https://doi.org/10.48009/2_iis_2009_421-429

"ROMAN 41, ROGER…WHAT IS YOUR POSITION?": THE INFOSCAPE OF AIR TRAFFIC CONTROLLERS

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ABSTRACT

The essay is a report of research carried out in an air traffic control environment. It is a description and analysis of the ethnosemantics of air traffic controllers and their social cultural environment of information flows and uses of information. Using Skovira's infoscape model and Hall's contexts of communication model, the paper analyzes air traffic controllers' communication contexts and situations.

Key words: air traffic control, infoscape, contexts of communication, information systems

INTRODUCTION

A person (if a student of information systems) making an online airline reservation, getting an e-ticket, checking in, and then waiting for his or her bags to appear on the conveyer belt, is probably aware of the multiple, varied, and complex information systems which encapsulate his or her traveling. There is one information system, not mentioned here, upon which a modern traveler implicitly depends; it is the completely tacit (to the traveler) information system of air traffic control.

Air traffic has increased exponentially in the United States since the first air traffic controller stood on the airfield at St. Louis Airport in 1929 using color flags to communicate with pilots [11]. Air traffic control has become increasingly complex and must be capable of handing the ever-increasing traffic demands. Information systems, to include people, content, process, and relationships, coupled with information technology, enable air traffic controllers to organize and expedite the flow of air traffic and avoid collisions between aircraft [4].

The air traffic control information system (ATCIS), as all other informing systems, resides in an environment, technological to be sure but mostly social cultural, which constitutes for the ATCIS its infoscape or information landscape. Moreover, while on the surface the ATCIS appears highly technical, it is primarily a social cultural environment (in short a "culture") whose appearance is in the form of communication between controllers and pilots, and other controllers. The interaction between controllers and pilots especially is dependent upon both sharing the same information space, a social cultural environment, which affords a context of elaborated or restricted communication.

While it is important to study this cultural scene in and of itself, it is of equal importance to study the situation because of the knowledge resulting from the study will be of value for the analysis and design of other, equally taken-for-granted, information systems.

Spradley and McCurdy approach the study of a culture by describing the culture in its own terms – "the New Ethnography or ethnographic semantics" [17, p. viii]. Their research method discovers "…the characteristic ways a people categorize, code, and define their own experience" [17, p. viii]. Spradley and McCurdy explain cultural scenes as "…the information shared by two or more people that defines some aspect of their experience" [17, p. 24]. Recurrent social situations are "settings for action, made up of behavior and artifacts" that an outsider can observe [17, p. 24]. The insider holds the definitions for these behaviors and artifacts.

This description and analysis follows the Spradley and McCurdy ethnographic semantic method of describing a particular culture [17]. Spradley and McCurdy believe that first hand cultural experience will enable the ethnographer to comprehend higher-level concepts, such as shared, and learned cultural knowledge [16]. This method of studying a culture led the researcher to communicate with and accept the air traffic control personnel in their en route center environment and culture. Specifically, the researcher employed Spradley's developmental research sequence (DRS) [15; 16]. The culture studied in this analysis is that of air traffic control. The environment is an air route traffic control center.

Studies using ethnographic methods not only reflect the appropriateness of ethnography in the analysis of the air traffic control culture, but also indicate the relevance of the air traffic control landscape in the study of information systems [1; 2; 9; 10]. One ethnographic study on air traffic controllers that sought to understand the nature of air traffic control as a cooperative activity resulted in the design of a new user information system [1]. Another study used ethnography as a method for information system design in air traffic control [10]. A study on the use of radar data in air traffic control used an ethnographic method of inquiry to examine how controllers used data from various information systems and the effect of lost or corrupt data on managing air traffic [2]. These studies reflect the applicability of ethnographic methods in the analysis of the air traffic control landscape and exhibit ATC as an information systems' culture [1; 2; 9; 10].

Purpose and Focus of Paper

The paper is a report describing and analyzing air traffic controllers as a social group sharing a system of meanings, practices, and situations constituting the group's "culture." It approaches this analysis through the theoretical lens of Skovira's information landscape "infoscape" – the people, content, process, and relationships comprising an information system [14]. Specifically, this analysis focuses on the communication frame of information use in the air traffic control infoscape using Hall's context of communication model [7]. Its purpose is also to serve as a possible case study for doctoral students proposing to do an ethnographic field research into information systems as a cultural system.

METHODOLOGY

The qualitative study reported here primarily used an ethnographic method [16; 17] of discovery to discern the cultural meaning of events, language, and activities for the participants at an Air Route Traffic Control Center in Virginia. The ethnographic study relied chiefly on observations, interviews, and artifacts. The researcher observed participants in the control room for six periods, in each instance, spending two or more hours observing the controllers in action. Each period of observation was followed by a debriefing interview with the FAA contact person, who also served as one of the informants. The researcher observed automation, maintenance, and national airspace system (NAS) operations' manager (NOM) technicians in their natural settings. The researcher held 20 controller and supervisor interviews and 4 technician interviews. Two FAA employees acted as academic informants (insiders) since the Center's management specifically assigned them to escort and assist the researcher throughout the data collection process. The researcher explored situations and places and asked specific questions about people, process, content, and relationships to discover and understand the stories of the air traffic controllers in relation to managing air traffic.

INFORMATION LANDSCAPE

The Skovira information landscape (infoscape) is a model "for analysis of information use and design" [13, p. 308]. Skovira explains, "[a]n information landscape is a place of framed information use" [13, p. 309]. The place of information use in this analysis is an air traffic control facility, specifically an Air Route Traffic Control Center (ARTCC) in Virginia. The infoscape model comprises "four aspects of an information system or informational situation … people, content, process, and relationships" [13, p. 308]. Figure 1 depicts the infoscape of an ARTCC in terms of its four aspects - people, content, process, and relationships.

See Figure 1

People

The infoscape model leads the researcher to determine that people are the focal point of any information system [13, p. 312]. People are the heart of an air traffic control system. Air traffic controllers need information, which they obtain from many sources to include radars, computers, flight plans, weather data, regulations and policies, training, pilots, supervisors, and other controllers [2; 13]. Controllers also need information requirements, which they obtain from FAA orders [2; 4; 5]. Controllers "need to know and require information to act appropriately" in managing air traffic [13, p. 312-313; 2]. Air traffic controllers are origins of information flows [2; 13, p. 313]. They provide pilots within their sector of responsibility with certain information such as weather conditions, traffic flows, and instructions on how to proceed through their sector to the next controller's sector [2]. They also provide information to and perform crosschecks with controllers in adjacent sectors and in other air traffic facilities [2, p. 126]. Controllers are also destinations of information [2; 13, p. 313]. They receive information from various systems, controllers in other sectors and other air traffic facilities, and pilots. Pilots provide controllers with such information as position reports, and sightings of other aircraft in the area [2].

Content

Informational content shows up in organizations in the form of "reports, conversations, budgets, emails, discussions and project timelines" [13, p. 313]. Air traffic controllers utilize all of these forms of content and more such as, radar displays, printed-paper information, paper strips, low altitude en route charts, mandatory briefings, computer generated text, database information, User Request Evaluation Tool (URET), En Route Traffic Management System (ETMS) (a moving picture of traffic), books and FAA orders [2, pp. 123-127].

Skovira explains, "[c]ontent is data to some, information and knowledge to others" [13, p. 313]. Content, to an air traffic controller, is all of this plus some. The primary purpose of the air traffic control systems is "to prevent a collision between aircraft operating in the system and to organize and expedite the flow of traffic" [4, p. 2-1-1]. Controllers must be able to manage "the safe, orderly and expeditious flow of aircraft through the National Air Space" in order to accomplish the goals and objectives associated with the primary purpose of the air traffic control system [2, p. 91; 13]. Controllers must adhere to information requirements contained in various FAA orders [2; 4; 5; 13].

Process

Skovira explains processes as "ways and means of acquiring, manipulating, representing, and presenting information contextually or within situations" [13, p. 313]. The radar controller's display, the User Request Evaluation Tool (URET), the pilot, and other controllers present information contextually to controllers [2]. The radar display provides controllers with real-time, correlated flight data, surveillance, and critical control information such as, aircraft type, identification, speed, altitude, and heading [2, pp. 74-75, p. 128]. The URET supplies present, past, and projected future data. The URET provides information to controllers on electronic flight plans, upper winds data, and projected flight paths [2, p. 75]. Pilots and adjacent sector controllers provide real-time information to controllers and confirmation of controllers' instructions.

Relationships

In the infoscape model "[r]elationships are possible and actual transactions among the model components … how and where and when people, content, processes, and context interact" [13, p. 312]. Transactions among people, content, procedures, and context form the "basis for possible and actual information events in an organization" [13, p. 312]. In the case of air traffic control, where people (controllers, supervisors, and pilots), content (training, FAA orders, and weather data), processes (real-time information on the radar display, URET flight plan data and projected flight paths), and context (controller's mental model of the situation in his sector) intersect, information events happen [2; 13, p. 312]. In an air traffic control facility, information events can include, training problems in the Dynamic Simulation Lab, and the safe, orderly, and expeditious flow of air traffic through an assigned sector. Other information events can include operational errors and pilot deviations.

Frames

Frames of information use, such as political, financial, legal, ethical, moral, psychological, and technological, as well as many other frames, "bound and structure this landscape" of people, content, process, and relationships [13, p. 309].

Roberts discusses the emergence of potentially hazardous new technologies and how high reliability organizations (HROs), such as air traffic control, manage these new technologies [12]. Grabowski and Roberts hail HROs for their "effective and varied communications, which provides a means of understanding, and relationships" [6, p. 156]. Communication addresses the needs of ATC as an HRO culture [6, p. 156]. Roberts discusses how air traffic control organizations manage complexity through training, redundancy, dual assignment of radars, use of specialized language, and technology [12]. Roberts provides appropriate frames of information use – training, equipment redundancy, dual assignment of radars, use of specialized language and technology – to investigate how to analyze and ask question about how controllers manage the complexity of their jobs. Grabowski and Roberts note, "[i]n HROs which already possess a culture of trust shared values, risk mitigating communications focus on enhancing the development of shared mental models among members of the organization" [6, p. 156]. Thus, communication in the air traffic control culture is another frame of information use to analyze how controllers manage air traffic.

Helmreich describes causes of errors in aviation [8]. Some of these causes are of specific interest in this analysis: imperfect information processing and flawed decision-making [8]. Helmreich explains that actions required in aviation to manage errors include, understanding the causes and extent of error, and finding ways to prevent or mitigate error [8]. Equipment malfunctions represent one of several sources of threat to the air traffic controller [8]. Procedural, communications, and flawed decision-making are some of the types of errors associated with those threats [8]. Helmreich's work provides additional frames of information use – procedures, communications, and decision-making processes - for use in analyzing an air traffic control infoscape.

"Contexting" in the Communications' Frame

Communication is just one frame of information use on how people, process, content, and relationships function in the life of air traffic control organizations [2; 13]. Information overload can be a job hazard for employees in high reliability organizations, such as air traffic control facilities [12]. Hall applies the technical term, *information overload* to information processing systems [7]. Hall notes that the information system "breaks down when it cannot properly handle the volume of information to which it is subjected" [7, p. 85]. The information systems in this paper comprise the air traffic control system and its human element – the air traffic controller. Hall suggests that information overloads afflict air controllers, as well as other professions [7]. How do air traffic control systems and air traffic controllers manage information overload? Helmreich points out that communication is one type of error associated with the threat of equipment malfunction [8]. Hall says, the "high-context rule" is the solution; "the only way to increase information handling capacity without increasing the mass and complexity of the system is to program the memory of the system so that less information is required to activate the system" [7, p. 85]. Hall points out, "the solution to the problem of coping with increased complexity and greater demands on the system, seems to lie in the preprogramming of the individual or organization" [7, p. 86], in other words – the "contexting" process.

Hall explains, "[a] high-context (HC) communication or message is one in which most of the information is either in the physical context or internalized in the person, while very little is in the coded, explicit, transmitted part of the message" [7, p. 91]. Conversely, "[a] low-context (LC) communication is just the opposite; the mass of the information is in the explicit code" [7, p. 91]. In attempting to determine if the air traffic control culture is an HC communication culture or an LC communication culture, one might jump to the premature conclusion that air traffic control is a low-context culture. Hall points out that low-contexting can be associated with telling someone more than they need to know [7]. In an ATC infoscape there are highly technical regulations and detailed management methods explicitly directing procedures and processes [2; 7]. This might point the analyst to consider ATC a low-context culture. However, upon deeper analysis, high-context communication appears to be the stable base of the air traffic control culture.

Hall notes, "HC actions are by definition, rooted in the past, slow to change, and highly stable" [7, p. 93]. The ATC system in the United States is rooted in the past. The year 1929 saw the first air traffic controller at the St. Louis airport – Archie W. League [11, p. 5]. To regulate air traffic, controllers stood on the airfield and communicated with the pilots using colored flags [11, p. 5]. In the 1930's, Cleveland Airport saw the first modern ATC system [11, p. 8]. The United States established the Bureau of Air Commerce within the Department of Commerce in 1934 [11, p. 10]. In 1937, the Department of Commerce standardized and implemented ATC procedures [11, p. 14]. One year later, the United States Congress created the Civil Aviation Authority (CAA) [11, p. 15]. In the late 1940's, controllers were still using procedures rooted in the early 1930's, and were "still tracking aircraft by writing their approximate positions on paper strips and moving shrimp boats along a map" [11, p. 20]. Congress created the Federal Aviation Agency (FAA) in 1958. By this point in time, "few administrative procedures had been developed nor had the CAA installed sufficient radars systems" [11, pp. 27-28]. The U.S. ATC system was and still is "slow to change, and highly stable" indicative of a high-context culture [7, p. 93].

Hall explains that transactions in HC "feature preprogrammed information that is in the receiver and in the setting, with only minimal information in the transmitted message" [7, p. 101]. Preprogramming is a necessity for air traffic controllers in terms of classroom and lab training, and phased on-the-job training. ATC personnel and pilots preprogram content in information systems in terms of flight plans, weather data, symbology, automated procedures, and other data. Regulations and FAA orders serve as preprogramming for processes. The controller as the receiver accesses several different preprogrammed systems in the setting. The URET is preprogrammed with electronic flight progress strips, upper winds data, flight plans, host computer identification numbers (ID), aircraft identification numbers (ID), aircraft type, equipment, altitude, beacon code, and route [2, pp. 75-76].

Conversely, LC transactions are the opposite in that "[m]ost of the information must be in the transmitted message in order to make up for what is missing in the context" [7, p. 101]. Most of the information controllers use is preprogrammed in the setting and in themselves. Training and experiences preprogram controllers. Therefore, the transmitted messages from the setting – people, content, process, and context – intersect at the controller's radar display. The controller can visualize and focus on all of the aircraft in his assigned sector. Figure 2 is a photograph of a controller's radar display with a close-up view of a data block [2, p. 75].

See Figure 2

The controller sees a data block and specific symbology for each aircraft. The air traffic control culture adopted a specialized language to reduce ambiguity in and shorten the length of their communications [12]. Pilots and controllers receive training in their specialized and abbreviated language [12]. Technicians and developers program the specialized language into information systems and software. A data block on a controller's display is one such manifestation of this culture's specialized and abbreviated language. Figure 3 shows an enlarged photograph of a data block on a radar display [2, p. 15].

See Figure 3

The symbology of the small square connected to the slash mark indicate to the controller, that the host computer married up the data from the ground-based radar and the radar beacon-interrogator system resulting in a correlated target. As seen in figure 3, a line connects the correlated target symbology with the data block for that specific aircraft. The information in the data block presents the controller with such information as aircraft ID, computer ID, attitude, ground speed in knots, destination, aircraft type, assigned heading, and other data [2, pp. 123-124]. The data block on the controller's screen is preprogrammed and only displays minimum information to the receivers. The controllers and pilots understand the meaning of this information, indicative of a high-context culture.

Hall suggests HC communication "is economical, fast, efficient, and satisfying; however, time must be devoted to programming …[i]f this programming does not take place, the communication is incomplete" [7, p. 101]. The voice communications between controller and pilot must be economical, fast, and efficient in order for controllers to manage air traffic within their assigned sector. Below is an example of pilot-controller communications the researcher documented during the observation phase of data collection. Note that the communication between pilot and controller was so fast and efficient that the researcher could not manually log in the entire dialogue quick enough, therefore a series of dots in the log entries indicate missing information:

Controller S (to pilots): Sector 21…
Sky West… 5853…approved
…traffic observed…
Sky Lane 593 Good Morning… Richmond Altimeter 5990…
…Richmond Altimeter 2990...
Eagle 669 climb and maintain 22,000…22,000 will be your final today…
Sector 21…
Flight... 731…approved
How about Piedmont 4361?
…4361 approved
Citrus...flight level 290 maintain normal speed…
Climb and maintain 22,000
Citrus 290 contact Washington Center 135.4
Eagle 669 contact Washington Center 127.75
Sector 21, point out…approved…
Roman 41, Roger…what is your position? What is your altitude?
Roman is sector 30
…317.7 contact Washington Center for advisories.
Centurion 7325 …altimeter…
Citrus…
Point out …approved…
Sector 21…Sector 28…point out …
Point out approved
(Researcher's Notes: I heard another sector warning Controller S of another Roman)
Water Ski... contact Washington Center…"
Air Shuttle 179 can you accept higher than …?
Climb and maintain…
Contact Washington Center…
Roman 61…
Eagle 732 climb and maintain 15,000

Another Sector Controller (to Controller S): can you descend Roman 41 to 7,000?
Controller S (to pilots): Roman 41 descend and maintain…
N3VV contact Washington Center…
Roman 61 contact Washington Center 290.42
Eagle 72 contact Washington Center…

Controllers and pilots use economical, fast, and efficient communications, as depicted above, to manage air traffic. The abbreviated language shown in the researcher's log entry such as, "Roman 41, Roger…what is your position? ... flight level 290 maintain normal speed …point out approved," might be difficult for the layperson to understand. However, training, experience, regulations, and orders serve to preprogram controllers and pilots in the meaning of the abbreviated language, typical of high-contexting.

HC communications "act as a unifying, cohesive force, are long-lived, and are slow to change" Hall suggests [7, p. 101]. The history of air traffic control in the United States indicates that this culture's communication system is "long-lived, and slow to change" [7, p. 101]. However, LC communications "can be changed easily and rapidly" [7, p. 101]. It is vital that air traffic controllers and their systems balance the "need to adapt and change (by moving in the low-context direction) and the need for stability (high-context)" [7, p. 101]. ATC must continually adapt to the "increased complexity and greater demands on the system" [7, p. 86]. Moving in the low-context communication direction, the FAA adapts to current national air space situation by encouraging change to their procedures and orders. The Air Traffic Control Order directs facility management and orders to submit recommended changes on procedures to the FAA [4, p. 1-1-1]. The LC communication aspect of this culture is evident in the frequency of changes to the ATC order. Table 1 shows the frequency of change in the ATC order in recent years [4, p. 1-1-1].

See Table 1

In a typical two-year period, the FAA republishes an entire basic FAA order and publishes three changes to that order [3; 4]. This reflects rapid change for the FAA to adapt to the increased complexity in the national air space and greater demand on the ATC system.

In HC systems Hall notes, "people in places of authority are personally and truly (not just in theory) responsible for the actions of subordinates down to the lowest man" [7, p. 113]. In LC systems Hall states, "responsibility is diffused throughout the system and difficult to pin down" [7, p. 113]. Responsibility in the ATC culture is not "difficult to pin down" and is not "diffused throughout the system" [7, p. 113]. The FAA ATC Order does not define absolute divisions of responsibilities within a sector, rather "[t]he team, as a whole, has responsibility for the safe and efficient operation of the sector" [4, p. 2-10-1]. In the event of an operational incident and accidents, the FAA does not "hold the team accountable for the action of individual members" [4, p. 2-10-1]. The Air Traffic Manager is the senior authority at an ATC facility and is personally responsible for the actions of subordinates [2; 7]. At the ARTCC in Virginia, the manager involves the entire chain of command "down to the lowest man" in any operational error, accident or incident. The Air Traffic Manager at the ARTCC notes, "regardless of what goes on in this facility, we must maintain a steadfast and solid composure for all employees" [2, p. 13]. He said, "we must maintain focus and direction in accomplishing the Agency's goals, direction, policies, procedures, and training" [2, p. 14].

High-context communication frames the relationship of the aspects of the ATC infoscape – people, content, process, and context [13]. However, in order to maintain its relevance, the ATC information system must periodically move towards the low-context end of the communication scale and update its procedures.

CONCLUSIONS

This paper described and analyzed the ethnosemantics of air traffic controllers and their social cultural environment of information flows and uses of information. Information systems are more than just technology systems. Information systems are not limited to hardware and software, but also include people and processes. This analysis demonstrated, through the theoretical lens of Skovira's infoscape, that people, content, process, and relationships comprise an information system.

Using Skovira's infoscape model and Hall's contexts of communication model, the paper analyzed air traffic controllers' communication contexts and situations. People, content, processes, and context are aspects of the air traffic control infoscape. High-context communication frames the relationships within the ATC infoscape. The U.S. ATC system was and remains today, highly stable, and slow to change, indicative of a high-context culture. The data block on the controller's screen is preprogrammed and only displays minimum information to the receivers. The controllers and pilots understand the meaning of this information - characteristic of high-context communication. Controllers and pilots use economical, fast, and efficient communications. Training, experience, regulations, and orders serve to preprogram controllers and pilots in the meaning of the abbreviated language, typical of high-contexting. However, in order to maintain its relevance, the ATC information system must periodically move towards the low-context end of the communication scale and update its procedures to meet the demands and handle the increased complexity of the national air space system.

This paper contributes to the field of information systems by presenting people, content, process, and relationships as information systems in and of themselves, but also as component parts of the larger air traffic information system. Researchers can benefit from the application of the infoscape and context of communication models presented in this paper, and utilize these analysis models to advance studies in the field information systems.

Air traffic control communication, to include language, contexting of that language, procedures, regulations, orders, symbology, and terminology is an information system. This intricate information system along with its component information systems – people, content, process, and relationships, enables controllers to manage air traffic in a safe, efficient, and expedient manner. People, content, process, and relationships comprise the air traffic control information landscape**.**

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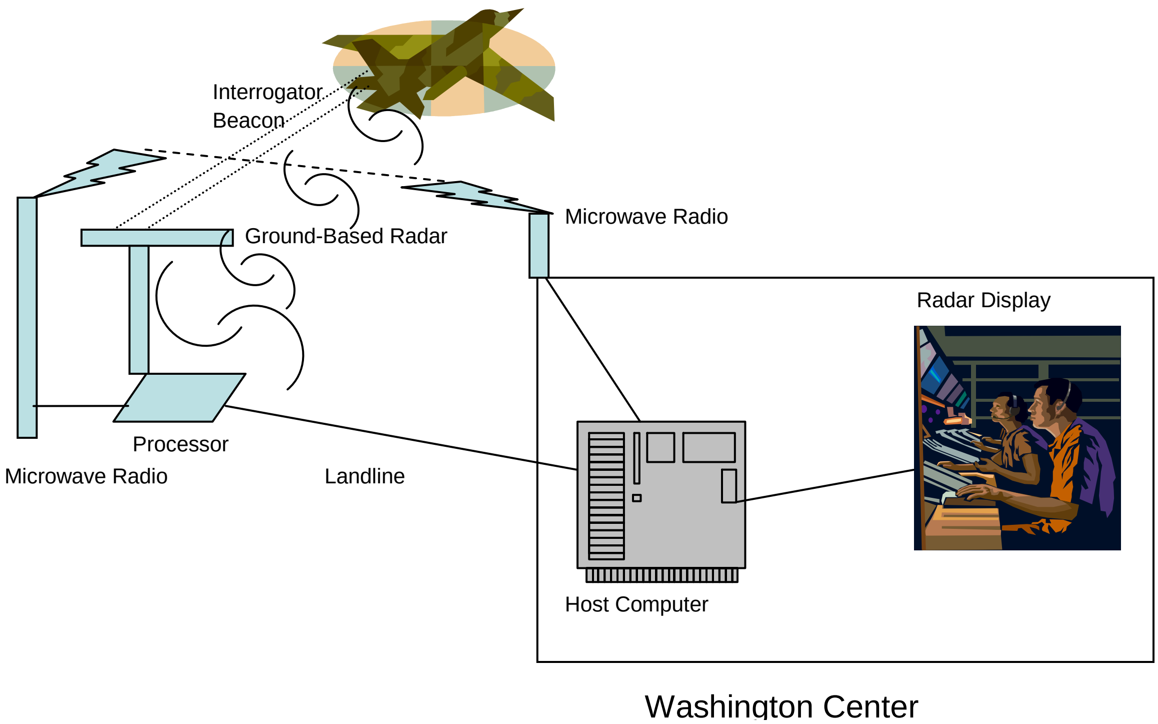

Figure 1. Information Landscape (infoscape) of an Air Route Traffic Control Facility

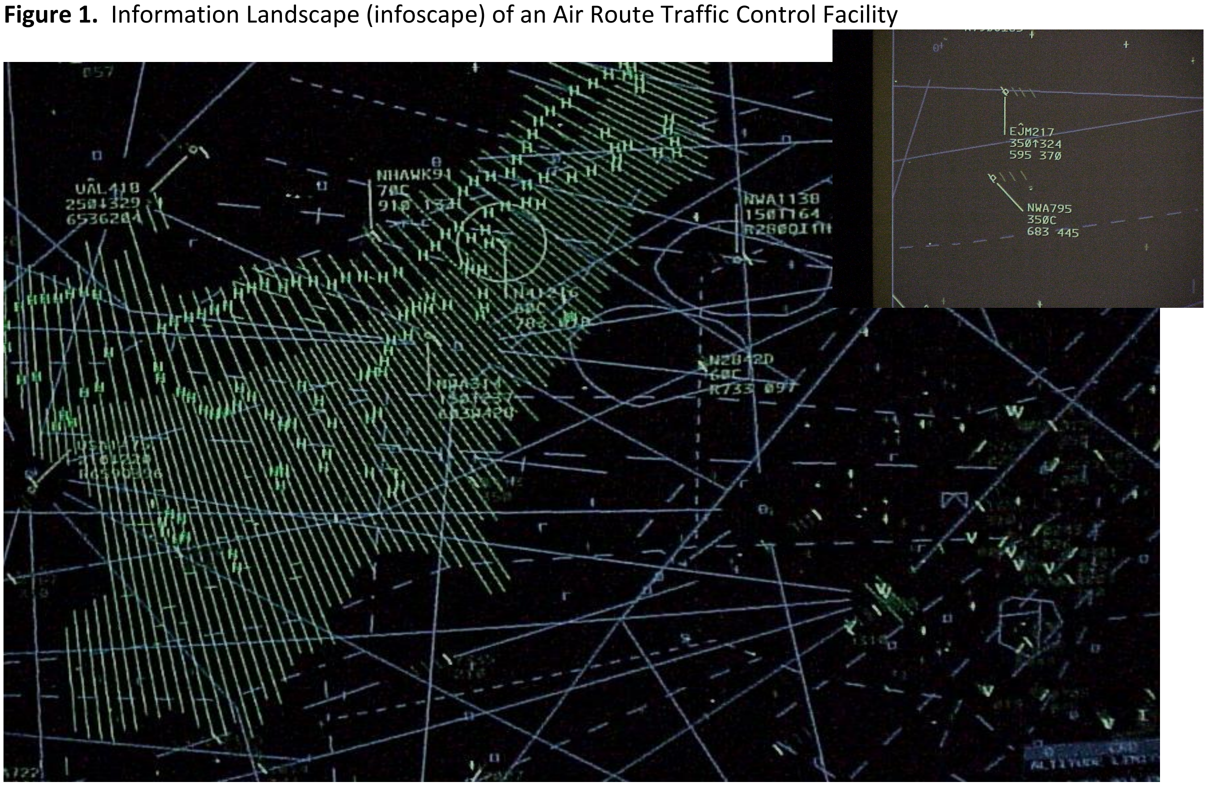

Figure 2. Radar Controller's Display with Data Block Zoom

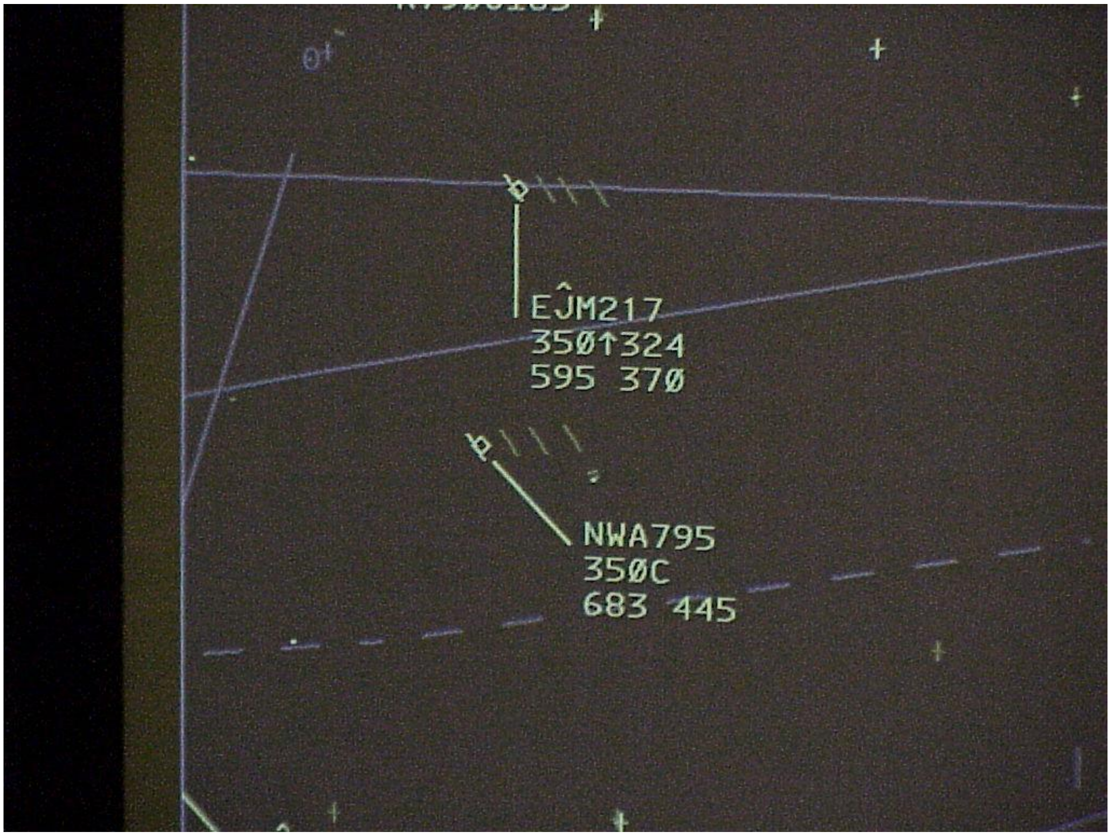

Figure 3. Enlarged Photograph of Two Data Bocks on a Radar Display

Table 1. Air Traffic Control Order Publication Timetable

Basic or Change	**Effective Date of Publication**
7110.65R Basic	2/16/06
Change 1	8/3/06
Change 2	3/15/07
Change 3	8/30/07
7110.65S Basic	2/14/08
Change 1	7/31/08
Change 2	3/12/09