Rethinking Collaborative Decision Making across Distributed Work Communities in Complex Work Settings

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ABSTRACT
Motivation – The motivation has been a recent shift in perception of decision making from an individual mental process to one that locates cognition within a rich ecology of social processes. The research aims to make theoretical contribution to this shift which would clarify and extend the current notion of decision making in real world collaborative work settings.

Research approach – Three phases of field studies were conducted to explore collaborative decision making taking place during everyday work practices of Airport Air Traffic Control Operations. The studies involved conducting observation and interviews with air traffic controllers in the Control Tower and Operations Centre of an airport. This was supplemented with other forms of data including organizational documents, audio recordings, and photographs. Data collection and analysis was founded on Grounded Theory Methodology.

Findings/Design – Four Patterns of Collaborative Decision Making emerge from the Grounded Theory analysis. They are: Sequential Decision Making, Mutually Consented Decision Making, Manipulative Decision Making, and Emergent Decision Making. These patterns characterise the ways in which decisions are made collaboratively during everyday work practices and depicts the situated, distributed, embedded, and embodied nature of decision making in a collaborative work setting.

Research limitations– Collaboration between multiple work communities involved in Airport ATC operations is studied only from the Control Tower and Operations Centre in one medium sized airport in the UK. Understanding of other various work community’s involvement in the work process is with respect to the operations taking place in these two control centres. This limits the findings to be based on exploration of one Airport ATC operations and two of the multiple work communities operating collaboratively.

Originality/Value – The research makes theoretical contribution to the recent shift in perception towards decision making from a purely mental activity to one that is situated, embedded, and embodied in the sociality of work.

Take away message – This study presents decision making activity as not just choice points to make a selection but as a fluid, momentary, and cumulative activity which is dissolved and incarnated in the various actions and interactions taking place during everyday work activities.

Keywords
Collaborative Decision Making, Naturalistic Decision Making, Distributed Work Communities, Air Traffic Control, Grounded Theory Methodology

INTRODUCTION
There is a strong tradition of decision making research which considers this from the perspective of individual cognitive processes as portrayed in the theoretical perspectives of Rationalistic Decision Making (Doyl e and Thomason 1999) and Bounded Rationality (Simon 1978). Much of the research on decision making is conducted under controlled laboratory settings. A criticism of such an approach has been its failure to capture how people make decisions in complex real-world settings. This resulted in the emergence of studies which look at decision making as it occurs in natural settings under the rubric of Naturalistic Decision Making (NDM) (Klein 1993; Orasanu and Connolly 1993). Exploring decision making ‘in the wild’ has also led to a shift in the perception of decision making from being an individual mental process to one that is situated and embedded in the complex work practices, and tightly integrated with an evolving context of social interaction.

Of late, the need to consider the bigger picture while investigating decision making by including the influence of context, culture, and sociality in the decision making process is being realised (Panzaras, Jennings and Norman 2002; Alby and Zucchermaglio 2006). This attitude is also reflected in the proliferation of research in the realm of NDM towards including analysis of macrocognition (Schraagen, et al. 2008) to broaden the focus of the field. Although the macrocognition framework includes social aspects such
as team work, coordination, and maintaining common ground, the emphasis in macrocognition is on cognitive functions (Klein, et al. 2003). Hence, research in decision making focuses primarily on cognitive functions even while situating decision making in a broader context in actual real world work environments. Such a perspective provides a restricted approach to investigating the situated, distributed, shared, embedded, and embodied aspects of decision making in real world work settings. There is need for a fresh approach to explore decision making in the broader setting involving context and sociality.

This research is such an endeavour which investigates the placement of decision making in natural real-world work settings by stepping away from the emphasis on just cognitive functions involved in decision making and focussing on the involved social functions. The research is undertaken by exploring how decisions are made collaboratively in complex work settings? In particular, this research explores how personnel belonging to distributed heterogeneous work communities in an Airport Air Traffic Control work setting make decisions collaboratively. A classification of Collaborative Decision Making (CDM) activity emerged from analysis of field data founded on Grounded Theory Methodology which depicts different ways in which CDM is achieved during everyday work practices. Patterns of CDM activity emerging from the data analysis depicts the situated, embedded, embodied nature of decision making and is presented in this paper.

The paper is organized as follows: The following section presents a brief background on existing approaches to exploring CDM. Research approach of this investigation is presented next. The ensuing section presents the findings emerging from the studies conducted to inform this research. The paper then concludes by presenting the inferences drawn from these findings.

EXPLORING COLLABORATIVE DECISION MAKING IN COMPLEX WORK SETTINGS

In complex work settings individuals rarely work autonomously, being required to cooperate and coordinate their activities in order to achieve both individual and collective goals. Personnel recognize the need to reason, negotiate, and agree appropriate goals, means achieving them, and to commit themselves to a given course of action (Panzarasa, et al. 2002). This phenomenon has been explored under various labels such as group decision making, shared decision making, and cooperative decision making. In this research, the phenomenon is considered to be Collaborative Decision Making (CDM) which is typically considered to be decisions made collectively by a set of individuals to achieve a common goal (Panzarasa, et al. 2002).

Research in the field of NDM has focussed primarily on individual decision making. Although research in this area has proliferated towards decision making involving multiple personnel, it has been done mostly under the influence of other disciplines such as cognitive psychology, social psychology, and organizational psychology. This has resulted in various concepts such as team situation awareness (Salas, et al. 1995), team mind (Klein 1998), shared mental models (Cannon-Bowers, Salas and Converse 1993) and the like. However, when adopting such an approach CDM is still perceived to be a variation of individual decision making arising through overlapping individual cognition (Cannon-Bowers, et al. 1993; Klein 1993; Cooke, et al. 2000). (Cooke, et al. 2000)) prefer to use the term team knowledge over shared mental models or shared cognition. Team knowledge however is not simply the aggregate knowledge of individual team members, rather it is a result of various interactions taking place between the team members (Klimosky and Mohammed 1994). In recent years there has been a growing belief in the field of psychology that in order to capture the multiple facets of individual cognition it is necessary to take into consideration how individuals act in a social context (Levine, Resnick and Higgins 1993). This view is corroborated by (Cooke, et al. 2000) who consider that team knowledge emerges from the application of various team process behaviors such as situation assessment, communication, coordination, and cooperation to the collective knowledge of individual team members.

Lately, ethnomethodological contributions have offered a shift in perception towards the conceptualization of decisions and the process of decision making. (Brown 2005) considers decisions to be ‘social objects’ which can be used to structure collaboration. So instead of regarding decisions to be embedded in the mind of individuals, they are seen as devices that can help coordinate activities in a work process. Decisions are considered to be mechanisms to implement many features of collaborative work such as coordinating social interaction, accounting for activities, structuring communication, coordinating the right resources for performing the task, and predicting future events. Hence, in order to understand the process of CDM it is important to not only focus on the information processing and situation assessment activities involved which lead to decisions, but also on posterior activities by exploring the implementation of decisions made and its consequence in the collaborative setting.

In order to achieve a balanced approach to investigating CDM, this study is not founded on the theoretical underpinnings presented by the different fields in discussion here. Instead, the researchers aim to obtain a fresh perspective to CDM by allowing the conceptualizations to emerge from the studied setting.

RESEARCH APPROACH

The research takes a qualitative approach and conducts empirical study of CDM in its natural work setting. Everyday work activities are explored as they take place, and work practices and social interactions involved in CDM are analyzed. Data collection and analysis is founded on Grounded Theory Methodology (GTM) (Glaser and Strauss 1967). There were two main
reasons for employing GTM here. GTM offers a systematic set of methods for qualitative data-gathering and analysis of real-world phenomenon which help address concerns raised about the lack of rigour in qualitative studies undertaken in NDM research (Lipshitz 2010). Second, GTM advocates an approach which is responsive to the data by being grounded in it such that the phenomenon of investigation is given priority over preconceived theories and assumptions. Such an approach seems appropriate for this research because the study is aimed at exploring CDM as it occurs in the natural work setting with the aim of allowing conceptualization of CDM to emerge from the investigation instead of approaching the phenomenon under the influence of existing theoretical connotations.

Grounded Theory Methodology (GTM)

GTM was developed originally by (Glaser and Strauss 1967) as an approach for generating theory of phenomenon grounded in a systematically gathered and analyzed data. Compared to other qualitative research methods, GTM places emphasis on continuous interplay between data collection, analysis, and conceptualization. The Grounded Theory process is both inductive and deductive. Inductive, in that instead of starting with a hypothesis or theory, relevant theoretical concepts are allowed to emerge from the data during the coding and categorization process. These concepts are then used to direct further data sampling and analysis thereby becoming a deductive process. This is a cyclic process during which the researcher goes back and forth between induction and deduction. Such interplay includes several phases of analysis such as: labelling data to derive codes, relating codes to derive categories, drawing relationship between categories, deriving core category, strengthening core category, saturating codes and categories, and written records of the researcher’s abstraction of the analysis in the form of memos. These phases are not undertaken in a linear manner, are interchangeable, and there is continuous interplay between the data collection and analysis.

The findings presented in this paper are part of a study undertaken to explore collaborative decision making across distributed work communities and Grounded Theory was its chosen research methodology. Hence, the authors did not choose this methodology with the aim of explicating the findings presented here. Instead the findings emerged during the process of Grounded Theory analysis. However, the rigorous approach to analysis provided by the methodology only strengthens the credibility of the findings presented. Also, since the methodology was employed to allow concepts to emerge from the data instead of approaching the analysis with preconceived notions, it has helped perceive and characterise decision making in a different light which contributes to current shift in perceiving decisions and decision making.

Data Collection

GTM advocates interplay between data collection and analysis. Analysis commences once initial set of data is obtained that is sufficient to generate initial concepts. Further data sampling then takes place based on the analysis and emerging theory (Goulding 1999). Data sampling in GTM is Theoretical Sampling which is based on contribution to theory generation and enriching understanding of phenomenon under investigation. Field studies were conducted over a period of three years in three phases. Visits to the study site during each phase were conducted for 7 days with each visit lasting up to 6 hours. The number of visits during each phase was decided based on the concepts and questions arising from the data analysis as well as available access.

Site Description

Selection of the site for conducting the field study was based on three broad criteria: a distributed work setting, work activities requiring distributed personnel to function collaboratively, and joint involvement of distributed personnel in the decision making process. For this research, Air Traffic Control (ATC) seemed to be an appropriate choice of domain as the work environment presents a good example of the above criteria and the work process is complex. Complexity in such work settings is characterised by the involvement of multiple people distributed in time and space, critical nature of work in terms of human and pecuniary safety, time pressure involved in undertaking work activities, and constantly changing work environment providing ill-defined goals (Berndtsson and Normark 1999). Besides, work activities of people involved in ATC operations are closely integrated, requiring them to operate cooperatively, and make complex judgements and decisions to accomplish tasks. In particular, the Airport was chosen as the site for the field study because it is a vastly distributed socio-technical work setting with vital placement in ATC process. Work involved in ATC operations at the Airport is distributed in and around the Airport among multiple personnel. These personnel are dispersed in time and space, function collaboratively, and are supported by myriad of technical artefacts. Also, decision making is vital for safe and efficient functioning of ATC at Airport because decisions made by personnel in this distributed yet interrelated setting are tightly coupled with each other’s work activities.

The field study was conducted at a medium sized airport in London, UK. A number of agencies are involved the management of safe and efficient movement of aircraft and are located both within and outside the Airport. Agencies located within the Airport include various commercial airlines such as Easyjet, Monarch Airlines, Thomson Airways, and Ryanair who have their own hangers in the Apron area, two Handling Agencies who provide various services (cabin, catering, passenger, and ramp service) to the Airlines, Control Tower, Engineers, Operations Centre, Airport Management Authority, and Emergency Services which includes Fire Station, Medical Service, and Police Service. The agencies which are located outside the Airport but are integral for
its ATC operation are the CFMU (Central Flow Management Unit) located in Brussels at Belgium, LTCC (London Terminal Control Centre) in Swanwick, Met Office at Devon, UK, and other Airports. These agencies form a network of organizations which work together to provide safe and efficient means of air transportation. Personnel belonging to these agencies can be stationary or mobile and can be co-located or distributed.

Two work centres, Control Tower and Operations Centre, were identified for undertaking the field studies at the Airport. Work carried out at these two control centres is integral to ATC operations at the Airport and is closely integrated with that of other above mentioned agencies. Hence, they provide an appropriate location for investigating collaborative decision making taking place in Airport ATC operations. A brief description of personnel working in these two control centres and their responsibilities is presented next.

Control Tower
The Control Tower is located near the runway higher than all the other buildings in the Airport to allow visual surveillance of surrounding area both on ground and in air. The primary function of personnel working in the Control Tower is to maintain safety of aircraft and efficiency of traffic movement in and out of the Airport. There are three air traffic controller positions in the Control Tower namely: Tower Controller (TC), Ground Controller (GC), and Ground Planner (GP), and one Assistant position. Each personnel is responsible for particular aspects of aircraft movement in and out of the Airport. They are responsible for controlling aircraft movement from ground level at the Airport up to 2500 feet in air and 2.0-2.5 nautical miles surrounding the Airport. They achieve this by giving instructions and guidance to aircraft pilots. Besides, they are responsible for recording and disseminating information related to air traffic management such as updating information in Flight Progress Strips (FPS), problems encountered during work activities, and changes in environmental conditions. They also issue clearance and guide other vehicles that need to use the taxiways, runway, and Apron area.

Operations Centre
In Luton Airport, the Operations Centre is located next to the Control Tower and Apron area. It was set up to integrate various operational facilities such as apron management and control, security, public information services, and passenger transportation into a single facility to improve operational services. The Operations Centre is an important control centre which is responsible for various functions involved in day-to-day operations in the Airport. They consider themselves to be the “information hub” of the Airport as any information related to ATC arriving and transmitted from the airport has to go through them. There are three positions in the Operations Centre: Assistant, Arrivals Controller, and Departure Controller. All operations controllers have the same expertise and interchange their roles while functioning. They monitor all Airport activities on the terminal side, airside, and landside as well as coordinate the activities of the various agencies within the Airport.

Data Collection Techniques
In this study the primary methods of data collection are non-participant observation and semi structured interviews coupled with concurrent protocol. Since, Air Traffic Control (ATC) is a dynamic work environment the interview questions needed to be adapted to the changing context in order to capture real world experience. Interview questions were based on immediate work context and asked in the course of the interviewee’s work. This involved interviews emerging from observation which increased the salience of questions to be matched to both individuals and context (Patton 1990). However, the interviews are not entirely open ended. The focus of study is established in advance. Before each phase of data collection, the researcher identified general themes to be addressed in each field study. The focus of the first field visit is based on the research questions and focus of subsequent visits is derived from the analysis of data collected in the previous visits. The interviews were audio taped and then transcribed verbatim for analysis. In addition, literature about the domain of study from secondary sources, organizational documents, and photographs of field site supplemented the data collected.

Grounded Theory Analysis
Data is conceptualized through coding which is the foundation of Grounded Theory development. In GTM, coding is conducted in phases and the procedure varies depending on which school of GTM is being followed. This research adopts Glaser’s approach who prescribes the following phases: Substantive Coding, Theoretical Coding, and Selective Coding (Glaser 1978). These phases are not entirely linear and work in conjunction with each other.

Substantive coding or in other words open coding is the first step in the analysis. In this research, the researcher undertook substantive coding by going through the data line by line and assigning labels to concepts identified in the process. This was done by asking neutral questions as prescribed by Glaser (Glaser 1978; Glaser 1992) such as: What is the data a study of? What category or what property of what category does this incident indicate? And, what is actually happening in the data? As open coding progressed categories were developed where patterns of similar incidents depicted by the codes were abstracted by attributing a conceptual name to it.

Theoretical coding is higher level of conceptualization where the Substantive codes are related as hypothesis to be integrated into a theory (Glaser 1978). As category development progressed the researcher started to determine the relationship between categories and their properties in order to generate conceptual ideas through Theoretical coding. This was captured in the form of
Grounded Theory analysis. In the following discussions categories and their relations emerging from the presented in the following sections through the forms of CDM activities and its characteristics will be emergent decision making interview transcripts. Also, text in italics font within from the Grounded Theory analysis and in some cases text in italics font represents codes and categories single quotes represents 'in-vivo' codes.

Selective coding involves the process of identifying a core category which is the main theme arising from the data. The researcher keeps a lookout for the core variable during the coding process. The criteria for judging the core category as prescribed by Glaser are: centrality, frequent reoccurrence, meaningful and easy connection to other categories, and clear implication for formal theory. Once the core category is selected, further data collection and analysis is delimitated to this category. The coding process is stopped when theoretical saturation is reached where no additional data is being found to develop the core category and its related categories and a clear demarcation of relations between them is achieved.

Patterns of CDM Activity

From the analysis of field data, CDM emerged as an activity during which the requirements arising during task performance are fulfilled by personnel through communication, coordination, and decision making. Personnel have to work together with others in order to make the necessary decisions to cater to requirements arising during task performance. This is because they have authority to make only certain decisions during task performance depending on their role and responsibility in the work process. The interconnected nature of work begets reliance on personnel from other work communities to make the necessary decisions during task performance.

Four forms of CDM activity emerged from the data analysis which is depicted by the theoretical constructs: Sequential Decision Making, Mutually Consented Decision Making, Manipulative Decision Making, and Emergent Decision Making. Emergence of each of these forms of CDM activities and its characteristics will be presented in the following sections through the categories and their relations emerging from the Grounded Theory analysis. In the following discussions P represents personnel, D represents decisions made, and text in italics font represents codes and categories from the Grounded Theory analysis and in some cases interview transcripts. Also, text in italics font within single quotes represents ‘in-vivo’ codes.

Sequential Decision Making

Sequential Decision Making represents the form of CDM in which personnel make decisions in response to stimuli provided during task performance (Figure 1). The stimuli can be decision made by personnel, action consequential to decision made, and information exchanged.

![Figure 1 Representation of Sequential Decision Making Activity](image1.png)

Decisions are made in succession where each decision is made in response to a previous decision or the effects of it. The categories Notifying, Requesting, and Acting in Response represent the action/interaction taking place during sequential decision making (Figure 2).

Sequential Decision Making

Acting in Response

Notifying

Requesting

![Figure 2 Related Categories of Sequential Decision Making Activity](image2.png)

During task performance the stimuli for sequential decision making is provided by two actions: notifying and requesting. Notifying occurs to inform others about one’s status in task performance such as decision made, action completed, action intended to be performed, and action required to be performed by others in order to cater to requirements arising during task performance. It also takes place to provide information required by other personnel. Notifying takes place verbally over telephone and non-verbally through various information artefacts. Another stimulus for sequential decision making is requesting. Personnel request others to provide assistance during task performance. Explicit verbal requests are made for certain actions which are necessary to accomplish the task to be. This leads to the other personnel in turn having to make decisions about actions to be performed in order to provide the required assistance. The distribution of work activities across the different work communities and the ensuing stratification in the work process bestows personnel with certain authority in task performance. However, the interconnection between their work activities requires them to request permission from each other to perform actions during task performance. These two forms of stimuli lead to personnel Acting in Response by making decisions reciprocal to decisions made by others during task performance. The following scenario obtained from the data collected during the field studies illustrates the sequential form of collaborative decision making activity.

Scenario: While making the routine weather observation, the Assistant notices that the temperature indicator was not giving proper reading. So she called the workshop and notified them. They sent their engineers to check the temperature sensor near the runway. The engineer calls the tower controller to give him the reading from the sensor. (Typically the engineer should call the Assistant but he could not get through to...
the Assistant’s telephone. So calls the tower controller on his frequency. The tower controller passes it onto assistant and asks her to make a comparison between the readings from the sensor and that displayed by the digital temperature indicator. The TC then passes on this information back to the engineer.

When a problem (system failure) arises during task performance (weather observation), a decision (D1) to notify the workshop authority is made by the Assistant (P1) in an attempt to solve the problem. So, P1 notifies the workshop engineers about the problem. The decision causes the involvement of the engineer (P2) from the workshop. In consequence, decision (D2) has to be made by the Engineer (P2) to solve the problem. This requires him to interact with the Assistant in the Control Tower. However, he is not able to get through to the Assistant on her telephone line. So he decides to call the Tower Controller (TC) on his telephone frequency. The decision made by P2 causes the involvement of TC (P3) to mediate the interaction between P1 and P2.

During task performance a decision is made by P1 causing the involvement of P2 whose decision in turn causes the involvement of P3. This leads to P1, P2, and P3 collaborating to achieve the task through the interactions taking place between them. The interactions take place as a consequence of the decisions made by each individual. Although, the decisions are made individually without consultation with other personnel involved in the task performance, the decisions made gains implicit acceptance by other personnel. This is made evident during the interactions taking place between them. Collaborating personnel acknowledge and conform to the decision made by each other during task performance by undertaking the necessary responsive actions.

Mutually Consented Decision Making

In Mutually Consented form of decision making, personnel jointly arrive at an agreement about the decision to be made during task performance (Figure 3). This takes place explicitly or tacitly. Explicitly, the decision making activity takes place through verbal communication where one personnel takes the initiative by either proposing the intended decision to others or places request for necessary decision to be made to undertake the task. This leads to discussion between them where either the proposed decision is accepted, rejected, changed, or a new decision is made.

Tacitly, this takes place by personnel acknowledging the decision made by other personnel and displaying their agreement to the decision made by performing the necessary consequential actions. Categories depicting the action/interaction taking place during Mutually Consented decision making activity is presented in (Figure 4).

\[ \text{Mutually Consented Decision Making} \]

\[ \text{Getting Approval} \quad \text{Confirming} \quad \text{"Work things between each other"} \]

**Figure 4 Related Categories of Mutually Consented Decision Making Activity**

Mutual consent is established by getting approval for decision or action to be taken, confirming decision made or intended action with other collaborating personnel, and “working things between” each other in order to arrive at a decision. Establishing mutual consent by getting approval and confirming is a straightforward process of verbally verifying decision or action to be taken with other personnel. However, establishing mutual consent by “working things between each other” is a more elaborate process because it involves discussing and negotiating. This is particularly so when there are problems to be addressed during task performance or task performance has to be optimized. In the following scenario P1 requires P2 to make a decision in order to optimise the way the task is performed by P1.

**Scenario:** There is a light aircraft waiting to take off at holding point C1 (see Figure 5) and a police helicopter at holding point B1. Also, there is an approaching aircraft on runway 08. The TC (exclaiming “This is going to be a good one!”) wants to send these two VFR flights and land the approaching aircraft at the same time. He can allow the two flights to take-off at the same time because they take different departure routes once they take-off. He calls the Approach Control and asks them to slow the approaching aircraft so that he can get these two aircraft to take-off and manages to do all three within a minute.

**Figure 5 Taxiway and Runway Layout at Airport**

The TC (P1) makes a decision to optimise the task performance (simultaneous aircraft landing and take-off). Because P1 needs to arrange the time gap to allow both helicopter and the aircraft to take-off in different
Manipulative Decision Making
In the investigated ATC work process decision making is highly procedural and strictly stratified. However, personnel device ways to work around the procedure and stratification during collaborative decision making to elicit decisions from others that would cater to their individual needs. Personnel tend to manipulate the decisions made by others during task performance to fulfill their needs by influencing the context on which the decision making rests (Figure 6). The following scenario illustrates the manipulative form of collaborative decision making.

Figure 6 Representation of Manipulative Decision Making Activity
Scenario: Appears that two flight plans (HCY441 and HCY441A) were filed for the same aircraft. Explanation given was that the airline hedges their bets by filing twice to get the best route or slot or whatever, deciding later which one to use. Controller called several times to Helios 441 with no response, and then called Helios 441 alpha and got an immediate reply - so aircraft had decided which one it was.

In this case, according to the procedure to be followed, the decision made by the ground controller (P1) determines the actions to be performed by the pilot (P2) during task performance (aircraft departure). The decision to be made is the aircraft departure time and the exit route from the Airport. However, P2 through his actions manipulates the decision made by P1 to suit his needs, thereby indirectly collaborating to make the decision.

Emergent Decision Making
In a dynamic work environment decision making activity is emergent with the changing context of work. Decisions made during task performance unfold or are altered with the emerging situation. Also, action and interaction involved in making decisions jointly varies with the changing context. Emergent decision making is a theoretical construct emerging from the data analysis. Collaborative decision making taking place in such dynamic work settings is influenced by the changes taking place in the work environment. Decisions made by personnel are based on conditions raised by current and expected situations including time constraints arising during task performance. The action and interaction taking place to prioritize actions and to optimize the way tasks are performed is based on the context of work.

Figure 7 Related Categories of Emergent Decision Making Activity
The following scenario presents an example of how the intensity of communication between personnel from different work communities changes with change in situation during collaborative decision making. The following extract presents part of the transcript from an interview conducted with the Tower Controller (TC) in the Control Tower.

I How often do they (tower controller) have to telephone the Radar Control?
TC If it’s a busy day where you have got lots of inbounds and lots of outbound. You might be on the phone with them up to a few minutes. On a quiet day when there are natural gaps in traffic and if it is not too busy you might not have to phone to them.

I So it depends on the situation?
TC It depends purely on the situation on what’s going on, how complex the traffic situation is, any instance going on. I sat in the tower position when I came in and I was there for an hour and a half and I probably spoke to the radar controller for maybe 5 times. That’s all. If considering the quite bad weather, because there are hardly any inbounds there is no reason to arrange for gaps. The only thing I had to do was to arrange for one gap and that rest was to do with coordination due to deteriorating weather.

In the above scenario, the Tower Controller (TC) in the Control Tower located in the Airport and the Radar Controller (RC) located elsewhere outside the Airport have to collaborate to make decisions to arrange gaps between aircraft arriving into the Airport in order to make space for departing aircraft to leave the Airport.

The intensity of communication between them varies during peak and non-peak traffic hours of the day. In this scenario the communication between them lessened considerably because of bad weather. The change in situation changes the intensity of communication taking place from every few minutes during heavy air traffic to few times, and sometimes no communication takes place between the TC and RC. Action and interaction taking place to make decisions in collaboration with other people varies with the changing context. Hence, the way decisions are made collaboratively unfolds and is altered with changing situations.
CONCLUSION
The patterns of CDM activity presented in this paper emerge from the analysis of action and interaction taking place during CDM. The patterns help elicit different ways in which CDM takes place across spatially distributed heterogeneous work communities in real world complex work settings. It is construed from the analysis of these patterns that decision making is a fluid, cumulative, and momentary activity.

It is a fluid activity because CDM is not just about personnel coming together at particular point in time to form consensus or agreement but is an ongoing activity taking place along a temporal continuum and involving convergence of decisions, actions, and interactions of multiple personnel in the course of task performance. This convergence is fragmented across everyday actions and interactions involved in task performance. CDM then is an accumulation of the various decisions, actions, and interactions thereby becoming a cumulative activity. It is also momentary as CDM is emergent with the changing context of work. Decisions made collaboratively have to be renegotiated with changing context of work and actions and interactions tailored accordingly.

Exploring the sociality involved in CDM rather than the typical cognitive aspect of it explicates these aspects. Making decisions collaboratively is depicted as highly visible social phenomenon where making judgements, planning, and deciding course of action during task performance is incarnated in the various actions and interactions taking place during the decision making process. Such a characterization of CDM activity depicts the situated, embedded, and embodied aspects of decision making.

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