IASDR 2019
International Association of Societies of Design Research Conference 2019
DESIGN REVOLUTIONS
Manchester School of Art
Manchester Metropolitan University
02-05 September 2019

A study on task analysis for development of air traffic control system

Hajime Hirako *[a]; Kazuhiko Yamazaki[b]

[a] Fuji Software Corp., Japan
[b] Musashino Art University, Japan
* hrkhjm0508@gmail.com

Air Traffic control tasks are very complex and hard to understand for task investigators and analysts. It is expected to improve task analysis method or technique for acquiring specific task contents. In this paper, we proposed the improved method and a case study of task analysis for air traffic control. The task analysis method of the air traffic control uses the visualization sheet of the task which displays the screen of the radar display. Analysis of this task analyzes ATC tasks based on the task visualization sheet.

Keywords: User Interface Design; Human-Centered Design; Air Traffic Control System

1 Introduction

The air traffic control is a task performed by air traffic controllers for supporting aircrafts from the ground so that they can be navigated safely from landing to take-off. The air traffic control system used for air traffic control gives directions at any time to controllers utilizing various information such as congestion conditions and meteorological conditions in the routes, so as to secure safety distance of aircrafts, based on current positions and altitudes of the aircrafts, as well as flight plans including departure place and destination. This task is called air-traffic control. Among the air-traffic control works, tasks called air route traffic control are usually performed by 2 persons, one person is the radar air traffic controller and the other one is the coordinator. The radar air traffic controller monitors safety distance of aircrafts based on radar information and gives directions such as location or altitude of the aircrafts in communication with pilots. The coordinator contacts controllers in charge of other airspace and coordinates the traffic referring to flight information of the aircrafts other than radar information (information required for aviation is inscribed) so that aircrafts can be navigated smoothly. The radar air traffic controller monitors all aircrafts flying in the airspace that they are in charge of and gives directions at need. The radar air traffic controller controls more than 20 aircrafts maximum at the same time. Although it is expected that the tasks of controllers will be even heavier in the future, smooth and safe navigation must be continuously secured. Therefore, it is important to obtain user interface which is easy for controllers to use for securing safe and smooth navigation. As one of the methods to consider usability of user interface of an air control system used for air traffic control tasks with high specialty, utilization of human-centered designing is expected. The process of human-centered designing is roughly divided into "Grasp and express of usage status", "Express of requirements of user and organization", "Preparation of solution by design" and "Evaluation of design for requirements". For "Grasp and express of usage status", consideration of a system desirable for users will be an important factor. There are qualitative and quantitative method for grasping what purpose the target users have and how they use the system in usage status. The quantitative method includes "questionnaire survey", "interview survey" and so on. When there are some kind of assumptions, question items that focus on them are prepared to verify the assumptions. There exist various methods such as "observational research" or "task analysis". In "task analysis", ergonomists, designers, operators and evaluators describe interaction between machine and persons and between persons, and use task analysis to evaluate them in some cases. "Task" is "an act to be performed to achieve goal". One task is comprised of plural tasks, and those subdivided into concrete acts are "subtasks" (Figure 1). The task analysis method consists of 2 phases, "description of task" and "analysis of task" (Figure 2) [1].

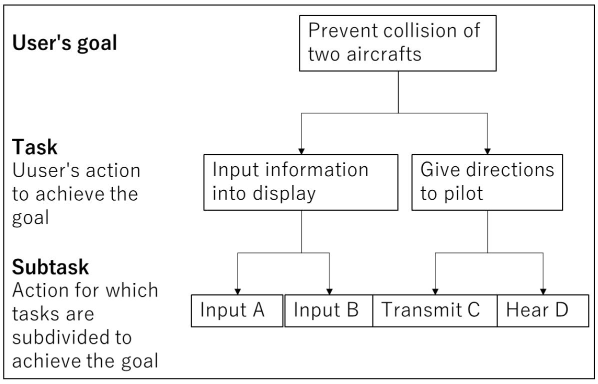

Figure 1 Configuration of task

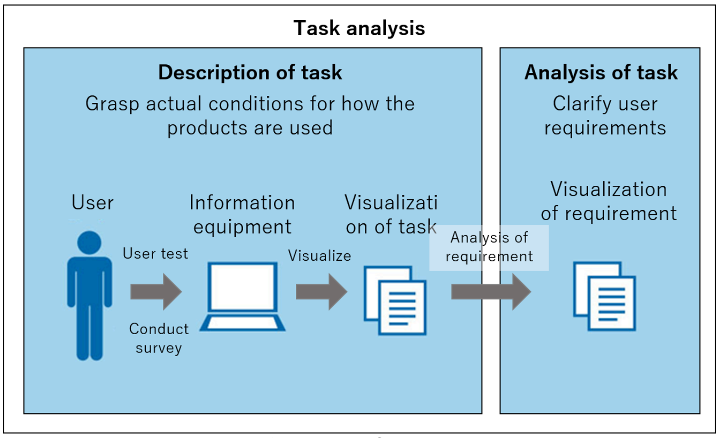

Figure 2 Phase of task analysis

"Description of task" is to describe a series of actions and works of a user as shown above, and "Analysis of task" is to clarify user requirements in actions and works subdivided individually. There are a number of case examples for consumer devices in task analysis. One of the main reasons is that designers have experience in using the target device in their daily life and feel easy to analyze the user interface, we presume. However, in the case that the analysis subject is a device specialized for the task, there are little number of case examples of task analyses in specialized tasks, and therefore designers have less chance to use such a device specialized for the task and can hardly obtain experience of its use. Above all, it is difficult for a designer to grasp the task of air-traffic control works and therefore the number of case examples of the task analyses is particularly small. Therefore, it is desired to improve the task analysis method so that designers can feel easier to grasp the task of air-traffic control works.

2 Purpose of this study

As one of the task analysis, there conventionally exists "sequential task analysis method". The sequential task analysis is a method that subdivides one task into several subtasks and analyzes them in the user interface of the device. Moreover, it subdivides a task into subtasks and arrange them from the viewpoint of "input" to information equipment by a user and "output" of input information for the user. There are various practice case examples of the sequential task analysis for consumer devices, such as "Work on usability in the field of home electric appliances", "Usability evaluation of voice interaction function in video reproduction operation of TV program", "Proposal of service presentation system based on the behavior forecast of user utilizing task model" and so on.

However, there are only few practice case examples of the task analysis in commercial devices that require specialized information. The reason why there have been only few case examples is that it is difficult to extract problems in a specialized commercial device in surveying tasks. Moreover, difference occurs in recognition of a designer and users or problem solving itself is not relatively easy in some cases. In particular, it is not easy to use "the sequential task analysis method" for devices that require much specialized information such as air traffic control system used in air-traffic control works, we presume. In this study, we aim at improving the Method of describing the task of sequential task analysis of the air-traffic control works can be grasped easily and task analysis of the air-traffic control works can be performed easily for air-traffic control works, even when a designer does not have knowledge on air-traffic control works.

3 Method

In this study, we first extract problems on sequential task analysis in air-traffic control work, improve the sequential task analysis method. In this report, Chapter 4 describes the verification of the sequential task analysis in air-traffic control works and problem extraction for the method of sequential task analysis in air-traffic control works. Chapters 5, 6 and 7 describes how to the method of the improved sequential task analysis and the verification of the improved sequential task analysis in an air traffic control system. Chapter 8 summarizes the entire study.

4 Problem extraction for the method of sequential task analysis in air-traffic control works

This chapter describes "observational research of air-traffic control works", "verification of task visualization", " task analysis" and "problems when using the sequential task analysis in air-traffic control works".

4.1 Observational research of air-traffic control works

In observational research of air-traffic control works, the task data of air-traffic control works are collected so as to verify the sequential task analysis of the air-traffic control works. The observational research of air-traffic control tasks was performed with cooperation from Tokyo Air Traffic Control Center (Tokorozawa). The observational research was performed with the control system "ECSS", which is an air traffic control simulator. The outline of the observational research is below. The time and date of the research was March 15, 2012. The observation was performed in Tokyo Air Traffic Control Center (Tokorozawa). The time required for the observational research was 20 minutes for instruments preparation, 15 minutes for instruments check and 30 minutes for observation. Control works are usually performed based on 30-60-minute shifts. Therefore, the observation time was 30 minutes, which corresponds to the time for one work. The participants are 2 simulator operators (the radar air traffic controller and the coordinator) + 1 controller (in charge of pilots), 4 members who have knowledge of basic air-traffic control works (understand functions of the air traffic control system and conversation between controllers on work) and 1 member who is qualified as a controller. Devices used for the observational research are four video cameras to record the display of the radar air traffic controller, the radar air traffic controller operation (display, TID (Touch Input Display: information input with touch panel display) and angles at which keyboards are entered), display of the coordinator, operation objects for the coordinator (display, TID and angles at which keyboards are entered) and voice recorder (the radar air traffic controller, the coordinator and pilot), which were placed as shown in Figure 3.

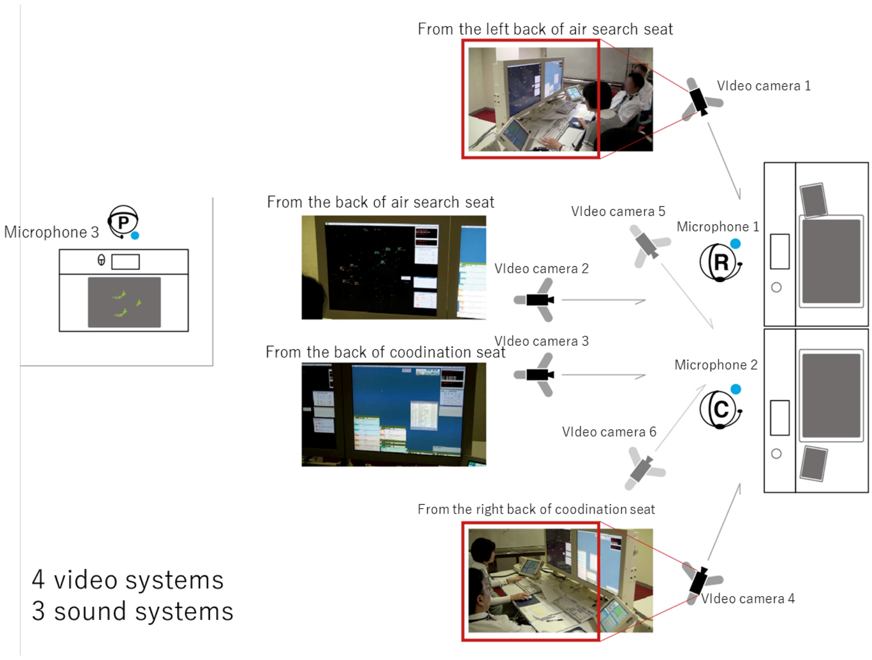

Figure 3 Arrangement of shooting device at the time of observational research

4.2 Verification of task visualization

The tasks are described and arranged by the sequential task analysis method so as to extract problems in task visualization in air-traffic control works. Data used for verification of task visualization were acquired in Chiba Institute of Technology on April 20, 2012. The time required for acquisition was 4 hours. Participants were 4 staff members having basic knowledge of air-traffic control works, and 1 member who was qualified as a controller. The items to describe the tasks were arranged as "communication with aircraft", "directions task in the communication", "duty hour", "aircraft controlled", "operation content" and "conversation with pilot" for the purpose of grasping what directions were given to which aircraft (Figure 4).

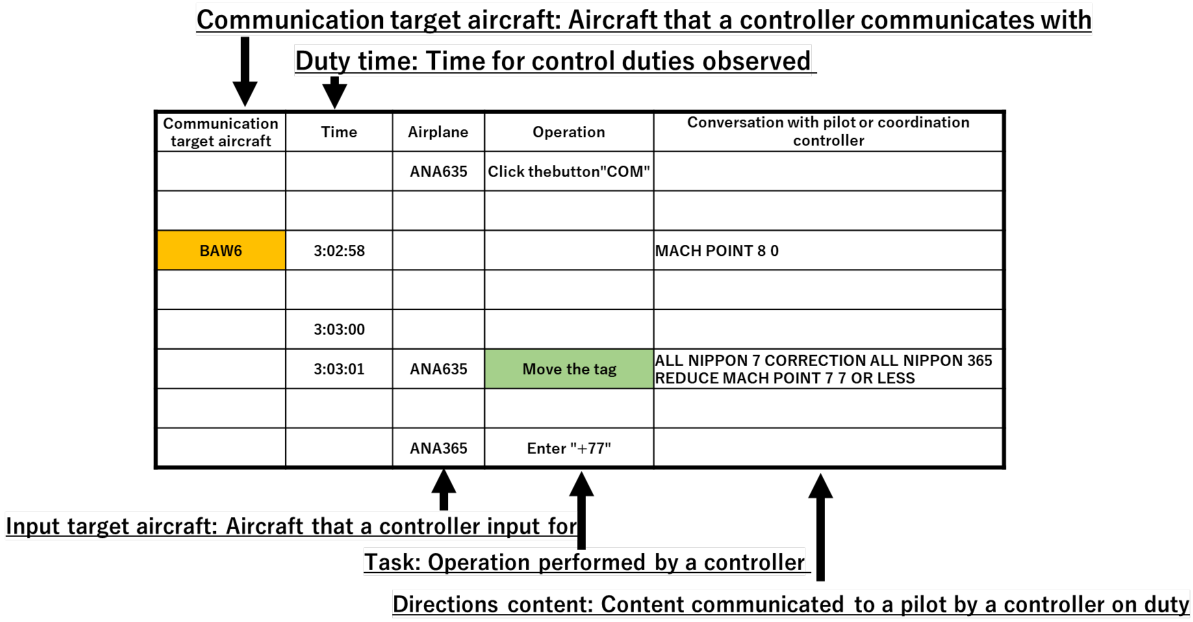

Figure 4 Task visualization by the sequential task analysis

Moreover, for the task visualization, the vertical axis was set as a temporal axis to make it easy to grasp control works, and all tasks observed during 30 minutes were described with the horizontal axis as task items to be described.

4.3 Task analysis

To find out problems of sequential task analysis for air-traffic control works again, the task analysis was performed based on the sequential task analysis. Outline of the task analysis is shown below. The task analysis was performed in Chiba Institute of Technology on April 20, 2012. The time required to analyze the task was 2 hours (one hour for confirmation of the video observed + 1 hour for confirmation of the task visualization). Participants were 4 staff members having basic knowledge of air-traffic control works (understand functions of the air traffic control system and conversation between the air traffic controllers on work), and 1 member who was qualified as a controller. The items to be recorded in the sheet for the task analysis are "Scenes" where the tasks were performed and "Characteristics of control work and request from controllers". The above items were selected for the purpose of making it easy to grasp contents of the tasks and when they were performed, based on characteristics of air-traffic control from the described air-traffic control tasks. As a result of the task analysis, three characteristics of the air-traffic control works were extracted (Table 1). Contents of the three extracted characteristics of the air-traffic control works were analyzed from usage frequency of the functions that air search used the air traffic control system. Moreover, requests from the controllers were extracted.

Table 1 Result of task analysis by the sequential task analysis

Scene			Characteristics of control work
Work hour	Aircraft	Task	
03:00;30～03:00;40	-	Display MAP3	The controller confirms the map display first it but does not almost use it after that.
03:02;18～03:02;28	JAL2201	Input MAC number	The controller often input mac number rather than header and speed.
03:06;00～03:06;07	-	Switch display by DCP8	The controller often confirmed fix before giving the direction of Direct .

4.4 Problems in the case that the sequential task analysis in air-traffic control works

Task observation, description analysis and task analysis were performed based on the sequential task analysis method in air-traffic control works. The result revealed that there were 2 major problems as below on the task visualization in the sequential task analysis. The first problem (Problem 1) is that "It is hard for a designer is grasp requests from controllers, who are users", in task visualization again. Technical terms are used in air-traffic control works, and many of the functions of the air traffic control are to be used in specialized information equipment. Therefore, it has been revealed that in the case that a designer does not have knowledge of air-traffic control, even if the tasks performed by a controller are summarized in character information, it is difficult to extract requests from controllers though some characteristics of a controller for air search are expressed. The second problem (Problem 2) is that "It is unclear in the task analysis where on the screen of the air traffic control system the tasks were performed by the controller". In the case that a designer did not have knowledge of air-traffic control works, the flow of the tasks were grasped on the temporal axis by confirming the tasks performed by the controller in time series, while on the other hand it was hard to grasp relationship between controller's tasks and the video. One of the reasons is that since the controller's tasks were described in time series and user interface of the radar control system was confirmed with video, it was difficult to confirm air traffic control works connecting them, we presume.

5 Improvement of the method of sequential task for development of air traffic control system

This chapter describes the improved model sequential task analysis method for developing air traffic control system based on the problems on the sequential task analysis obtained in the preceding chapter.

- Step 1. The radar display sheet for the task visualization

The radar display is utilized for the task visualization. Background of the radar display is black. Therefore, background of the task visualization sheet is white so that tasks can be seen when they are written on the sheet. Moreover, airspace and routes displayed on the radar display are shown on the sheet (Figure 5).

Figure 5 Radar display sheet

- Step 2. Description of the trace of controller's operation

The trace of the cursor operated by the controller on the radar display of the control system is drawn on the sheet made at Step 1 for every minute. The trace of the operation is to be expressed with clear initial and end points (Figure 6).

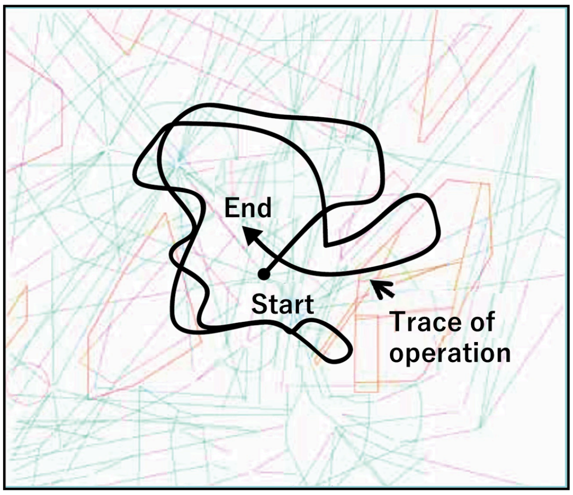

Figure 6 Radar display sheet on which trajectory of operation is drawn

- Step 3. Task visualization for air-traffic control works

The tasks of air-traffic control works are described on the radar display sheet made at Step 1 (Figure 7). For the tasks to be described, content of the task for one minute is written on one sheet. Contents for the task visualization are shown below.

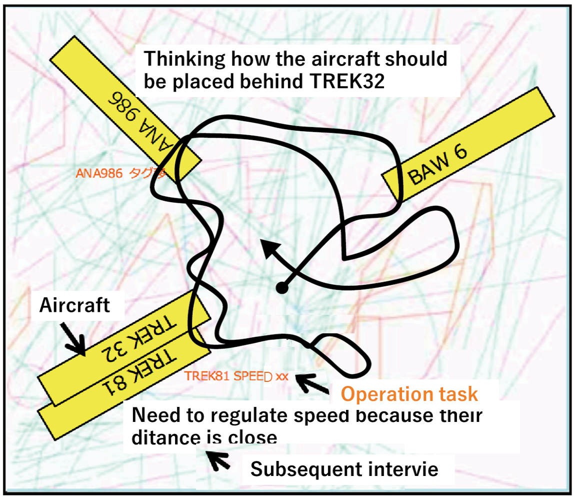

Figure 7 Radar display sheet on which began air-traffic control task is drawn

1. Display content

The aircrafts displayed on the radar control system are described with tags. The directions of aircrafts flying are made same as those shown on the radar display with reference to the video of the observational research. The aircrafts' names are shown on the tags.

2. Content of subsequent interview

The contents of the subsequent interview of controllers obtained by the observational research are described along the temporal axis of the trace of the controllers' operation.

3. Content of the operation task

Numerical information such as altitude or velocity of aircraft input by the controller input with a radar control system is described along the temporal axis.

The task visualization method was improved for the two problems shown in the preceding chapter as described below.

- Problem 1: It is hard for a designer is grasp requests from controllers, who are users
- Problem 2: It is not clear where on the display of the air traffic control system the controller's tasks were operated

As a method for solving Problem 1, trace of the controller's operation with the radar control system is described on the display of the radar control system. The intention of this method is that describing trace of controllers' operation has an advantage that a designer can visually see ideas of the controllers' directions, which makes it easy to grasp air-traffic control works. As a method for solving Problem 2, controllers' tasks are described on the display of the radar control system. The intention of this method is that a designer can easily connect controllers' tasks and the user interface. For such a reason, tasks are described on the sheet with the display of the radar control system on it. Moreover, the tasks are described with the trace of the controllers' operations, which is an improvement point of Problem 1, as an axis. Describing the task along the trace of operation allows to confirm tasks while following the trace of operation. Therefore, the intention is that it will become easy to grasp ideas of controllers' directions. The improvement of description of the two tasks mentioned above will make it easier for a designer to grasp air-traffic control works. Therefore, we supposed that combining the improved task visualization and task analysis of the sequential task analysis would make the improved task analysis in the air traffic control system development effective for understanding air-traffic control works.

6 Verification of the improved sequential task analysis for air traffic control system development

Our idea was that the improvement of the description of two tasks mentioned above would make it easy for a designer for to grasp air-traffic control works. Therefore, we supposed that combining the improved task visualization and task analysis of the sequential task analysis will make the improved sequential task analysis in the air traffic control system development effective for understanding air-traffic control works.

6.1 Verification of the improved task visualization

Outline of verification of the improved task visualization. Verification was performed in Electronic Navigation Research Institute on August 24, 2012. The time required to describe in the improved task visualization was 6 hours. Participants were 2 staff members having basic knowledge of air-traffic control works (understand functions of the air traffic control table and conversation between controllers on work), and 1 member who was qualified as a controller. The instruments used for the verification were writing implements, video of air-traffic control works, tags and radar display sheets for describing tasks (30 pieces of A4 paper). The verification process is described below.

- Process 1: Preparation of sheet for describing tasks

Describe basic information (including airspace and routes) displayed on the radar control system in the sheets for describing tasks.

- Process 2: Confirmation of the video of air-traffic control works

Perform observational research based on the video data of approximately 30 minutes obtained by the observational research of the air-traffic control works that were used for the verification of the sequential task analysis.

- Process 3: Description of the task of air-traffic control works

Describe "content of the display", "operation task", "subsequent interview content", and "trace of the user operation" on one sheet for every minute (Figure 8).

The improved task visualization method allowed to describe all air-traffic control tasks of the observational research of 30 minutes.

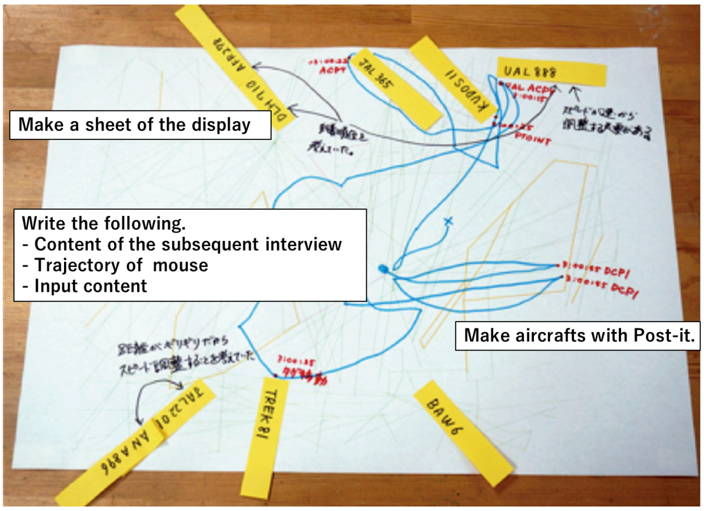

Figure 8 task visualization by the improved task analysis for air traffic control system development

6.2 Task analysis

Outline of the task analysis is described below. The task analysis was performed in Electronic Navigation Research Institute on August 24, 2012. The time required to analyze the task was 2 hours (1 hour for confirmation of the video observed + 1 hour for confirmation of the task visualization). Participants were 2 staff members having basic knowledge of air-traffic control works (understand functions of the air traffic control table and conversation between controllers on duty), and 1 member who was qualified as a controller. Instruments used for the task analysis were PC1 to confirm video of the controllers' tasks obtained by observational research, PC1 to describe tasks and sheets to analyze the tasks. Items of the tasks were "Scene" and "Characteristic of air-traffic control works" which were performed in the same way as the sequential task analysis. As a result of the task analysis, 20 characteristics of air-traffic control works were extracted (Table 2). Moreover, the results of the improved task analysis revealed that control works were analyzed together with reasons for the tasks such as "Influence on aircrafts behind" and "Analysis on priority of aircrafts to be converged" for the tasks performed by controllers.

Table 2 Result of task analysis by the improved task analysis

Scene			Characteristics of control work
Work hour	Aircraft	Task	
03:00;30～03:00;40	-	Display MAP3	Need to arrange the operation by predicting arrival orders of AFR278,DLH710 and UAL888 separating operation display and arrival prediction
03:02;18～03:02;28	JAL2201	Input MAC number	The controller confirms the map display first it but does not almost use it after that
03:00;30～03:00;40	-	Display MAP3	When the distance between two aircrafts is close, the operation will be smoother by giving directions to the preceding one.
03:03;01～03:03;09	ANA365	Input MAC number	When confirming AAR102 and KUDOS11, other directions are given more easily by deciding clear directions when dodging by altitude directions first.
03:04;56～03:05;03	ADO45	Communication (direction)	Directions are limited by restricted area.
03:06;51～03:07;03	JAL2201	Communication (altitude)	Confirm fix after the aircraft enters the restricted area to some extent.
03:07;58～03:08;01	ADO45	Move tag	It is difficult to give new directions to the following aircraft unless directions to the preceding aircraft is completed.
03:08;58～03:09;00	BAW6	Communication (altitude)	When status changes under the influence of wind, the priority of the aircrafts changes.
03:09;25～03:09;26	UAL888	Communication (altitude)	Lowering speed causes risks to the following aircraft.
03:09;50～03:10;06	AFR278	ACPT	Overall directions are influenced by changed separation.
03:11;02～03:11;07	BAW6	Communication (altitude)	Directions are limited by restricted area.
03:12;14～03:12;15	KUDOS11	Communication (altitude)	Need to think about structure of future directions for operating the aircrafts of the same destination.
03:13;54～03:14;00	BAW6	Move tag	The controller wants to transfer under a sufficiently safe a situation though it's not allowed to do so.
03:14;59～03:15;02	IBEX3147	Communication (ACPT)	The following aircrafts are influenced by the undecided orders of them.
03:15;58～03:16;01	IBEX3147	Input altitude	The controller does not want to change flight plan
03:18;02～03:18;04	UAL888	Input altitude	The controller wants get the aircraft back to the original route and reduce directions.
03:19;01～03:19;02	ANA748	Communication (altitude)	Make aircrafts detour to make it converge with others.
03:19;57～03:20;02	IBEX3147	Communication (altitude)	Lowering speed causes risks to the following aircraft.
03:20;58～03:20;59	AAR102	Communication (altitude)	Trying to make aircrafts cross giving different altitudes.
03:22;39～03:22;42	ANA50	Communication (altitude)	Maintain separation by uniformizing speed.

7 Summary of the improved sequential task analysis for traffic control system development

This chapter describes characteristics of the improved sequential task analysis method for air traffic control system development from the viewpoint of "time required of verification", "the number of characteristics of the extracted air-traffic control works" and "content of characteristics of the extracted air-traffic control works". Verification of the sequential task analysis was completed in 4 hours. On the other hand, verification of the improved sequential task analysis for air traffic control system development required 6 hours. The result revealed that the improved model sequential task analysis for air traffic control system development took longer by 2 hours than the sequential task analysis. Now, the number of characteristics of the air-traffic control works extracted from the analysis is discussed. Verification of the sequential task analysis extracted three characteristics of the air-traffic control works. On the other hand, the improved sequential task analysis for air traffic control system development extracted 20 characteristics of the air-traffic control works. The reason why 20 characteristics were extracted is that it became easier for a designer who does not have specialized knowledge to grasp the works by confirming tasks on figures, we reckon. Next, details of contents of the characteristics of the extracted air-traffic control works are discussed. The sequential task analysis has a characteristic to analyze the works based on controllers' usage frequency of functions of the air traffic control system while the improved task analysis has a characteristic to analyze the works based on the controllers' intentions for operation of the air traffic control system. These analyses are described with examples below. As a verification result of the sequential task analysis, a number of problems on usage frequency of functions of the radar control system such as "The controller uses the map display change function at the time of the initial setting. However, it is always displayed even though the controller does not almost use it after the initial setting." were extracted. In contrast, as a verification result of the improved task analysis for air-traffic control works, characteristics of what the controller minded for the later direction such as "Because the aircraft AAR102 which entered the airspace was going to cross KUDOS11 later, the controller frequently checked their positions by mouse." were extracted (Table 3). The above results revealed that superficial characteristics such as the number of times of operations are easily seen in the sequential task analysis while the improved task analysis realizes not only the superficial analysis of the tasks performed but also task analysis with better understanding on works such as why the controller performed the operation.

Table 3 Comparison of task analysis result

Scene			Task analysis results	
Duty hour	Aircraft	Task	Characteristics extracted from the sequential task analysis	Characteristic extracted from the improved model task analysis
03:00;30～03:00;40	-	Display MAP3	The controller confirms the map display first it but does not almost use it after that	The controller confirms the map display first it but does not almost use it after that
03:00;40～03:00;45	-	Cancel MAP3 display		
03:00;45～03:01;04	BAW6	Move tag		
03:01;04～03:01;33	TREK81	ACPT		
03:01;33～03:01;36	TREK81	Communication (ACPT)		
03:01;36～03:01;41	TREK81	Communication (altitude maintenance)		
03:01;41～03:01;50	BAW6	Move tag		
03:01;50～03:02;05	JAL2201	ACPT		
03:02;05～03:02;07	JAL2201	Communication (ACPT)		
03:02;07～03:02;11	JAL2201	Communication (velocity)		
03:02;11～03:02;14	JAL2201	COM		
03:02;14～03:02;18	JAL2201	Move tag		
03:02;18～03:02;28	JAL2201	Input MAC number	Input mac number more often than header and speed.	When the distance between two aircrafts is close, the operation will be smoother by giving directions to the preceding one.
03:02;28～03:02;31	TREK81	Move tag		
03:02;31～03:02;41	ANA365	ACPT		
03:02;41～03:02;46	ANA748	Move tag		
03:02;46～03:02;48	AAR102	Move tag		
03:02;48～03:02;50	ANA036	Communication (ACPT)		
03:02;50～03:02;54	SKY703	Move tag		
03:02;54～03:02;55	ANA036	Communication (velocity)		
03:02;55～03:02;56	ANA365	COM		
03:02;56～03:03;01	ANA365	Move tag		
03:03;01～03:03;09	ANA365	Input MAC number		When confirming AAR102 and KUDOS11, other directions are given more easily by deciding clear directions when dodging by altitude directions first.
		Communication (velocity)		
03:03;09～[illegible]	ADO45	Move tag		

8 Conclusion

This paper described the improved sequential task analysis for air traffic control system development for the purpose of improving the sequential task analysis method to make it easier to grasp tasks of the air-traffic control works in the case that a designer does not have knowledge of air-traffic control works. We extract problems on the sequential task analysis in air-traffic control works from the sequential task analysis, and proposed the improved sequential task analysis for air traffic control system development for which the improved task visualization and the task analysis of the sequential task analysis were combined. Moreover, we verified if the improved sequential task analysis for air traffic control system development is effective for a designer who does not have knowledge of air traffic control works. The result revealed that the improved sequential task analysis for air traffic control system development was successfully improved so as to make it easier to grasp air-traffic control works than the sequential task analysis. However, since the time required for the task analysis is long, it is necessary to improve it so as to shorten the time required for the improved sequential task visualization. In the future, we think that it is necessary to examine the idea of the user interface of the air traffic control system and verify the effectiveness of the idea in order to verify whether the features of the extracted air traffic control work are effective in the development of the air traffic control system. Also, we want to be able to improve the sequential task analysis so that it can be generally generic in product development for the business.

9 References

Masaaki Kurosu (2013), *Basics of human-centered design*, Modern Science

Usability handbook editor (2007), *Usability Handbook*, Kyoritsu Shuppan.

Toshiki Yamaoka (2000), *Comparison of three points task analysis and protocol analysis (1)*, Japan Ergonomics Research Society.

Midori Fukaya (2003), *Measures for usability in the field of home electric appliances*, The Information Processing Society of Japan.

Kazunori Imoto (2005), *Usability evaluation of voice interaction function in recording and playing operation of TV program*, The Information Processing Society of Japan.

Yusuke Fukazawa (2006), *Proposal of service presentation system based on the user behavior prediction with task model*, The Information Processing Society of Japan.

Toshiki Yamaoka (2003), *Introduction to human technology*, Morikita Shuppan.

Annett, J.& Stanton (2000), *Task Analysis*, N.A.

Kentaro Suzuki, Masato Sasaki (2001), *Study on GUI design method based on utilized human design technology*, Japanese Cognitive Science Society.

Arisa Sakamoto (2012), *Design and implementation of visualization mechanism of undo operation based on display change on desktop*, The Information Processing Society of Japan.

Masaaki Kurosu (2003), *Usability testing*, Kyoritsu Shuppan.

Tarumoto Tetsuya (2005), *Usability engineering*, Ohmsha.

Norman, D. A (1999), *Whom is the design for?* Shinyosha.

Masaaki Kurosu (2011), *Understanding ISO012407*, Ohmsha.

About the Authors:

Hajime Hirako: 2014 Chiba Institute of Technology Graduate School of Engineering Graduate School of Engineering Design Doctorate PhD.Currently engaged in UIUX design with Digital Design Group Leader of Takaki Design Office, Fuji Software Co., Ltd.

Acknowledgement: In advancing this research, Professor Kazuhiko Yamazaki and the Electric Navigation Research Institute offered great advice from the supervising instructor. Thank you very much.