature of hybrid work with the aim of designing hybrid technologies. We in this paper, try to extend this current research by learning from the past.

4 RESULTS

4.1 The Hybrid Work Arrangements

One of the essential dimensions in hybrid work centers on the actors involved in the cooperative work. Therefore, we initiate our analysis by focusing on the actors. We explored questions such as: Who are the actors? What are their professional disciplines? How do the actors' individual, yet interdependent, professional practices unfold during the accomplishment of the cooperative activity?

We begin by looking at the study by Paoletti [83] on communication challenges related to emergency operators' diagnosis work. The paper introduces empirical data on a hybrid work arrangement where all actors are geographically distributed on fewer sites than the number of actors. All actors are dependent on collaboration with others and the work is characterized by interdisciplinary cooperation organized in time-dependent work activity. The empirical data demonstrate how the cooperative work is challenged by the professional disciplines of the actors (factory worker, emergency phone operator, medical doctor), consequentially leading to wrong decision-making. Let us take a closer look.

The situation starts when a factory worker calls the emergency call center to report the accident at the factory and request an ambulance. The call is received by two operators on duty at the call center. One operator receives the information from the factory worker while the other operator dispatches an ambulance to the factory. To do medical assessment and diagnosis appropriately the operators need precise information from the factory worker, and they follow a protocol (script) for receiving emergency calls. Decision-making is dependent on information provided by the caller, and ambulances cannot be dispatched without knowing what type of medical help is requested. In the example analyzed by Paoletti [83], the factory worker (the caller) explains that the accident appears to be a fainting fit, yet urgent since the patient is unconscious. The operators reach out to the ambulance station asking to dispatch an ambulance, specifying the emergency code as 'fainting fit' indicating the urgency. When the paramedics arrive at the factory, they call the operators. The paramedics report that the patient is under an engine and "seemed not to be alive" [83], thus it is a work accident and not a 'fainting fit'. Determining the appropriate action, and not erasing the previous information provided by the original caller (the factory worker) who reported a less severe situation, they dispatch a helicopter with a doctor on board. When the doctor arrives, he confirms that the patient is dead. The doctor files a complaint about the operators' incorrect decision of dispatching a helicopter, as helicopters should only be dispatched when the patient is alive.

In this hybrid work situation, we have four geographical sites: The factory, the dispatch center, the ambulance center, and the helicopter center – however the main hybrid interaction takes place at two sites: The factory and the dispatch center. At the factory site the factory worker and then later two paramedics and the doctor arriving by helicopter are physically collocated. At the dispatch center, the two operators are collocated. What we see in this example is that the nature of a hybrid situation is malleable as the temporal development of the location change as time passes. Which actors are geographically dispersed and who are collocated is thus not a straightforward question to answer as it might change as the cooperative work situation develop over time. Answering the question of who are collocated is dependent upon '*when* we ask' during the cooperative activity. Further, we also see from this empirical example how the different professional disciplines matter for how the hybrid work task is accomplished. While the factory worker initially reporting the accident does not have medical expertise, the operators, the paramedics, and the doctor each have different types of medical skills and expertise. Communicating across the different types of medical expertise while working across disciplinary boundaries combined with the changes in geographical boundaries of the actors are all factors shaping the nature of the hybrid work situation, and, in this case, produce a communication breakdown.

The second empirical case of hybrid work arrives from Engström et al.'s [36] study of the live broadcasting of an Ice Hockey Game. In this case, the actors include camera operators, commentators, and visual image providers. All actors involved are divided into sub-groups, each with clearly defined roles and activities. The three camera operators cooperate to produce audio-visual material from different perspectives, e.g., overview shots and close-up shots. The vision mixer cooperates closely with the replay operator to decide on what to broadcast. The visual mixer decides *what* to broadcast, while the replay operator managed the work related to *editing* the sequences to be replayed, involving the producer, the script operator, and the graphic operator. The camera operators record the images selected for broadcasting by the vision mixer. The commentators make the audio speech. During this process, the replay operator simultaneously selects and organizes recordings for replays of the game. The replay operator scrolls through recordings and selects moments that are valuable to replay for the audience. The empirical case on the broadcasting of an ice hockey game provides insights into how closely coupled work tasks organized in tight coordination activities across three geographical sites take place. The geographical locations include the bus, the arena, and the studio, and the hybrid team includes 16 actors working in four different sub-groups.

The third empirical case arrives from a study of offshore oil production by Bayerl and Lauche [11]. The study of Offshore Oil Production consists of actors who continuously coordinate interdependent tasks required in the production and maintenance of the oil platform. The overall distribution of actors is divided between the onshore and offshore personnel containing sub-groups of actors. Onshore includes support engineers, team leaders, technical authorities, and field operators. Offshore includes technicians, petroleum engineers, team leaders, operations engineers, and installation managers. Bayerl and Lauche [11] identify three main areas of recurrent coordination activities between onshore and offshore. These activities include 1) the well and plant configuration for optimized production, 2) planned and unplanned maintenance of the offshore installation, and 3) reactions to unexpected events. All three types of activities are related to planning, executing, reporting, and negotiating across the geographical sites and sub-groups with different professional backgrounds [11]. Coordination across the actors is guided and managed by the actors located onshore, while execution and monitoring activities are performed offshore (at the oil platform). For example, the specialized onshore engineers ensure that materials are available for the personnel on the rig in due time. The control room at the oil platform has access to data on the valves, pumps, flow rates, fire alarm systems, fluid pressures and temperatures in the plant. The main responsibility of monitoring and controlling the data is with the offshore personnel, only sharing the data upon request. The Offshore Oil production case is thus a hybrid cooperative situation, where long-term coordination and division of tasks onshore/offshore impact the access to data. The empirical case shows how changing the access to data in a hybrid work arrangement impacts the cooperative work arrangement in important ways.

The last empirical case by Mark et al. [72] takes place in a hybrid office environment. This case involves actors that are closely aligned in their engineering disciplines yet with different professional expertise. The study focuses on a cooperative task of a space mission design, which took nine hours distributed over a week – three hours on three different days. The work activity is distributed over four different teams with 1, 9, 12, and 26 actors, whereas each team is placed in different geographical positions. The cooperative work aims to combine different specialized expertise across various areas of responsibility relevant for the shared cooperative task. All teams had different methodological engineering approaches, which were required to be aligned to achieve the joined task.

4.2 Cooperative Technologies

All the selected empirical cases describe work activities that require highly cooperative activities between the different actors working in different types of hybrid settings. These cooperative tasks are enabled by different technologies that support the individual's activity, as well as the coordination, and communication across individuals. Exploring the use of technologies in the selected cases allows us to explore and potentially identify the unique technological features embedded in hybrid cooperative settings as well as investigate how actors follow different strategies to bridge the hybrid setup.

In the Emergency Calls case, the technical setup is characterized by disconnections and unstable infrastructure. The technological setup includes telephones, computers, and radio communication. All the interaction is enabled by audio technologies (phone or radio). The operators communicate with the factory worker reporting the case using the phone, however, the factory worker ends up hanging up in frustration. The factory worker's frustration is grounded in misunderstandings and unclear information about whether an ambulance has been dispatched or not. The paramedics call the operator using a phone when they arrived at the factory. In this call, the paramedics and the dispatch center are interrupted technically and experience several disconnections in their use of both the radio and the cellular phone for interaction. The operator can

hear the paramedics, but the paramedics cannot hear the operator. The lack of a stable technical setup made it impossible to discuss questions and concerns, which then influenced their opportunities for developing common ground as part of the hybrid setup.

In the offshore Oil Production case, the technologies that the company implemented to support the cooperation between the onshore office and the offshore rig include videoconferencing, desktop-sharing, and real-time access to plant and process data – all in addition to technologies such as phone, email, and audio-conferencing. One core shared activity between onshore and offshore is the information exchange of data between the sub-groups. The onshore team offices have large, shared screens installed where real-time data about the oil platform is visualized. This allows the onshore engineers to follow the status of the plant from afar limiting the need to request information from the offshore personnel. However, the introduction of new technology also changed the collocated activities as the projection of data on the shared screens in the room "provoke a conversation" [11]. With the data visually available for everyone to see (both onshore and offshore), the onshore sub-group had immediate reactions to the data and was able to effectively start investigations of sudden changes. Moreover, the offshore control room had video-connections implemented, allowing the onshore personnel to visually follow the activities. Implementing live-feed video provided new ways for doing information exchange temporally, compared to the previous use of sending emails with images. With the videoconferencing, geographically distributed actors showed the relevant information directly during the call. The technologies in the Oil Production case enable cooperation by increasing the distribution of data and providing (almost) synchronous access to information for both collocated and distributed team actors.

Differently, the technologies used to facilitate interaction in the Ice Hockey case did not increase access to information, instead, the technology setup was structured to limit the actors' access to information. Let us take a close look. In the Ice Hockey case, actors use several different technologies. The producer, script operator, and graphic operator each have different screens however they all display and provide access to the same information. Some of the other actors, e.g., the vision mixer and the replay operator, has different technological setup providing different visual streams to be available. The replay operator is collocated with other actors but has a split-screen display of all four live camera feeds combined with two monitors which are used to record and manipulate video footage for replay. As such, the replay operator can react immediately when situations arise in the match stipulating the need for replay – and then use the technical setup to scroll back in time for any of the four camera feeds. The cooperation between the actors is enabled by radio communication, however, not all actors have radio access. The vision mixer and replay operator do not have radio access and can instead overhear the interaction by listing to the commentators from the loudspeakers. The vision mixer has direct audible contact with the commentators (due to physical proximity), while the replay operator is only able to contact the commentators by pressing a button to create an audio-stream. The technical setup shapes the access to information and access across sub-groups, professional expertise, and geographical sites, and thus creates the shared hybrid workspace for all actors.

In the Office Work case, the collaboration between the four teams is enabled by a video conferencing service that displays the video stream from the site that is most vocally active. The sites have different large displays matching the size of the local contexts; Site 1 has three public displays of 12 x 6 feet, Site 2 has two displays of 6 x 5 feet, and site 3 has a display of 6 x 5 feet. Additionally, they use a shared application linking spreadsheets and graphics, which enabled the actors to publish relevant specifications and parameters. The collaboration across the different teams is mediated by video teleconferencing, which is available for all actors, and as part of subgroup conversation which is only available for selected actors either locally or across the four sites. Finally, the actors use telephones and voice conferencing technology.

In all four selected cases, the hybrid setup includes multiple technological systems that together formed the technical infrastructure required to accomplish the work. While the technical setups were different across the four empirical cases, they all confirm that the implementation and use of technologies shape the basic nature for which type of cooperative engagement can take place [51] is also relevant in a hybrid work setting.

4.3 Breakdowns in Communication and Creating Common Ground

Collaboration between different actors requires a shared understanding of coordination and communication. The selected cases exemplified both breakdowns and successes in creating common ground, which in hybrid arrangements is not only required for the geographically distributed actors but also the collocated sub-groups.

The selected cases represent work where different professions and expertise is present, and that potential communication breakdowns can emerge due to the interdisciplinary nature of the work and the lack of common vocabulary. Unpacking the communication breakdown in the emergency call case, we find that the call operator and the factory worker reporting the accident lacked a shared understanding of the situation at the factory. The operator misunderstood the factory worker reporting the accident [83]. Developing common ground in the distributed situation was challenged by the actors' (in)access to information. The operator strictly follows protocol, but the factory worker does not understand *why* he must provide the information requested and gets provoked by the assumed lack of action: "[the caller] see the questioning as an unreasonable way of postponing the delivery of help" [83:236–237]. In this case, the factory worker utters profanity and then hangs up, with no attempt to close the call. That the call operator has already requested an ambulance while starting the questionnaire with the factory worker was not visibly available for the factory worker. Thus, using the protocol for questions became a provocation for the factory worker who then expressed anger. After hanging-up the phone, the connection between the factory worker and the call operator was re-established (new call) but continued in the same unproductive tone. In the control room at the dispatch center, the computer monitors enabled the operators to see that an ambulance *is* on its way. However, the factory worker does not have access to this information and complaints about the lack of action by the operator. To establish common ground concerning the actions that

have been taken, the operators need to convey such information to the factory worker, and in the situation this did not happen.

The inaccurate information provided by the factory worker, further complicated due to stress and anxiety, makes the call operator misinterpret the accident as a fainting accident, rather than as a severe work accident. Despite the frustration in the communication between the two, the operator sticks to the information first provided and registers the emergency as a 'fainting fit' and dispatches an ambulance. It then turned out that two different people had reported the accident - the first factory worker reports a fainting fit and is unable to explain what has happened but can only report a colleague is on the ground unconscious; the second factory worker reporting the accident also mentions the fainting fit but also reports that his colleague is breathing but unable to talk. The operator presumed that *all collocated actors* (first and second factory workers) have equal access to the same information. The operator presumes that the local actors must have access to the same and correct information since they are collocated. When the paramedics report that the patient is dead, the operator does not "erase" the information previously provided by the two factory workers and decides to dispatch a helicopter with a doctor on board. Currently, we have three collocated actors (two factory workers and a paramedic) and the operator continues to assume that all collocated actors share the same information. It turned out that the patient was dead already when the paramedics arrived, also verified by the doctor when they arrive at the factory. What this empirical case demonstrates is that we cannot assume that actors involved in hybrid work have access to the same information and share common ground despite being collocated.

In contrast, the case of broadcasting an ice hockey game [36] demonstrates how the communication across disciplinary boundaries was successful despite the hybrid setup, because of the important effort of all actors in establishing common ground. Let us explore the concrete situation. A gaming incident where a penalty is committed takes place in the hockey game. When a gaming incident occurs, the footage must be replayed for the audience. The replay operator searches the video bank and produces the relevant replay footage. Another penalty is committed in the game, while the replay operator is searching for replay footage of the first penalty. The new incident needs to be replayed directly after the first incident. However, the replay operator does not look at the live footage while searching the video bank for the first incident, thus they do not know who did the second penalty and the commentators' reactions (audio) are temporally out-of-synch with the game event. To reestablish common ground, the replay operator needs information from other actors. The replay operator requests additional information by asking openly, which makes their request for information audibly available to all collocated actors involved. The vision mixer hears the request and since he has access to different visual streams, he can identify the person involved in the second penalty and provide the number of the player to the replay operator. Further, to give the replay operator more time, the vision mixer asks the camera operators to swift their tasks. All this coordination work is enabled by audio communication and all actors have a shared understanding of all actors' actions in the cooperative activities. Engström et al. write that "It is the availability of several media, visual and auditory, that makes this split of attention possible." [36:1499]. The hybrid cooperative work therefore only succeeded because of the technology-enabled communication of the actors related to their activity and not related to their physical location. The vision mixer and replay operator act as distributed actors, so while all actors are geographically close to each other during the hockey game, not all are collocated. Yet, each specifically defined work activity is accomplished only due to the seamless interaction solving the interdependence of the other actors' access to information. The replay operator is dependent on the commentator and vision mixer's information as they do not have visual access to this themselves.

In the Oil Production case, the geographical distance between sites in the hybrid setup is several kilometers, yet the technological setup made the distributed actors achieve an experience of copresence. As the study is conducted under the process of implementing new information and communication technologies in the oil production setup, the paper provides empirical data that display the change in technology and how such changes shape the condition for common ground in hybrid work. The core technological change is two-folded: 1) providing direct access to the data onshore and 2) a continuous video link across the two sites. While some of the actors prefer using emails to document the coordinative decisions, the video links replaced a significant amount of phone calls and emails. One of the video connections is placed in the control room on the rig, which by the offshore personnel is perceived as intrusive and adds pressure from the onshore. Bayerl and Lauche document in their finding: "[. . .] '*I just don't like it. I mean, maybe it's a bit of added pressure if somebody is watching you*'. Especially in the early stages after the implementation of video-links, offshore technicians reacted by placing coffee cups and hardhats on cameras or by pointing the cameras to ceilings or corner." [11:151]. Thus, despite the technologies enabling synchronous collaboration improving the conditions for common ground, the technological setup also introduces new challenges to the hybrid setup such as the relations between surveillance and privacy. Over time it facilitates new opportunities for hybrid collaboration and some actors experience a social connection between the onshore and offshore engineers, a social connection they had not previously had: "some of the guys that I've hardly ever spoken to before I'm now chatting away like we're best of friends" [11:152]. In this way, the continuous synchronous connection over time supports the shared meaning context across sub-groups in the hybrid setup. While the video link impacts the hybrid work, the new data-sharing setup across onshore and offshore also transforms the cooperation. After the implementation of the new technology setup, data are shared automatically between onshore and offshore. This allows onshore personnel to monitor the plant from afar, yet it also blurs the boundaries between specific roles and responsibilities across sites. The actors involved in the hybrid setup on the platform can be divided into the generalists and specialists, whereas the specialists are placed onshore to plan and guide the tasks, while the generalists organize the everyday work on the platform. It is the generalists' job to analyze the day-to-day data, but the new setup of real-time sharing of data transforms the work. "[W]ith the availability of real-time data and the easier access to the control room, onshore engineers were now drawn closer into the day-to-day issues on the platform with the danger of losing their longer-term, strategic focus" [11:159]. Thus, the data sharing

invites onshore specialists to act upon the daily tasks, which blurs the roles between the actors. Consequently, this transformation in work adds additional work to the specialists, while erasing the job functions of the generalists. The Oil Production case reminds us that when designing technology setups, it is important to find ways to facilitate the establishment of common ground, but we must be aware of the potential consequences our efforts might also produce, which might be counter to our initial purpose.

In the Office Work case, creating common ground was challenged by the different sub-groups. Mark et al. [72] explain how all teams entered the collaborative work with their own culture and practices, which complicate their ability to create shared language and terminology to solve the specific space design activity. For example, the largest of the collocated teams (26 local actors) had worked together for several years. Therefore, they had shared experiences supporting the development of common ground. In such group-to-group collaboration, the actors know about the methodology used by their collocated group, but the practices and processes of the groups are not visible between different groups. Technology can be used to enable a shared understanding between the different groups; however, it can also extend the misalignment between the actors - what Mark et al. [72] define as the "space between" the subgroups. During the articulation work that supports the cooperative work, the actors achieved to create hybrid solutions to create common ground, yet the subgroups were challenged in adopting the new language created, as they still hold on to their subgroup's methodologies and processes. In this way, the Office Case shows an example of hybrid work that succeeds in the creation of common ground between the distributed teams, however, this does not necessarily mean that the subgroups adapt to the new understanding created across the teams, as the collocated practices risk taking precedence.

5 DISCUSSION

We have explored the characteristics of hybrid cooperative work in diverse cases from previously published papers. Our selected empirical cases allowed us to scrutinize the nuances in hybrid work situations as an analytical frame for depicting the subtle differences between distributed work and hybrid work. The subtle differences become pertinent for design decisions for hybrid work and rest on the fundamental similarity between distributed and hybrid work in that they both are cases where the accomplishment of the cooperative task produces interdependence across actors requiring them to engage in articulation work despite geographical dislocation. As such, we view hybrid work as a subset of distributed work. This allowed us to consider hybrid work as a special entity and area of interest for CSCW design while utilizing the existing theoretical contributions emerging from literature on distributed work as a steppingstone.

5.1 Hybrid Work as a subset of Distributed Work and Cooperative Work: Collocated Distance

Across all the selected empirical cases, we identified an interesting design challenge: The design of cooperative technologies tends to focus on the problem of creating common ground *across geographical sites*, yet another equally important design challenge emerging from our analyses is the challenge of supporting the development of common ground *in the collocated part of the hybrid setup* – however this design challenge tends to be completely neglected in hybrid technologies. In the Emergency Call case [83] the challenge became pertinent when the data revealed that the two collocated participants in the factory who were assumed to have common ground, clearly had divergent perspectives on the situation (as described in section 4.3). Or in the case of the Ice Hockey Game [36] where the participants who were collocated turned out to have very different access to information and thus did not have the otherwise assumed common ground which arrived with collocation. Across all our cases, *collocation without common ground* emerged as an interesting and surprising design challenge that is uniquely shaped in hybrid work situations, and we suggest labeling this challenge, the design challenge of *collocated distance* in hybrid work.

Collocated distance refers to the challenge in hybrid work where collocated actors do not share common ground despite their immediate shared context. In this way, collocated distance can be considered as depicting a boundary that entails a 'distance' within the collocated actors. Across all four cases, we saw that the hybrid work setup produced different types of sub-groups. The sub-groups emerged and were enforced by the technology setup where people who were geographically distributed emerged as sub-groups. However, sub-groups also emerged between people who were collocated in all our cases. For example, in the Emergency Call case, the call center sub-group assumed that the factory sub-group was collocated and thus had access to the same information and were interacting with each other. Similarly, in the Hockey Game, the control room sub-group and the camera sub-group had assumptions about the other sub-groups as well as who had access to the same information. However, in both cases, the actors in the collocated sub-groups were not interacting and thus did not share information, nor had access to the same information which created a situation of miscommunication. Miscommunication has been a core challenge within cooperative work for decades, and we therefore explore this issue further.

In previous literature on common ground, the focus has been on the boundaries created by the geographical distance jeopardizing the establishment and maintenance of common ground. As such, prior research tends to focus on miscommunications between geographical dispersion, and not within the collocated context. Distributed work has similar challenges as collocated cooperative work, but the introduction of geographical distance transformed some of the conditions for how actors could engage. When we explore hybrid work within prior conceptual understanding of space and place [38, 51], our analysis shows how the opportunities for interactions in hybrid work technologies tend to focus on the remote situations – the digital 'space' providing the opportunity for interaction despite dispersed participation. The design challenge in current research tends to focus on 'creating a space' for interaction when no resources exist without the technology. We expand this argument by emphasizing that – yes – we do need to consider how hybrid technologies can produce opportunities for interaction between distributed actors – however in this attempt we must not

forget that the space for interaction in hybrid work *also exists between collocated actors.* Based upon our analysis, we argue that the design challenge for hybrid technologies cannot take the 'space for cooperation' (the opportunity for interaction) in the collocated context for granted when designing hybrid technologies. Instead, the design of hybrid technologies must simultaneously find ways to shape the *remote* as well as *collocated space* for interaction - if we are to produce a hybrid space for collaboration where placed-based activities can take place.

Considering geography at a dimensional scale [62, 103] mixing collocation with remote participation introduces potential challenges of different life worlds, time zones, assumptions, and languages into the mix of distributed work [18]. In all our selected empirical cases, the geographical distribution did shape the kind of collaboration that could take place. The geographical distance between some but not all participants produced sub-groups as pertinent for the hybrid setup. However, we identified that an essential 'distance' that jeopardized the establishment of common ground was not between remote participants but instead between the collocated sub-groups. The distinction between geographical distance and perceived geographical distance matters [23]; however, in our selected cases it was not the perceived geographical distance or geographical distance which mattered the most. Instead, it was the non-geographical distance created *within* the collocated setup, shaped by access/lack of access to information combined with different types of professional expertise.

We found that hybrid work situations *inherit all the challenges* and aspects from both collocated cooperative work and distributed work, including the challenges of creating common ground, identifying the appropriate coordination strategies, supporting mutual awareness, and balancing the geography dimension to find ways to navigate multiple lifeworlds, assumptions, languages, etc. Further, we found that professional expertise, hierarchy, and information access matter for how the hybrid work situations produce certain conditions for establishing and maintaining common ground. All these factors can potentially also emerge in collocated cooperative work and distributed work. However, we would argue that these factors have increased complexity in hybrid work settings. Why? Firstly, in all the selected cases we found that when introducing collocated sub-groups into the mix of geographically distributed actors introduced misalignment and asymmetry by default. When we have a cooperative situation where actors do not have equal access to the same information, to other actors, or to monitor others' activities and act accordantly, additional boundaries emerge. Sub-group dynamics can be essential to all types of collocated and distributed work – however *sub-groups based upon some participants being collocated and others not, are always part* of hybrid work situations. The geographically collocated sub-groups consequentially increase the difficulties of establishing and maintaining common ground [81]. Not because common ground is only difficult in hybrid work (it is always difficult), but because the condition for grounding activities is constrained due to unequal access. Further, we found that the additional boundary of collocated distance was pertinent impacting the potential for creating common ground.

This means that when we design technologies for hybrid work, we can not only focus on the boundaries across geographical distances but must remember the potential boundaries which can be pertinent for the whole hybrid setup which is emergent within *one* geographical location. We propose collocated distance as a way to remind ourselves not to forget the collocated interaction when we design cooperative technologies for hybrid work and to pay attention to sub-groups that are collocated yet exist due to e.g., professional expertise, hierarchy, and differences in information accessibility despite the collocation. Collocated distance complements previous distance conceptualizations such as geographical distance as a scale [62] and perceived distance [23], by nuancing our vocabulary and thus our design focus when developing hybrid technologies. Collocated distance teaches us that we must not forget the potential challenges that can arise in collocated work even though our design 'entity' includes geographical distance. If we are to design technologies that support hybrid work, we need to consider the dispersed nature of knowledge involved in cooperative work – in Hutchins's words the distributed cognition [56] – since all cooperation is immediate social by nature and thus the knowledge and activities are distributed across actors (also between collocated actors). We must pay equal attention to the interaction *across* geographical sites and the interaction *within* geographical sites. Finally, we must remember that hybridity in a cooperative setup might change over time, thus we should consider the spatial-temporal aspects of hybrid work in future design.

5.2 Design Challenges for Hybrid Work Technologies: Professional Disciplines, Hierarchy, and Information Accessibility

As we have emphasized throughout the paper, the core challenges in hybrid work circle around the difficulties in establishing and maintaining common ground. The tools and technologies enacted in cooperative engagements shape the conditions for common ground, and many CSCW researchers have explored different technological design strategies to improve the conditions for common ground in distributed work, such as feed-through [49], articulation spaces [22], and interaction walls [60]. However, most of these solutions are based upon a situation where either all participants are geographically dispersed, or all participants are collocated, with only a few exceptions [37].

Where current design approaches for cooperative technologies tend to simplify the situation to be able to address the challenge of common ground [9, 17, 50]. Instead, we tried to follow the complexities in the cases to see if they would allow us to create a nuanced understanding of the challenge. Following the complexities in developing common ground in the selected cases, we identified *two important dimensions* which shape the characteristics of hybrid work, *namely relations between hierarchy and professional expertise*, and the relations between *information access and the diverse technological contexts.* Let us look at each in turn.

Across the cases, the conditions for establishing common ground were impacted by which actors are involved (who) and how these actors are 'sorted' *hierarchically* within the organizational setup. The actors involved each have their own *disciplinary background* including domain-specific language, procedures, and practices. Professional backgrounds impact participants' expectations of the cooperation. In this way, each actor brings with them to the interaction in the hybrid work their own social context including professional

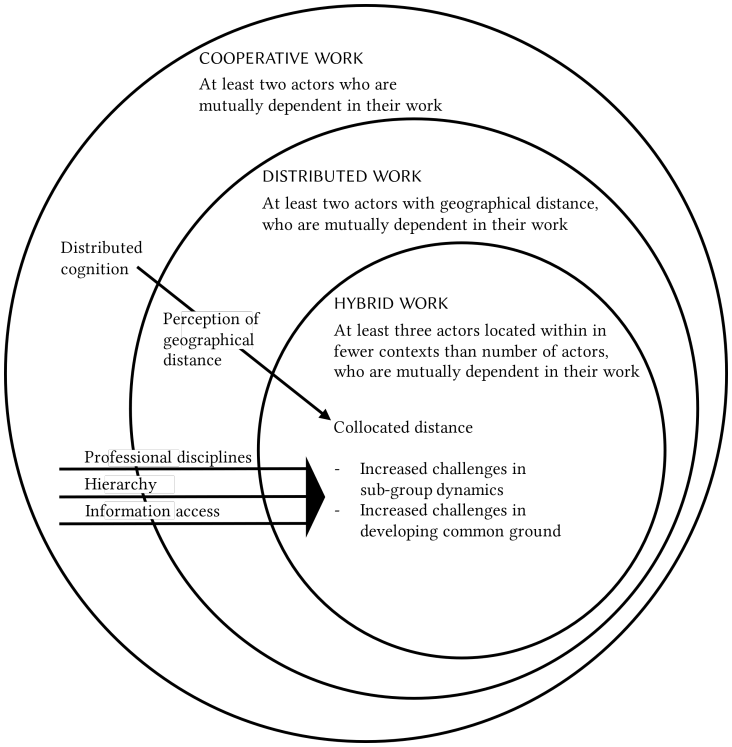

Figure 2: Visualizing Hybrid work as a subset of Distributed work and Cooperative work

language and assumptions [18], which are challenged when interacting with others with different professional disciplinary backgrounds. For example, this was the situation in the Office Work paper [72] where the different groups brought their individual and professional practices into the mix, challenging the development of a shared understanding across all participants. When various actors interact, each bringing their own background assumptions and social contexts into the mix, they negotiate the common field of work by engaging in grounding activities [29]. However, the geographical dispersion of the actors and the constellation of who is collocated and who is dislocated impact the conditions for creating common ground *across professional boundaries*. In the Oil Production case, the actors making the long-term planning were placed onshore while the actors the activities were placed offshore. Thus, the professional disciplinary boundaries aligned with the geographical boundaries. Not only did the different professional expertise complicate the establishment of common ground in the Oil case, but the *hierarchical positioning of the actors* also impacted the hybrid situation. Professional background and hierarchy are often linked together, as different professional disciplines often are situated in a hierarchical order. When dividing shared tasks into subtasks through segregation the purpose is to reduce the complexity of solving the task through coordination [40], in such a way that everyone does not need the complete overview of the shared task but only focuses on specific assigned tasks. Decisions on who then should do which subtasks are then decided upon based on professional expertise as well as hierarchy – thus simpler tasks are distributed to people with less expertise, allowing for people with high expertise to focus on the more complex part of the work and solve complicated problems and breakdowns. Such setup often means that the details of the work become invisible by distance [98], and thus the detailed information of certain tasks slides into the background.

Interestingly, the Oil Production case showed that providing *information access* to all actors, risks moving the tasks and responsibilities across actors and in this way erases job functions. In contrast, the actors in the Ice Hockey game case are limited to only accessing the information relevant to their own individual activity. In this way, the *hierarchy defined by expertise and the hierarchy across members* in the collaboration was shifted by the changes in setup and information accessibility in the Oil case. From the early days of groupware research, we know that cooperative technologies can disrupt social processes [48]. For example, email can disrupt the hierarchy in an organization by allowing low-level organizational members to have direct access to top management by sending them an email. The Oil Production case does not refer to email, but what emerged in the case was that the *accessibility to information was transformed* because of a re-arrangement of the technological setup which again disrupted existing professional expertise division of the tasks, impacting the actors' conditions for establishing common ground.

Professional expertise and hierarchy thus shaped and were shaped by the technological context stipulating specific conditions for information accessibility. Further, we also saw that specific subgroup dynamics [35] emerged within the hybrid setup – and in the cases where the demarcation of the sub-groups was overlapping

with both professional discipline and hierarchy – and the impact of 'distance' was increased and can consequentially develop fault lines within the cooperation [35]. This means that if the sub-groups shaped by geographical distance also overlap with differences in professional disciplines and hierarchy it *increased the impact of distance and challenged* the conditions for creating common ground.

Considering our analytical findings in a design context for hybrid work technologies, we propose that hybrid technologies should not simply focus on supporting the remoteness embedded within the arrangement. We argue that by only focusing on the remote boundaries, we risk neglecting the important collocated boundaries. Further, we argue that in this attention to collocated distance, we must consider the professional disciplines, the hierarchy, and the organization of information accessibility. So how does this extend the design space? Referring to one concrete hybrid technology namely the Sidebar technology [37], we see an example of how the designers focused on facilitating the connections between distributed actors placed in hybrid meetings. However, we also discover that their design is based upon the assumption that the collocated participants in the hybrid meetings do not experience any boundaries for interaction requiring technology support.

We argue that designers of hybrid technologies cannot assume that collocated actors share the same information and have the opportunities for seamless interaction simply because they are collocated. Thus, our work extends the design challenge for hybrid work technologies such as Sidebar [37] to include additional design considerations for supporting or reducing the risk of collocated distance jeopardizing the development of common ground.

6 CONCLUSION

We sat out to investigate the characteristics of hybrid cooperative work to determine how hybrid work situations introduce unique design challenges for hybrid technologies. Through cross-case analysis of existing empirical cases from literature, we categorized hybrid work into four categories: Hybrid work in healthcare, Hybrid work in performance, Hybrid work in the office, and Hybrid work in non-office work. Selecting one paper from each category each providing rich empirical details allowed us to unpack the characteristics of hybrid work as a subset of distributed work with related design challenges. We propose *collocated distance*, an oxymoron, which makes visible an overlooked challenge reminding us not only to focus on the geographical boundaries but also to pay attention to the collocated boundaries which are produced in hybrid setups when we design hybrid technologies. Hybrid work arrangements take many different formats – and our conceptualization proposes hybrid work as a continuum of different work setups. We know that we have not unpacked all the variety within hybrid work in this paper, and we will encourage future research to further nuance the details embedded within hybrid work, for us to start classifying and developing different categories of hybrid work technologies. Finally, we hope that our categorization and visualization of hybrid work can help others to continue the work of understanding the special characteristic of hybrid work with the aim of designing hybrid technologies.

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