AN ABSTRACT OF THE THESIS OF

Marie-Anne Midy for the degree of Master of Science in Computer Science presented on October 1, 2007.

Title: The Commentator Information System: Understanding Journalists' needs to Overcome Cognitive Load and Navigation Issues.

Abstract approved: ____

Carlos Jensen

Nowadays, sports events are a significant part of the every-day entertainment with local, national, and international championships. A lot of money is invested by broadcasting companies to attract new and more viewers, acquire broadcasting rights, or send entire crews on site to cover such events. Journalists are among the few who go on site. To perform their job and make appealing live commentaries, journalists need a lot of information about athletes, past and live results, records, etc. The Commentator Information System (CIS) is the on-site tool used by journalists for these purposes, and made available by the organizers.

The CIS is an LCD touch-screen device that allows users to retrieve sports data by selecting specific buttons on the interface: final or heat results, intermediate times, weather conditions, medal standings, etc. There is one CIS per event; hence the system can cover dozens of different disciplines (e.g. during the Olympic Games) at the same time.

There has been research conducted on how to improve TV and online viewers' experience during sports events but nothing, as of today, about improving journalists' work environment. Moreover, their work conditions are very stressful; if they make mistakes in their statements, it can have negative consequences on their career. Thus, the CIS has to be reliable from both a system and usability perspective.

Through this study I found important navigation issues and some missing information concerns. I observed that journalists rely heavily on their own notes and not much on the CIS. I discovered, users do make mistakes and have difficulties multitasking under this type of pressure. Finally, I noticed some gender differences in the task performances when users have to find information in the CIS.

The Commentator Information System: Understanding Journalists' needs to Overcome Cognitive Load and Navigation Issues.

by
Marie-Anne Midy

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented October 1, 2007
Commencement June 2008

Master of Science thesis of Marie-Anne Midy presented on October 1, 2007

APPROVED:

Major Professor, representing Computer Science

Director of the School of Electrical Engineering and Computer Science

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Marie-Anne Midy, Author

ACKNOWLEDGEMENTS

First I would like to thank my advisor, Dr. Carlos Jensen, for his feedback and guidance through my research. Thank you also for the freedom I had over the past years, it helped me realizing how important some decisions and their consequences on my work could be. Thank you for the opportunities you gave me by being able to travel and meet new people from the sports and HCI fields. And thank you for your help while writing my first paper.

Most of the theoretical analysis was a team work; thank you Yunrim for the time you spent with me on the transcripts. Also thank you to all the students who contributed to implement the CIS; your ideas, insights and time were valuable.

My time in Sweden was precious; thank you Oscar for the time you spent and for your contacts. I would not have been able to find major results without your help. Alain, Rüdiger and Ernest, thank you for your help and comments.

I would like to thank my committee members: Dr. Margaret Burnett, Dr. Ron Metoyer and Dr. Shoichi Kimura for their feedback and contribution to my thesis.

Finally, I would like to thank my parents for their support; Elisabeth and Eric for their understanding. Thank you to those who changed their schedule according to mine, I really appreciated it.

To c.m.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

LIST OF APPENDICES

LIST OF APPENDICES (Continued)

LIST OF FIGURES

Figure | Page

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

The Commentator Information System: Understanding Journalists' needs to Overcome Cognitive Load and Navigation Issues

1. Introduction

The use of computer technology in sports is a pervasive phenomenon. Athletes and their coaches use computers to analyze results and performance, create simulations, and manage schedules (Vicon). Event organizers and sports federations, especially those responsible for large international events such as the Olympic Games, World Cup Soccer, or World and European Athletics Championships, use computers extensively in the planning, management, and dissemination of information about their events. Sports are also increasingly relying on networked sensors, or high-speed camera systems like Hawk-Eye (Hawk-Eye), to gather and relay results, rulings, and other data which may affect the event or score. This data has five main consumers; the athletes, judges, organizers hosting the event, the audience (whether in the stadium or at home), and the media.

Most recent work in the Human-Computer Interaction (HCI) field has focused on the needs of spectators, both on-site, and at home, watching television or online (Page and Moere 2006). Relatively little work has been done on understanding and meeting broadcasters' needs. The data required for this group is more complex, as it must has detailed, timely, and correct information in order to plan and produce compelling programming.

Sports broadcasting is big business, regularly attracting prime-time crowds, generating large revenue streams, and requiring large investments in acquiring broadcast rights, purchasing or moving equipment (especially when the events take place abroad), coordination, and production. For the Turin 2006 Winter Olympic Games, broadcasters paid over $833 million in licensing rights alone, and it is estimated that this investment will reach $1.7 billion dollars for the Beijing 2008 Summer Olympic Games (IOC-1). Obviously, with such a large investment, broadcasters are under pressure to capitalize by producing the best viewing experience possible. This is not always an easy job, especially due to the scale of many of these events. During the 14 days of the Athens 2004 Summer Olympic Games there were 301 events in 28 different sports, with 11,099 athletes representing 202 countries. According to the International Olympic Committee (IOC), over 44,000 hours of TV coverage were dedicated to these Games globally, which translated into 34.4 billion viewer hours (IOC-6 2004). In order to produce this content, TV and radio broadcasters had more than 12,000 journalistic and support staff on-site. NBC Universal alone paid a record $793 million for the broadcast rights, and produced 1,200 hours of coverage of the Athens 2004 Olympic Games (IOC-2).

Given the magnitude, and concentration of competitions at events like the Olympic Games, broadcasters and commentators are highly dependent on accurate, reliable, and timely computer support systems to help them do their job. To help broadcasters handle the complexity of these major events and help them plan and produce better programming, organizers will sometimes offer a broadcaster a system called a Commentator Information System (CIS). While different events will have different CIS implementations, these follow a general template.

From a usability perspective applications such as the CIS pose very interesting challenges. The users, though highly skilled, have to operate these systems while delivering compelling and engaging live commentary to millions of viewers. Timing is crucial, and the cognitive load and level of stress is very high. Mistakes, while not life-threatening, can effectively end a lucrative career.

In addition to its usefulness to commentators and broadcasters, the potential for further enhancing the local or remote viewing experience, as well as that of sports related games, by giving viewers access to CIS-like systems is promising. One example of where this possibility is currently being explored is NASCAR and Formula 1 racing in the USA, with the NEXTEL FanView™ (Nextel). The NEXTEL FanView™ is a portable device providing custom views of official live and past data about racing events. This system could easily evolve to cover other sports, or replicated online by tapping into the CIS data-stream.

For this thesis I decided to examine the CIS from a usability perspective, principally the system used for the Olympic Games, to determine how well these systems meet broadcasters' needs. In order to do this I performed a study of TV sports broadcasts, the accompanying CIS, its layout and content, conducted an ethnographic study of commentators doing their job, and ran a controlled experiment with subjects using a prototype of the Olympic Games CIS I implemented. The rest of this thesis is structured as follows: first, I give a brief summary of related work before describing the CIS in more details followed by a description of my broadcast study, usability study, field study, and experiment. I wrap up by presenting my observations, my findings, my results and some suggestions for future work.

2. Related work

Sports and sports-related entertainment are big business. Companies have invested heavily in sports to maximize the benefit from their broadcast rights. This includes a sizable investment in the exploration of technology meant to enhance viewing experience, and to reach wider audiences.

In this chapter I will be focusing on the work that has been done on sports and entertainment, the information technologies used, the target users, and the main findings. First of all, I will define who the main users are. Then I will mention the main topics, technologies and results related to these studies. The second part of this section will be about the IT infrastructures for important events such as the Olympic Games, the technologies used and their evolution over the years.

2.1. Target audience

Because sports can be watched and followed from different places, the audience can be on site viewers during an event, viewers at home watching TV, or interacting online when they have Internet access for example.

On site audience includes sports journalists, broadcasters, judges, coaches, athletes, and spectators. Remote audience consists of TV viewers, radio listeners, and people using online services to retrieve information such as scores, records, etc. In addition to their location, they may have different viewing habits or needs, they may like more a specific sport than others, and they may be fans who get involved a lot in those sports events, or just viewers who watch sports occasionally. Additionally, there are the novices who do not know the rules, or barely, of specific sports.

Because each category of audience behaves differently and has different perceptions of the games, the matches, etc., their needs are different. Some studies have been conducted to focus on one of these categories like novices for instance (Cavallaro 1997), others tried to focus on the gender factor (Sargent, Zillmann et al. 1998). As results, statistics, surveys or experiments provide data to understand the relationship between sports, enjoyment and end users.

In my study, the audience is made of journalists, broadcasters, or any other persons who need to have access to live results and to the CIS. Because I want to compare the studies and their findings for other end users than journalists, I will present in the next section the main results of published work. This is a way to map the available resources for different types of audience and the attention paid to one or another.

2.2. Sports excitement detection

Because sports events can last for hours and everyone is able to watch them completely at once, users like to go back to a past game, race, etc. to look at a key action they missed. In order not to have to go through the entire video, researchers have focused on programming algorithms that detect interesting video portions based on crowd's excitement.

One of the hot topics related to sports and IT is to search a method that identifies a replay depending on the content of the video and audio feeds. When there are hours of video, it is usually quite difficult to find a specific portion of a sport event. The use of summarized videos is a solution to access the desired information more easily and more quickly. Also, creating summaries of such media is very useful to represent the content and could be used to compress the entire video, keeping only the interesting parts. By doing so, viewers, as well as broadcasters, can locate and access without much difficulties the data they want.

The techniques used focus on detecting the key events using replays, keywords from close-caption and speech recognition, and object and motion recognition. This kind of research maps the actions that take place during a game to the feedback / excitement from the audience in order to improve the recognition process (Huayong and Hui 2005). The use of complex algorithms and formulas allows an accurate analysis that can be automated to split a video in pieces with a similar content.

In addition to providing information about the content of a video (Tjondronegoro, Chen et al. 2004), the technique also used the excitement and enjoyment of viewers to detect when an action occurs, either good, like a goal, or bad, like a sanction during a soccer event. Because research focuses on several sports, the whistle and excitement measures provide results for each of them. This data would allow, in the future, researchers to pay attention to how to enhance people experience with sports depending on how they respond during a game or when no reaction is detected. (Tjondronegoro, Chen et al. 2004) used their algorithm to first focus on detecting actions based on whistles, then based on excitement during several sports events. Overall, the percentage of errors goes from 0% to 40%. As of today, further research is being conducted to improve this model.

By using this kind of algorithm, researchers (Huayong and Hui 2005) implemented an interface that displays the different video clips where key actions happened. It allows end users to directly access a portion of the video they want to replay without having to browse the entire file to find a goal, for soccer as example. Users just have to select the clips they want to watch.

This study uses algorithms to analyze events that are over in order to provide information afterward to remote users. This data is available to different audiences: remote viewers, judges, and commentators, but mostly used by remote viewers. The next studies focus on other technologies to provide almost live additional information to viewers. Those also focus on improving remote viewers' experience.

2.3. Technologies for additional on-screen information

2.3.1. Tracking cameras

The main technology currently used for augmented information on TV screen is tracking cameras. The main purpose of this method is to display the path of objects like balls during a tennis game for example, or like people providing statistics about the time spent in specific areas for instance. Then the information gathered from the cameras are put on the TV screen or online depending on the program and end users; they are mostly used in replays (Figure 1) or as basis for statistics (Page and Moere 2006). Figure 1 is a screenshot of a soccer game where the trajectory of the ball has been added to the video to enhance, from a viewer's perceptive, the replay of the action.

Figure 1: StroMotion and SimulCam technologies (Sportvision)

Others use the tracking color technique to display information on TV screen in real time, the main applications being with tennis balls and the areas where athletes spent their time during a game (Pingali, Jean et al. 1998). The cameras used to track the objects are very accurate and put under many tests by the international federations before validation and use authorization (ITF 2004; Johnson 2004).

The frequent systems based on this technology are Hawk-Eye (Hawk-Eye), Auto-Ref (Auto-Ref), PointTracker (Figure 2 on the next page) (IBM 2007), Cyclops, etc. If we look at

Figure 2 we see that users have a virtual image of the tennis court (in the middle of the window). On this court are 2 lines, one green and one purple to identify the ball trajectory of each player. On the upper left corner of the tennis court are the scores and a tennis ball in front of the current game to indicate who is serving, like on TV. Below the court area are the different camera angles the users can choose from in order to replay an exchange. They also have access to each point of the games through the right panel. After selecting the set (on the top of the panel), they click on the point they want to see which will be displayed in the court window. This data is about the same as shown on viewers' TV screen. However, even if a lot of information is gathered and available, only a few is shown on screen. According to its owner, Hawk-Eye (Hawk-Eye) is a powerful system used to track balls, during tennis games for example; but a lot more information is captured than what TV viewers or online users are shown. Using tennis as an example, an analysis has been done to illustrate these facts (Wang and Parameswaran 2004).

Figure 2: IBM PointTracker (IBM 2007)

In addition to sorting and indexing videos, the tracking cameras are also tools to analyze players' tactics (Vicon). Especially for soccer, users have an online access to replays when they missed goals or if they want to look back at an action from a different camera angle (BBC). With this kind of program, end users are in total control of what they see.

Augmenting viewing experiences does not always lead to better or more enjoyable viewing experiences. A study, which did not succeed in convincing the audience, was based on tracking the puck during ice hockey games (Cavallaro 1997). It was called the FoxTrax system and used high technology to provide additional information on the TV screen like the "comet tail" of the puck. In order to do so, tracking cameras were placed all over the ice ring. The system was used for a couple of years and then cancelled by the national league when fans started to complain about the fact that it was more disturbing than helping.

For these studies, again, the primary target is the remote viewer. With these new technologies they have access to more detailed replays, additional games statistics, etc. The data only available online is accessible by journalists when they have an Internet access. This is not always the case since not all of them have personal computers with them when doing their job. Hence, remote viewers are able to retrieve more information than journalists when the latter do not have additional source of information.

Tracking cameras represent an important percentage of the technology used to provide information during sports events. An emergent technology, which could lead to more detailed data, is the sensor technology.

2.3.2. Ubiquitous sensors

Tracking cameras are useful to detect when balls are in or out during games (tennis, football, baseball, etc.). It provides information to athletes, judges, spectators, etc. In addition, recent studies have focused on the sensor technology; athletes are asked to wear detecting devices which will provide additional data to the viewers. It goes from heart beat (Hallberg, Svensson et al. 2004), detection of kicks for martial arts (Chi 2005), or distance covered (Cromley 2006; theage.com.au 2006). However, sometimes the information is not shown to general audience because it is for judgment purposes or for personal use. Experiments have been conducted about the use of such technologies in order to provide detailed statistics

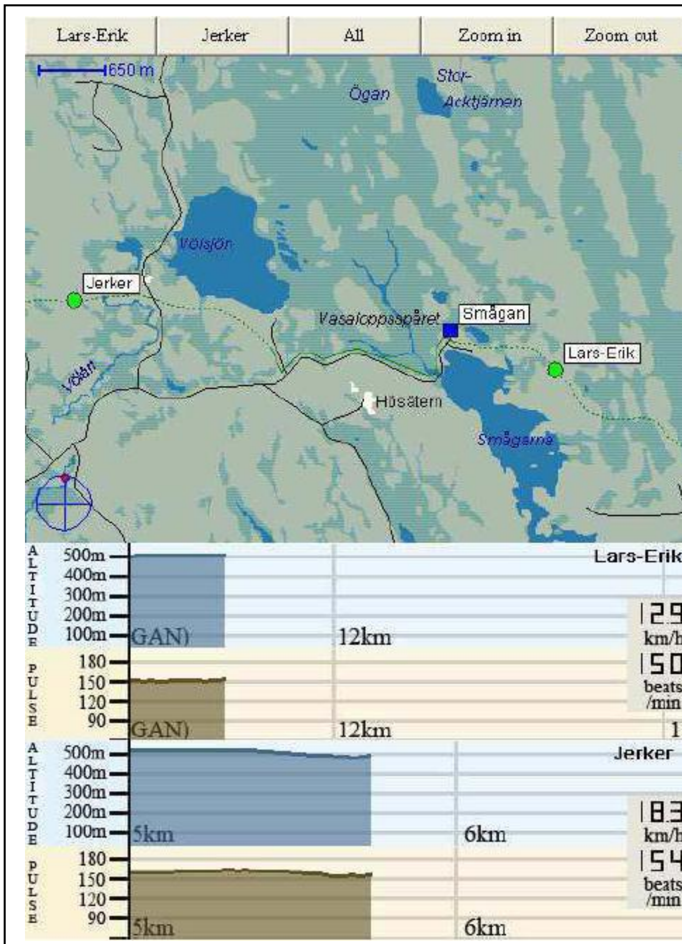


Figure 3: GPS and sensors applet (Hallberg, Svensson et al. 2004)

and updates to remote viewers. Additionally, ethical issues have also been studied (Chi 2005; Chi, Borriello et al. 2005) to take into account judges and athletes' concerns.

Another experiment involving GPS and sensors was during a cross-country skiing event in 2004 (Hallberg, Svensson et al. 2004). Two skiers wore chest belts equipped with a heart beat sensor and GPS devices. The rest of the team followed remotely their location, the distance they had skied, their altitude and their pulse using an applet on a computer. With a web-based application, they kept track of the data for the entire event (Figure 3 on the previous page). The test was overall a success; however they had a few issues during a short period of time due to some sensors that did not work properly. The information was very detailed compared to what is currently shown on TV.

For a solution less accurate and less expensive than GPS devices ($30 vs. $30s0) Nike and iPod from Apple have designed a small sensor, for a more general audience, which can be inserted into the runners' shoe (Apple 2006; Cromley 2006). The small device sends data to the iPod users like distance, calories burnt, etc. It also has the capacity to change the rhythm of the music depending on the runners' speed. Though the feature is quite simple according to those who tested it (Cromley 2006), it helps users to keep running and gives new ideas for future research with sensors.

Once again this very interesting data has very limited audience and the target users do not include journalists yet. However it provides suggestions for more technologies and tools for additional sports results. Another technology, which can only be used on site by local viewers and maybe journalists, are the handheld devices.

2.3.3. Handheld devices

Because the target audience not only interact with sports on TV or during broadcasted events, but also at home or remotely, new technologies have been developed for those end users.

The first category represents the use of devices when people can not access all courts for tennis, or can not see the entire track for car races, because they are happening at the same time, or the stadium or track area is too big for instance. To solve these issues Nextel and NASCAR created a

Figure 4: NASCAR Nextel FanView (Nextel)

small device, the FanView™ (Figure 4 on the previous page), which allows fans to follow the entire race and to have complete statistics about the drivers and their car (Nextel). This device is now in sell for a cost of $369.95, when a year ago it was only for rent during a couple of days. Similar research has been conducted by IBM for tennis (Singer and Hanapole 2006), especially for the Wimbledon tournament. With their device, spectators would be able to have a look at every single match during the entire venue without moving from one court to another.

Other tools, not for local but remote users, are those using the GPS technology (motionbased 2004). Both athletes and occasional runners wear a small device that records their speed, distance, elevation, etc. After their race, they upload their data and receive a complete summary of their training session. By providing such services, it improves athletes' interest in keeping track of their performances.

Obviously the handheld devices are made for remote and local viewers; not for journalists. When there are many types of audience, as listed previously, studies focus definitely less on the commentators than on the viewers. The next section is going to confirm this observation.

2.3.4. Interactive games

To attract more viewers to watch sports on TV, some studies focused on games and how to integrate them to the TV. In 2001, researchers paid a close attention to adding games and polls on TV screen as a top layer (Gibbs, Hoch et al. 2001). The sport they chose for their experiment was Formula 1. They allowed TV viewers to rate their famous drivers and to give their opinion on who was going to win the race. In addition, they could drive a car to compete with the drivers through a game included in the system using both camera and sensor technologies. To enhance users' experience during the test, they were able to race not only with real drivers but with their friends too. It was either in real time or with short time delays.

The main target for this type of entertainment is the remote viewer. Companies want TV viewers to stay the entire race in front of their TV and add games and polls on that purpose. When one can argue viewers watch sports on TV for leisure and journalists do so for their job, the goal was to show here the advanced studies conducted with this type of audience as end users.

These results focus on different sports such as tennis, soccer, Formula 1, etc. It seems the list of sports, companies decide to focus on, is quite narrow, maybe due to what viewers like to watch. The next section presents the results from several surveys about viewers' sport preferences. The purpose is to see if there are significant differences that could affect the amount and type of information provided to users depending on the sports themselves.

2.4. Viewing preferences

In order to know what the different types of audience needs are, some surveys have been conducted about what spectators like, what sports they watch on TV and if specific factors, like gender, really matters in their sports perceptions.

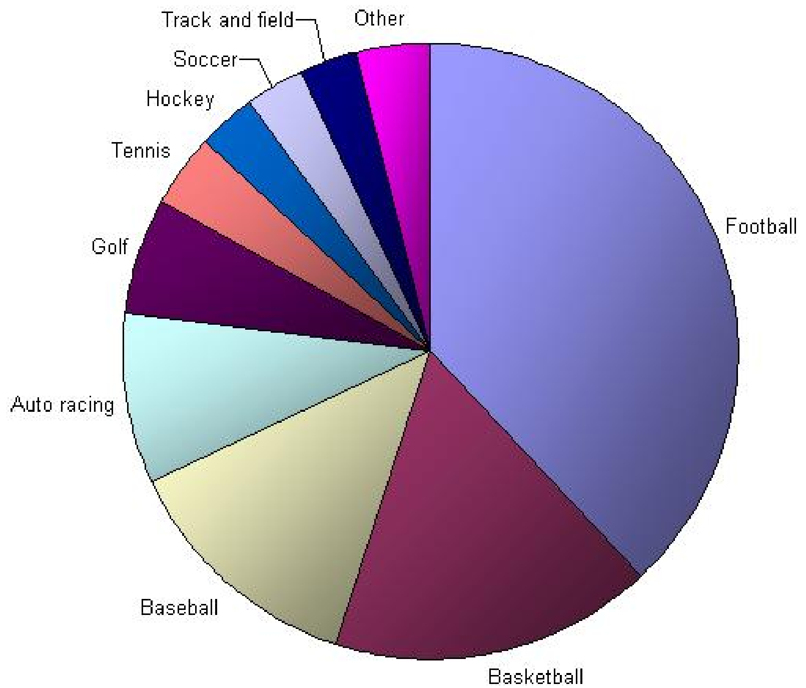


Figure 5: Favorite sport

The question asked to people by the Harris Poll was: "If you had to choose, which of these sports would say is your favorite?" (PollingReport.com 2001). Figure 5 illustrates their answers. Clearly football in the USA is one of the favorite sports with about 1/3 of the votes; in second position is basketball, followed by baseball. Auto racing also represents an important percentage of the answers.

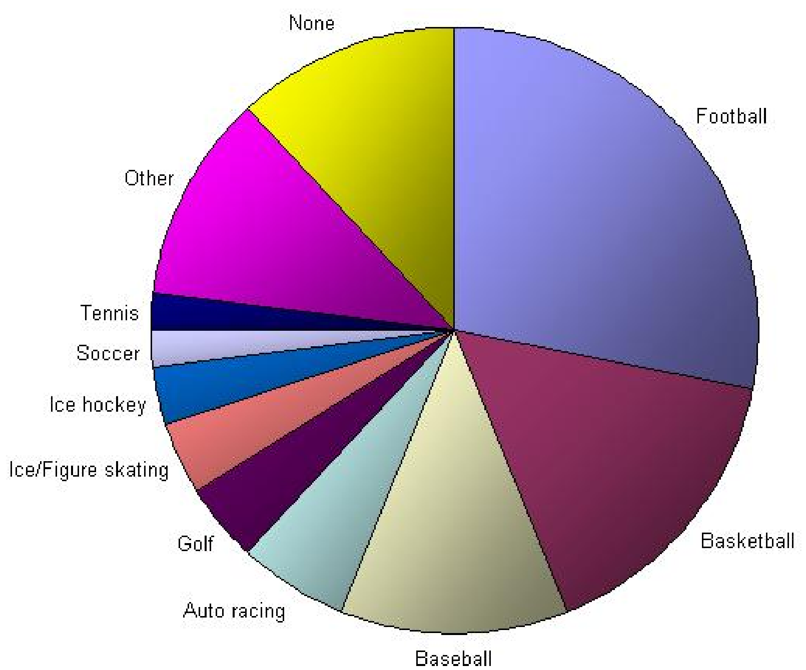


Figure 6: Favorite sport to watch

The Gallup Poll asked another question to American people: "What is your favorite sport to watch?" (PollingReport.com 2003). Figure 6 represents their answers. Here the percentage for football is smaller (28% vs. 38% for the previous results) and a large part of the population, 12%, does not have a favorite sport they like to watch. The other point to notice is that 1/3 of the people who like golf do not like to watch it. As of today, no further study has been conducted in order to understand these facts.

According to viewers, not all the sports are interesting to watch. Something needs to be done to change their opinion about sports on TV. This is maybe also a reason why some sports have more additional information about athletes, scores, replays, etc. on screen than others; broadcasting companies prefer investing in the favorite sports on TV.

One study gave some information about the data available on the TV screen, online, or on site, which could account as a factor for such results. In the next section are the details of this study conducted to analyze the various kinds of visual information provided to remote and local viewers, judges, and athletes.

2.5. Available information to different audiences

Remote and local viewers often do not have access to the same kind of information during sports events. The same is also true for judges, athletes, coaches, or journalists. Studies have been conducted about this observation (Page and Moere 2006); it summarizes the different forms of visual information provided to different end users.

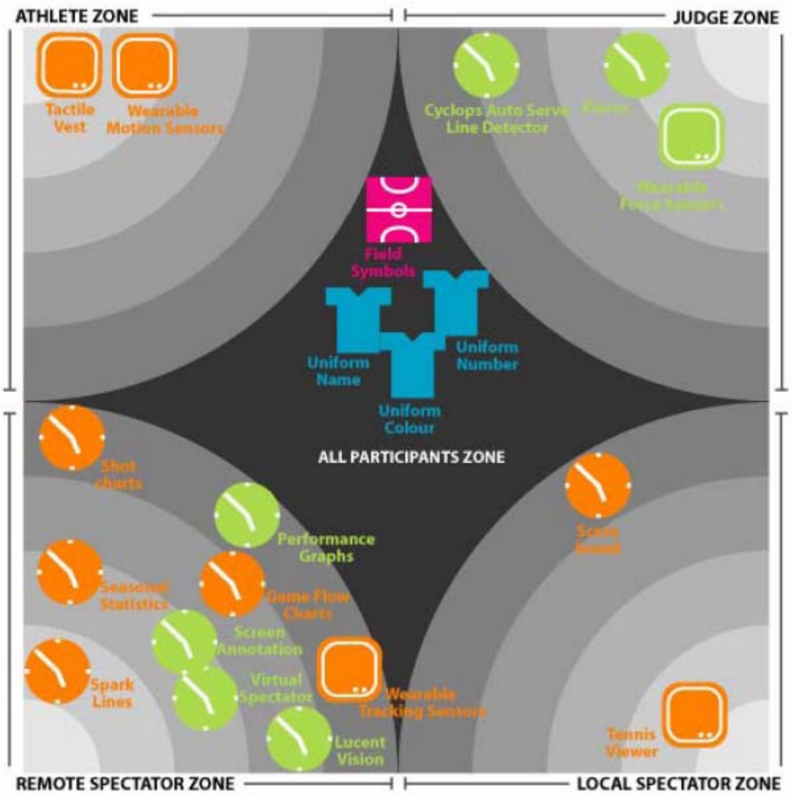


Figure 7: Loaf model front view (Page and Moere 2006)

The goal of their study was to show the different visual clue gaps depending on the types of audience and their location. For instance, athletes recognize their teammates by looking at the color of their shirts; remote spectators have additional information on their TV screen such as charts of statistics. Besides, this study analyzes the processing efforts the audience needs to do in order to identify and understand what they see. Indeed, the location and distance from the field of action can be an important factor.

The authors noticed that clothes, usually with names, numbers and the color of the team, helped the remote / local viewers, judges, and players themselves identifying the players of a game. In addition, the players' environment is very useful and mainly used for rules; every types of audience can refer to these visual clues. The on TV screen information and online statistics are more for remote spectators and involve high technologies like mentioned previously. Finally, the wearable computing is used to relaying direct information from athletes to audience with the use of sensors for example.

Based on those facts, the authors created their "Loaf model" represented as a 3D cube. Figure 7 (on the previous page) and Figure 8 represent its front and side views.

The front view has 4 different corners based on the types of viewers. The upper left corner represents the information provided to the athletes: the athlete zone; the upper right corner is the same for the judges: the judge zone. The two zones at the bottom of the front view are the remote (left) and local (right) spectator zones. In the middle of the model is the information accessible to any viewers. Each icon represents a specific source of information. Refer to Figure 9 for the legend.

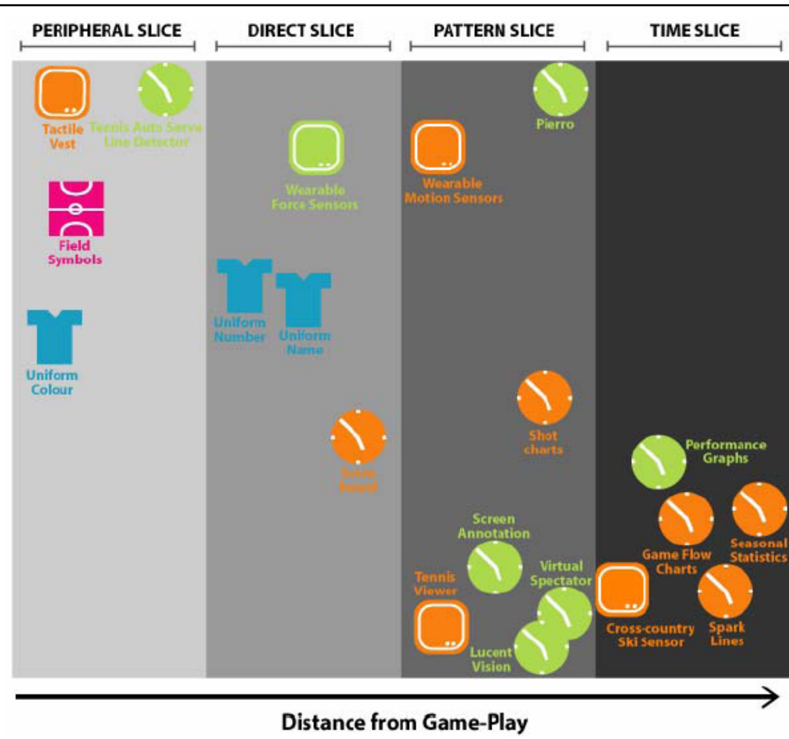


Figure 8: Loaf model side view (Page and Moere 2006)

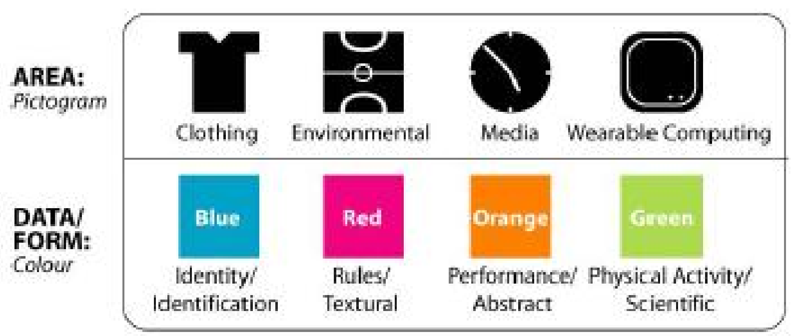


Figure 9: Legend for the Loaf model (Page and Moere 2006)

The side view (Figure 8 on the previous page) has 4 layers depending on the distance from the event. The icons represent at what moment the information becomes available and the time it takes to understand the visual clues. For a legend, refer to Figure 9 (on the previous page). Their main conclusion is that there are important gaps between the type and quantity of visual information available for specific kind of audience.

Some studies focused on the sports, other on the viewers, other on the technologies, the next section will present some results about the gender effect.

2.6. Gender differences

In addition to surveys for various sports, a study has been conducted in 1998 on students about their perceptions of sports (Sargent, Zillmann et al. 1998). The gender segmentation was used as a basis for the results. 94 females and 96 males answered the questionnaires.

Some of the conclusions from this study are that males and females have similar habits, opinions and perceptions about sports. However, there are some differences about what sports they enjoy and what sports they watch. While men enjoy and watch the most combative sports (Refer to Table 1 for a list of the categories), women watch them too but enjoy the most risky stylistic sports more. As for their perceptions, both men and women find the same sports boring: violent, active and elegant. Yet, while men find the violent combative team sports exciting, women pay more attention to risky stylistic sports. About the dangerous perception of sports, for men it is about violent combative team sports and for women about violent combative individual sports. Hence, gender is an important factor in sports and entertainment.

Combative violent team	**Combative aggressive team**	**Combative violent individual**	**Risky stylistic**	**Elegant stylistic**	**Nonrisky stylistic**	**Nonrisky mechanized**	**Active mechanized**	**Violent mechanized**
Football	Basketball	Boxing	Gymnastics	Diving	Swimming	Fishing	Hang gliding	Hunting
Ice hockey	Soccer	Karate	Skiing	Figure skating	Tennis	Golf	Mountain biking	Auto racing
	Baseball				Aerobics	Polo	Rock climbing	
						Archery	Scuba diving	
							Whitewater rafting	

Table 1: Categories and sports defined by (Sargent, Zillmann et al. 1998)

The past section presented the work done with a focus on the audience, sports and on TV screen information. Because the CIS is part of a complex IT infrastructure, I will explain the context in which it is being used. I will take the example of the Olympic Games, the biggest international sports event as example. Indeed, with many people involved, high technology, and lots of terminals (personal computer and CIS screens) all over the Olympics site, the challenges are very important.

2.7. IT infrastructure

Every two years, during the Olympic Games, a massive IT infrastructure is created and monitored over the total period of time when the Olympics occur. Once the event is over, an audit report is generated; it lists the technologies used, the main difficulties encountered, the successes and the key figures. I will be using these reports to present the environment the CIS is embedded in, and the high stakes such an event involves.

Studies conducted about the overall organization of the Olympic Games IT infrastructure have been published for some of the past events. Usually they focus on the resources used, the technologies involved, and the results obtained through data and feedback from viewers, athletes, and media (Hunter 2001; Takizawa 2001; Toftemo and Ekholdt 2001). Previsions for the upcoming games, at the time of this study, had been published too (Koulouris 2001). Though not the primary focus of these papers, some details and information related to the production, deployment, and use of the CIS is available.

Starting from the 1992 Summer Olympic Games in Barcelona to the 2004 Summer Olympic Games in Athens (Hunter 2001; Koulouris 2001; Takizawa 2001; Toftemo and Ekholdt 2001), the technical resources used in the Olympic Games organization have greatly evolved in quantity and quality over the years. The network architecture has gone from coaxial cable to optic fibers and the communication from wired to cellular. Furthermore, the number of people involved in the planning and organization of the Games is significantly growing (Hunter 2001), as is the demand for information during the events. Because some reports are issued prior to the end of the Games and without final statistics about the event (Koulouris 2001), they give an idea of the planning and the expectations for such international occasions. The focus seems to be mainly on the success of the Olympic Games from a local audience perspective and is not so much on the information delivered by radio or TV journalists.

To fully understand the impact of the IT infrastructure over a period of time of ten years, from 1994 to 2004, I will present a summary of the technologies used during 4 specific Olympic Games.

More than 10 years ago, in 1994, the resources used were not as advanced as they are nowadays (Toftemo and Ekholdt 2001) and the supplies were in smaller quantities. Most of the efforts were based on radio telecommunications when optic fibers were not very popular yet. The main difficulties the organizers had to face were related to the planning phase. Because scheduling starts usually several years before the Games, it is very difficult to have an accurate idea about the necessary type and amount of technologies / resources, the kind of equipment, and the investment without going over budget. Introducing new technologies is important but dealing with unknown issues can be a problem at the same time. A compromise has to be made.

For the 1994 Winter Olympics in Lillehammer, no complain was received, it was a success. Starting early enough was said to be the key point when planning such international events.

In 1998, again, the most difficult part was to plan the Games early enough to be on time (Takizawa 2001). Even with the statistics, feedback and experience received from the Lillehammer Games, having an idea of the resources needed was not easy according to the organizers. However, no real difficulties were noticed during those Games. Duplicating lines was crucial in the reliability area and the provision of high standard services. A lot of help from staff was available during the event to avoid technical or customer issues. Additional networks were used to complete the national network already set up prior to the event. The organizers observed that Internet Protocol (IP)-based services were probably going to be the next generation of technology that would suit the best the next Olympic Games. After those Games, the results were good and the feedback very positive too.

During the 2000 Olympic Games in Sydney, there were new statistical records due to new facilities, new technical equipments, more resources, and more people (Hunter 2001). These Games were very expensive but it was an overall success. The main difficulty organizers had to face was the amount of cell phones, which had increased significantly over the past few years. In addition to the Olympic Games, the event managers focused on providing equivalent quality of services for the Paralympics. Both targets were reached according to them. At the end of the events, the technologies that made their proofs for the next Games were the wireless connections, the video streaming via IP and the VoIP (Voice over IP), and the Internet among others.

The previsions for the 2004 Athens Games, made in 2000, were not complete yet when the report was released (Koulouris 2001) However some decisions had been made such as not using the wireless connections to access the network. The reason was mainly because of potential security risks. Again, the redundancy and backup were the keywords during the 2 weeks the event was scheduled. A lot of information was gathered from the previous Games to help the organizers to plan well in advance.

For these four Olympic Games, the techniques evolved and the lessons learned from the previous years were successfully used to organizing in the best possible conditions the next Olympic Games. Looking at some figures of the Olympics over a period of 10 years, we went from about 1,800 to 2,400 athletes and officials, from 9,000 to 22,000 volunteers, from 67 to 77 nations (IOC-2; Toftemo and Ekholdt 2001). About the IT aspect, the number of wireless lines went from 2,000 to 10,000 over 8 years; the kilometers of fiber optics went from 3,000 to 51,000 in counts over 6 years (from 1996 to 2002).

To understand the “big picture”, we need to see the density of the IT network during international championships. Figure 10 (Bassin, Biyani et al. 2002) represents the complexity of the Olympic Games IT network. Clearly a lot of data is going through the network from the venues to the central repository, which dispatches the data back to the Venue Results, and to the Information Management System (IMS). All the information is connected to the Venue Results entity as well, which acts as a major intermediate data conveyor. If one of these entities crashes, it is the entire system that stops working. As consequences, officials, athletes, scoreboards, or the CIS do not have anymore access to data which is very critical for this type of events. Among these entities, the INFO database where are stored the CIS data, and the CIS itself, which need to work properly as well not to impact the functioning of the entire network.

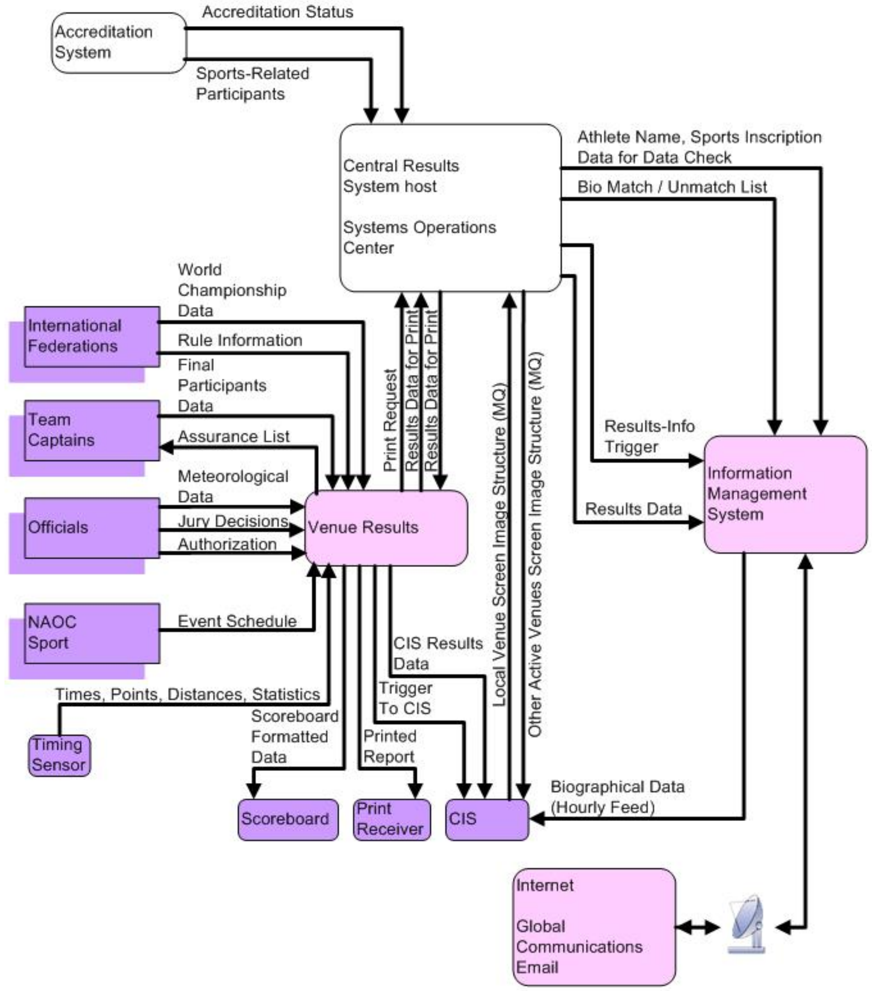


Figure 10: Overall IT architecture (Bassin, Biyani et al. 2002)

A few figures to introduce the CIS, although there are only a few statistical reports about the Olympic Games, which focused on the number of CIS terminals, which have been published. During the Winter Olympic Games there are about 500,000 past records, about 1,500,000 in summer; 8,000 biographical records in winter, 35,000 in summer, and 535 CIS screens in winter vs. 800 in summer (Bassin, Biyani et al. 2002).

Summary

A lot of studies are being conducted in different sports areas and with different goals, either focusing on the audience broadcasters have to deal with, or on the improvements related to technologies used for sports. However, few scientists have focused on the real needs of the audience before suggesting new products. The best example is the FoxTrax system (Cavallaro 1997), for ice hockey games, mentioned previously.

Probably one of the main challenges today is to combine high technology with sports that have been known and practiced for decades. There is a real challenge when adding new features to track the data and information about athletes, balls, etc. As a result, rules may have to change to match the new equipment and this can be welcomed, or rejected, by players and viewers. The most recent example is the line detector used during tennis games to know when a serve is in or out. Replays allow the remote viewers to see the exact impact of the ball, enhancing their interaction with tennis. On the other hand, new rules have been introduced to allow the players to challenge the “mechanic” judge. Some viewers may find it more interesting, others may think it alters the games and therefore the sport. As of today, no further research has been conducted to know how viewers, or other end users, feel about such drastic changes.

Lately, high-technology studies have been performed to analyze and store sports videos. With the Internet being so important and used world wide, sports media has to be accessible from everywhere and to everyone. As a result, videos have to be short, light and understandable. The other current well-used technology is the tracking system. With several cameras around the court, during tennis games for instance, it is now possible to keep track of the balls, the players and almost everything engineers in charge of these systems want. It provides dedicated tools to judge the games but also additional statistics and replays for online spectators. Additionally to this data, other visual clues already exist for judges, athletes, remote and local viewers but some gaps between each category still remain. Another difference in viewers’ sports preferences is based on gender. Men and women do not have the same interests in the sports they like watching and therefore do not have the same expectations and reactions to the information provided and the technologies used.

Games are also a new way to attract and entertain more viewers with interactive TVs. Finally, besides adding information, research focused on providing extra devices to users is getting more important nowadays and could be expended to more sports than tennis or NASCAR for example.

When some of the studies deal with entertainment, other reports are more technical and with higher stakes like those provided by the IOC for the Olympic Games audit. The environment in which the CIS is embedded is very complex and does not allow a lot of flexibility. Everything has to be working perfectly; there is no space for error.

As seen, results have been found about viewers, judges, athletes but not much about media staff and especially journalists. This thesis gives a first idea about what they do, how they work, and explain the functioning of the main system they use, the CIS, to perform their work and some of its shortcomings.

3. Background

To understand the high stakes of the CIS use and the reasons why this system needs to be reliable, I will be presenting in this chapter the investments broadcasting companies make to use the CIS. I will give a brief overview of the journalists' work conditions and finally a description of the CIS itself.

Nowadays sport events are global events. It means companies have to send journalists almost everywhere to cover international sports championships. Investments and expenses are high and they need to be worth it; that is why usually not many commentators, from a company or country, have the opportunity of being in the stadium using the CIS and watching the events live (Figure 11). For some broadcasting companies with low budgets, sending journalists on site is not something they can afford. To understand why using the CIS in a stadium is a privilege, I am going to detail what it implies.

Figure 11: Journalist using the CIS in a stadium

First, the broadcasting company needs to send abroad, most of the time, an entire crew: technicians, representatives, journalists, etc. Then, they have to set up an office to run their TV or radio news. Since it requires several days to build this temporary office, most of the crew members in charge of its construction have to be on site well ahead of time. They also need time to test it and be ready when it will be live. Additionally, for the journalists, to be in the stadium, the broadcasting companies have to rent the specific number of seats they want to use during the entire event. Finally, the use of the CIS itself is not free of charge, the broadcasting companies have to rent it (about $3,000 for 2 weeks) for the entire event as well. All this is necessary because the CIS is an essential tool for the journalists' work and is only available on site. Hence companies with lower financial resources prefer reducing their expenses by hosting the journalist outside the stadium, like in a private booth; however if the CIS was available remotely this could be done from home. These are the reasons why the CIS is very expensive to use and why it requires an important investment from the broadcasting companies.

3.1. Work conditions

Journalists cover many sports events every year and they do not always have time to be aware of the latest results from previous competition due to time constraints. Despite the fact that the CIS is available only on site and just a few days before the events start, the journalists are expected to be ready and to do a good job. If they want to become familiar with the system, they have to use it on their own during their free time before the event starts. A couple of CIS are in the broadcasting companies' main offices, free to use. However, those in the stadium are forbidden to access until the beginning of the championship. Additionally, no training is offered, no documentation provided, and if users need help, they have to ask the developers, who are not usually on site. All these disadvantages make the task difficult for journalist to completely understand the system.

Figure 12: Journalists in a stadium (Atos-1)

As you can see on Figure 12, journalists' work environment can be chaotic. On their desk they have the CIS, a TV monitor, several guide books, large files with many loose sheets full of their own notes, additional papers spread all over their desk, and for some of them one or two laptops. In addition, they need the required broadcasting equipment: microphone, headset, broadcasting commuter, etc. Everything has to fit on one desk used by two journalists usually working for the same broadcasting company. Figure 12 and Figure 13 (on the next page) illustrate the space journalists have next to each other and how noisy it must be since they are all commenting out loud at the same time. The number of journalists per square foot is very high and makes it even more chaotic. Moreover, during the Winter Olympics, they have to stay for hours in outdoor stadiums with a below zero temperature. A basic example is during the opening and closing ceremonies, which lasts for hours, when they have to comment almost without any breaks. Given that it is an outdoor event, light becomes an issue when the events continue after sunset. Figure 13 shows the regular conditions for the 2006 Winter Olympic Games in Italy for the Opening ceremony.

Another important issue is the way journalists work for companies. Because it takes time to get used to the pressure, the audience expectations, the amount of information, etc. the career

Figure 13: Journalists working outside (zol.com.cn)

of commentators is very long and typically lasts until they retire. As a result, broadcasting companies have few employees who are expert in commenting, they do not hire many live commentators and they do not have to pay for training sessions. Since journalists bring their own documentations, extra sources of information or any other personal data with them (Midy, Jensen et al. 2007), their companies rely a lot on them. Indeed, it would be very difficult to hire new journalists and ask them to use other commentators' own notes. As explained, work conditions are quite difficult for media staff; the system they are provided with has to be 100% reliable because it is the only one they have. Indeed, they cannot afford to have their mind on technical issues when they already have to deal with many external factors and live events.

We saw the conditions the journalists have to deal with and where they use the CIS. In the next section I will present the system and its main characteristics.

3.2. The CIS functioning

The CIS is an LCD touch-screen system, it means users do not have a pointing device but use their fingers to browse the different screens. By touching a name, a country, a sport, or any other buttons, they display real time information such as live results, start lists, heat results, ranking, biographies, past records, weather conditions, etc. In one CIS, all these categories are available for each discipline and users can bring up to 500 different screens.

The CIS operates on an intranet-based network (application based on Java and multiple layers of hardware and software). During events such as the Olympics, it enables more than 1,000 broadcasters, journalists and other media staff to access the main server to retrieve both real-time and archive information. Indeed, the system uses the XML messages, containing all the event statistics, sent to the main database, called the INFO database, with 0.3 second delay. The sensor technology is used to providing external information, such as weather conditions, and most venues are wired and send constant flow of data to the main server repository.

The CIS is not only used by commentators but also by broadcasting directors, who position cameras based on the athletes likely to be in winning positions. In addition, TV editors rely extensively on its results when working on the sports section for the live news. Hence, the CIS is used both inside and outside the stadium.

For such event as the 2006 Winter Olympic Games a new version of the CIS was available to journalists. With 15 disciplines, 18 venues and over 2 weeks, 260,000 XML feeds were provided to allow the 929 CIS terminals to retrieve sports information. For the Summer Olympics, the number are even higher (Bassin, Biyani et al. 2002). This is why the amount of data, the hardware used and the entire IT architecture is very important and complex.

If we look at the Olympic Games network from a higher lever, we have the Figure 14 (Atos-2). It shows that the CIS is directly linked to the Central Repository that stores all the data (Biographies, Venues Information, Historical Results, etc.) as well as a live feed coming from the venue results.

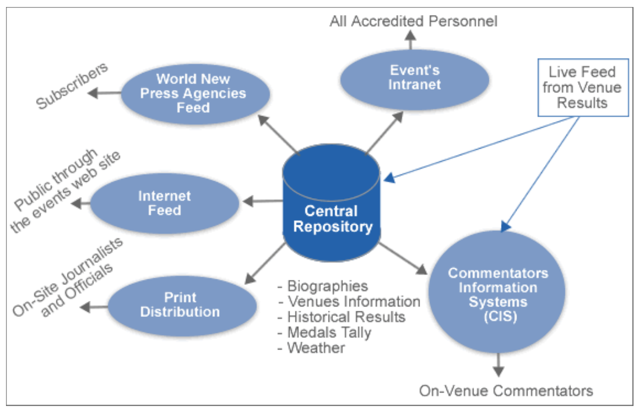


Figure 14: Information diffusion network (Atos-2)

For more details, we need to refer to Figure 15 (on the next page) already explained in the previous chapter through Figure 16 (Bassin, Biyani et al. 2002), (on the next page). I simplified that network diagram to only focus on the CIS. The first thing we notice is that the CIS is linked to a central server that dispatches the data to the Venue Results and to the Information Management System. The system is getting a lot of information from various sources; furthermore when we know the number of XML messages fed to the CIS during the 2006 Olympics, we can imagine the amount of data such a network is dealing with during a period of 2 weeks.

Because the stakes are very high, the journalists' work conditions very difficult and the IT network very complex, users have high expectations about the CIS functioning. In the next section I will show some of the CIS screens to introduce the layout of the system.

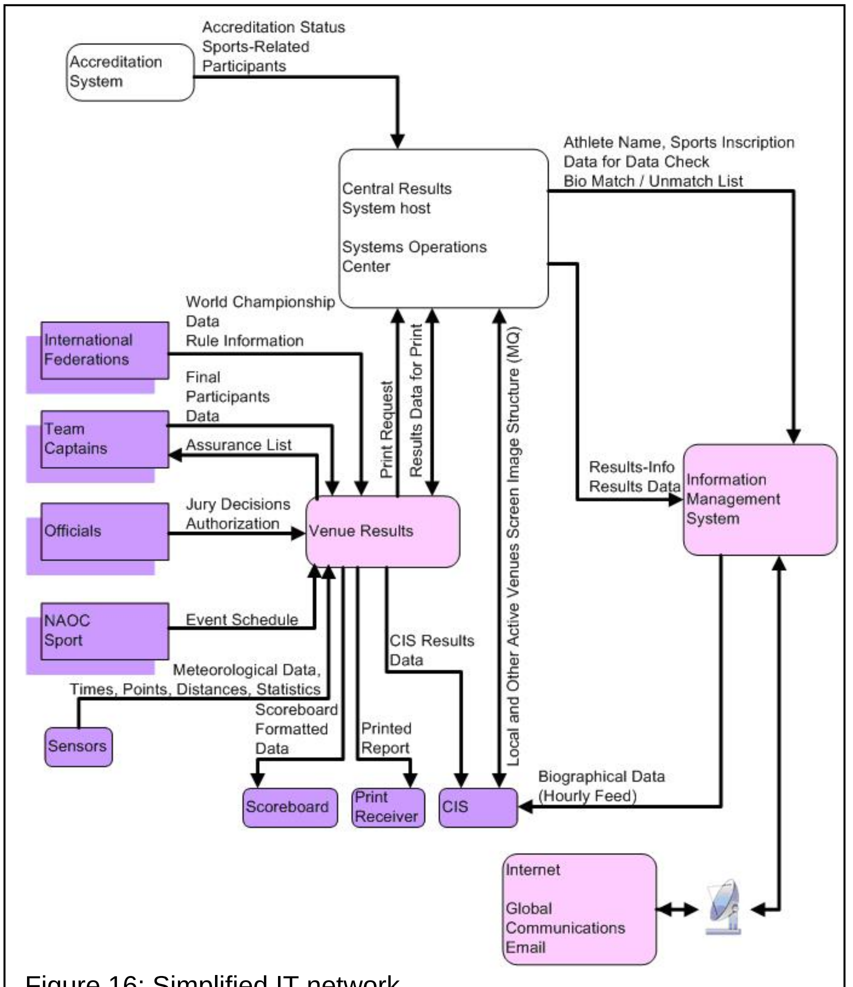


Figure 16: Simplified IT network

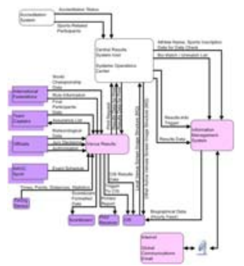


Figure 15: IT network (Bassin, Biyani et al. 2002)

3.3. The CIS interface

We saw the significant number of CIS screens, sports, venues, etc. and what the main network entities the system was linked to. In order to relay the information to the users, the developers provided an interface with color, icons and tables to display the results. Figures 17 and 18 (on the next page) are two major screens; Figure 17 is the Home screen with the different disciplines available; Figure 18 is a shooting results screen during a biathlon event

When the CIS starts, the Home screen is the default screen. Depending on the current sports, some of the buttons may be disabled (light blue) or enabled (dark blue). For instance, on Figure 17, only the Snowboarding events are on-going at the time of the screen capture; hence, only the Snowboarding icon is enabled. The Sports icon is also enabled since it lists all disciplines scheduled for the day. When the user presses the Snowboarding icon, it brings the snowboarding schedule on screen.

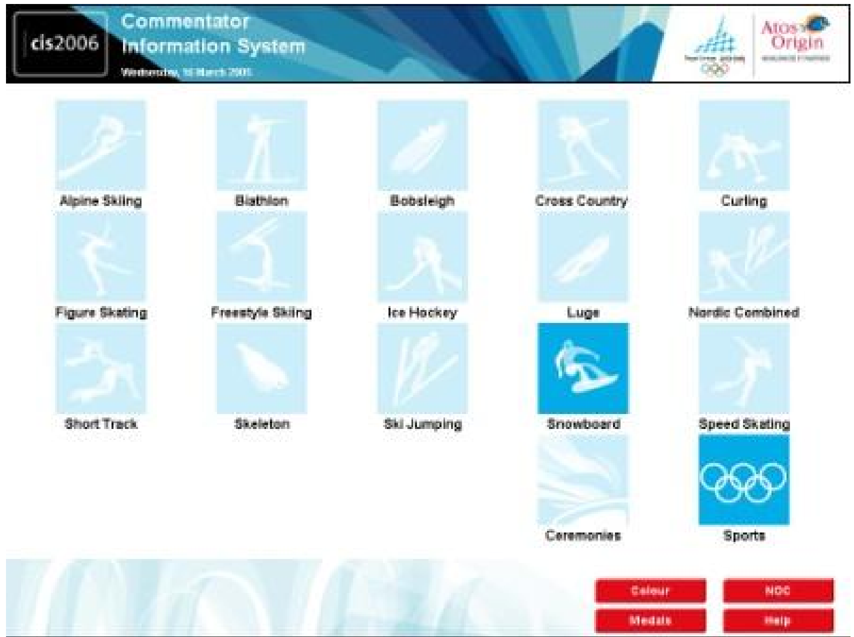


Figure 17: Home screen of the 2006 CIS (Atos-8 2006)

Figure 18: Results screen of the 2006 CIS

Once athletes score, cross a check point, have penalties, or when a game ends, live results are sent to the INFO database in real time. At that time, the information is available in the CIS and can be displayed by pressing the adequate buttons. On Figure 18 is the shooting results page for a biathlon event. Usually the same layout is found for every discipline: extensive use of large tables full of data. When the users want to go to the bottom of the tables, they have to scroll down with their fingers using the scroll bars on the right of the table. Depending on the sport, event or stage of the competition, different navigation buttons are available on the screens like those at the bottom of Figure 18 (in white, blue and red from left to right).

I will go into more details about the CIS interface and its functioning in my design analysis chapter.

Summary

We have seen the technical and financial constraints broadcasting companies have to deal with in order to use the system in the best environment possible. Unfortunately not all the companies can afford it but for those who can, the journalists’ work conditions turn out not to be ideal. The CIS is the only source of information provided by the event organizers; it encompasses a lot of data but is only available on site. When commenting live results, journalists need to rely extensively on this system, as a result the system needs to be reliable, easy to use and up to date. These key points will lead to the next chapter which will cover some of my research questions about the system, its functioning and how the journalists take advantage of such a powerful tool.

4. Scope / Hypothesis

Based on feedback from the users of the Commentator Information System, some research questions presented themselves. This chapter gives an overview of the questions and my approaches to answering them

4.1. Does the system meet users' needs?

In order to answer this essential usability question, I will ask three more detailed research questions. I will use a theoretical analysis to answer all of them and I will confirm my findings with a field study.

4.1.1. Is there an information overload?

Given the complexity of such systems and the cognitive load of users, I wanted to know if there was any information overload. Indeed, with so many disciplines and so many athletes the amount of data the CIS has to display is colossal. Each screen has to display a lot of information and as a consequence, the users would have to look at screens full of results, which would lower their efficiency in finding a specific score, time, etc. during their browsing experience.

Approach

In order to answer this question, I re-created the screens mockup of the CIS for biathlon, ice hockey, and ski jumping. For each event per discipline, I linked all the screens together using arrows from a button to the mockup it displays. Doing so, I had a mapping of the entire event and knew how to navigate through the different screens. This was a way to see the amount of information on screen as well as the options the users had to go from one screen to another. To compute the time it took the journalists to process the information or to make their decisions based on the number of links or buttons, I used Hick's law. Finally, to study how the users behaved with the system and dealt with the amount of information on screen, I went to Sweden to conduct an ethnographic study during an athletics European championship.

4.1.2. Are there any navigation issues?

A lot of information is displayed by the CIS and therefore it needs a lot of screens connected together. Hundreds of screens are available to end users and so many paths could get them confused. If the journalists spend more time on finding the correct screen than on commenting, they probably will not even try to find this screen. They need a quick access to specific information without having to deal with other navigation issues

Approach

With a similar approach as the information overload study, I used the screens and their mapping to analyze if it was easy to go from one screen to another. This time, I looked at Fitts' law (Preece, Sharp et al. 2007) to compute the access time it took to the journalists to select a specific link, a specific button. I added Hick's and fitts' times to know the total time it took to the users from making their decision to actually selecting any buttons. To backup these first results, I took advantage of my ethnographic study in Sweden to observe the journalists doing live their job to see if they encountered any navigation issues.

4.1.3. Is there enough information?

The CIS is said to be a real time system that commentators rely on for their live commentaries. If the system gets delayed, no live information is available to journalists anymore. If they do not have any other sources of information they cannot do their job. Because the data sent to the CIS comes from sensors and other complex systems, if one of those stops functioning, or if it is not set properly to send the information as soon as an athlete scores but after a period of time for instance, information gaps can occur.

Approach

To answer this question, I studied the XML messages, which are the records stored in the database queried by the CIS, and I looked at their formatting and their content. To know if the types of comments the journalists were saying were stored in the system, I took notes of the content of their comments. To know the source of their commentaries, I transcribed the content of videos from the same sports events and mapped the sports actions, the on TV screen information, and the comments to the XML messages – therefore to the CIS data, according to the exact same reference time. As a result I had what the commentators were saying, what was available, when and if they had to rely on additional source due to information gaps. Finally, the ethnographic study was also the occasion for me to observe how the users were dealing with these gaps if any.

4.2. When do users make mistakes?

Due to pressure, stress, and live conditions, journalists have to browse the system very quickly. For instance, if the navigation buttons are too close to each other users can make mistakes and they waste time. Because a lot of screens are available and a lot of data is conveyed to the commentators, mistakes are likely to happen.

Approach

To identify why, when and using what screens, I conducted a controlled experiment to force the subjects I recruited to make use of the different screens of the system under pressure and when multitasking. This way, some of the journalists' work conditions were replicated and I would know some of the shortcomings of the CIS in this specific environment.

4.3. How do the users deal with these mistakes?

If users make mistakes, they need to recover from them. It means spending even more time using the system than doing their job. If the CIS has major drawbacks, the mistakes are going to be common and the fact that journalists may have to deal with them is very likely.

Approach

To have an idea of the options the end users opt for while using the CIS, I videotaped the entire experiment, I recorded the screens participants used during the session as well as their reactions when making mistakes. Even though the subjects were not journalists but students, I felt studying their behaviors and solutions to errors they made, when browsing the CIS in difficult conditions, would give me an idea of what journalists might face in their work.

4.4. How to customize the interface for a better usability?

If the results of the analysis show that there are major navigation issues, information overload, etc. the interface of the system needs to be improved. Depending on the quantity of negative feedback received from users' experience, the CIS may have to change drastically.

Approach

To know what aspects of the CIS to improve, what is good and should be kept, what is not convenient and should be fixed, subjects from my experiment had a chance to express their opinions and their suggestions about the overall system. Also, based on the analysis of the participants' behavior, it gave me some guidelines on what features they liked to use, what made them struggling, or what navigation pattern they followed.

Summary

Table 2 (on the next page) gives a summary of the questions and methodologies I used during my study to investigate these questions.

Question \ Approach		Design analysis: Screen mockup	Design analysis: Mapping	Design analysis: Hick / Fitts	Content analysis: Data (XML) analysis	Content analysis: Audio analysis	Content analysis: Video analysis	Experimental analysis: Ethnographic study	Experimental analysis: Controlled experiment
Does the system meet users' needs?	Is there an information overload?	X	X	X				X	
	Are there any navigation issues?	X	X	X				X	
	Is there enough information?				X	X	X	X	
When do the users make mistakes?									X
How do the users deal with these mistakes?									X
How to customize the interface for a better usability?									X

Table 2: Research questions and approaches

I decided to divide this table into 3: the design analysis, the content analysis and the experimental analysis. These are the three main methodologies I used to gather and analyze my data. The content analysis ended when I found my first interesting results that led to new research questions. The experimental analysis was a method to confirm what I had studied and found during the previous analysis phases. With the two experimental studies, I was able to answer all the research questions asked from the very beginning of my study. The next chapters will describe each analysis, their methodology and results.

5. Design analysis

As part of my theoretical analysis I focused on two things, the design/layout, and the content of the system. In my design study, I paid more attention to the layout and presentation of information, including the number of screens available to commentators for each discipline / event, and the navigation between the screens.

To examine the effectiveness and usability of the Commentator Information System, I approached several major European broadcasters, as well as the providers of these systems at two major sporting events: the Turin, Italy 2006 Winter Olympic Games (10-26 February 2006), and the 2006 European Athletics Championships in Gothenburg, Sweden (6-13 August 2006). While two different systems were used (developed and administered by Atos Origin (Atos-1) and ST SportService (SportService 2007) respectively), with a different set of sports in mind, the basic design and usability concepts examined in this study were comparable.

First I focused on the 2006 Winter Olympic Games. Since I started to study the CIS in September 2005 and the next Olympic Games were in February 2006, it gave me enough time to understand how the system worked and to be ready to study the real version when available.

During the Games in Italy, 80 nations were represented, 2,508 athletes competed in 15 disciplines, and 7 sports (IOC-4) over 84 events were held during the 16 days of the competition (refer to Appendix 1 for a list of disciplines and sports). With such figures and an event known all over the world, the results gathered from the study of its CIS would be relevant enough to be used for other Commentator Information Systems.

Because I had to conduct a thorough study of some of the disciplines, I decided to focus on 3 of them to limit the amount of work. Among the 15 disciplines (refer to Appendix 1) I opted for biathlon, ski jumping and ice hockey. I made this decision because they are quite different from each other. Indeed, they have varying degrees of CIS information and complexity in terms of CIS screens and messages (from high to low respectively) but also because ice hockey is a team sport whereas biathlon and ski jumping are individual and team sports. Table 3 (on the next page) is the list of events for biathlon and ski jumping; ice hockey just has team games.

Type of event \ Sports	Biathlon	Ski Jumping
Team	Relay	Large Hill Team Jump
Individual	Individual	Large Hill
	Mass Start	Normal Hill
	Pursuit	
	Sprint	

Table 3: Lists of events for 2 disciplines: biathlon and ski jumping

These three disciplines have drastically different number of events too. For instance biathlon has ten events, five for men and five women, while ski jumping only has three events, only for men, as listed above. Ice hockey is different since it only has 2 events, one for men and one for women, but with 58 games total. This broad variety of disciplines and games gave me enough types of events as basis for my study. Note that the ski jumping discipline does not have a women's competition.

Except the number of events for each discipline, there are differences in terms of their nature. Ice hockey is practiced indoor and is more of a contact sport with a lot of actions; biathlon and ski jumping are practiced outside, and take hours or couple of minutes, respectively, for one round. With these differences, the comments from sports journalists, the information they need, or the data they use during their live commentaries, may differ significantly.

Based on the different events happening during the 2006 Winter Olympic Games for biathlon, ski jumping and ice hockey, I knew approximately the number of CIS screens I would have to re-create in order to understand the functioning of the system. Therefore, to know the global overview of each CIS screen, I used the official specification documentations (Atos-3 2004; Atos-4 2005; Atos-5 2005; Atos-6 2005; Atos-7 2005) provided by Atos Origin and I designed the mockups.

5.1. Screens mockups

Since there is one CIS per sport events like the Olympics, it receives an important amount of data and everything has to be displayed. It represents hundreds of screens, available at any time, which journalists can browse while commenting. The next paragraph will focus on the CIS screens mapping for biathlon, ski jumping, and ice hockey, and later I will argue on if having that much information is convenient for the users or not.

5.1.1. Methodology

The main reason for why I decided to re-create some of the CIS screens was because in fall 2005 the 2006 Olympics had not happened yet and no screenshot, or picture, of the system had been released at that time. To be able to manipulate and interact with the system prior February 2006, start date for the Olympics, I decided to design the CIS screen mockups. I received copies of, and analyzed the design and implementation documents for the Turin CIS. Since these records came directly from the developer, Atos Origin, and the International Olympic Committee (Atos-3 2004; Atos-4 2005; Atos-5 2005; Atos-6 2005; Atos-7 2005), they were the most accurate and detailed available at that time.

The methodology I followed was first to read the entire documentation for the general screen definitions (Atos-4 2005). It provided me with the main frame of the CIS screens (Appendix 2) and with the buttons users have to click on to go from one screen to another (Appendix 3).

The next step was for me to know the content of each screen. I looked at the biathlon (Atos-5 2005), ski jumping (Atos-7 2005), and ice hockey (Atos-6 2005) specific documentations, which were available during the implementation phase to help developers to find information about the Turin 2006 CIS before it became available in February 2006; these records gave me an idea of the global results layout. For example, in order to re-design the Start List screen for the biathlon individual event, I had to refer to the

2.2.5 Start List

The type of start used for the Biathlon events varies; therefore, a number of start lists are necessary.

Note that the Biathlon start lists are similar to, but not exactly the same as, the Cross-Country start lists.

2.2.5.1 Individual Start List (BTS1)

The Individual Start List is used for all individual Biathlon events.

ID	Screen Name	Number of Entries	Sort Order
BTS1	Individual Start List	All Competitors. Visible: maximum possible. Scrollable.	Start Order

ID	Category	Data Elements	Headers
BTS1	Individual Start List	Athlete Status: 'ghost' column Display if status is DSQ, DNS or DNF.	<none>
		Athlete Information	<none>
		Only for Interval Start: Start Group	Start Group
		Bib Number	Bib No
		Athlete Name: an asterisk (*) is moved in front if the competitor is under review for possible disqualification or time adjustment.	Name
		NOC Code	NOC
		Age: An asterisk (*) is appended to the age if the current date is the competitor's birthday.	Age
		Start Time Pursuit Start Time: displayed as 0:00 for first competitor and as a Time Behind for the subsequent competitors, e.g. 0:00, 0:15. Interval Start Time: actual start time, e.g. 13:00:00, 13:00:30.	Start Time

<u>Results Shading – Columns</u>

Results Shading N/A

<u>Temporary Highlighting – Fields</u>

Rank Highlighting N/A

Result Highlighting N/A

Current Highlighting Bib Number

Figure 19: Explanation for the biathlon Start List screen (Atos-5 2005)

Figure 19 (on the previous page) and Figure 20. I looked at the same information for each of the three disciplines in order to know the mapping of the screens belonging to each specific event. Using these documents, I produced full-scale mockups of biathlon and ski jumping, and a team member created the ice hockey mockups.

Start List

	Start Group	Bib No	Name	NOC	Age	Start Time
	1	1	Frode Andersen	NOR	23	13:00:30
	1	2	Guenther Dengg	AUT	---	13:01:00
DNF	1	3	Pier Alberto Carrara	ITA	---	13:01:30
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---
	---	---	-------	---	---	---

Figure 20: Content of the screen called: "Individual Start List (BTS1)" (Atos-5 2005)

Note: For a comparison between the real CIS screens and my mockups, refer to the section 5.2.2, Figure 25 and Figure 26.

5.1.2. Results

As explained previously, I used the Appendix 2 and Appendix 3 to know how the main frame looked like and I came up with the Figure 21.

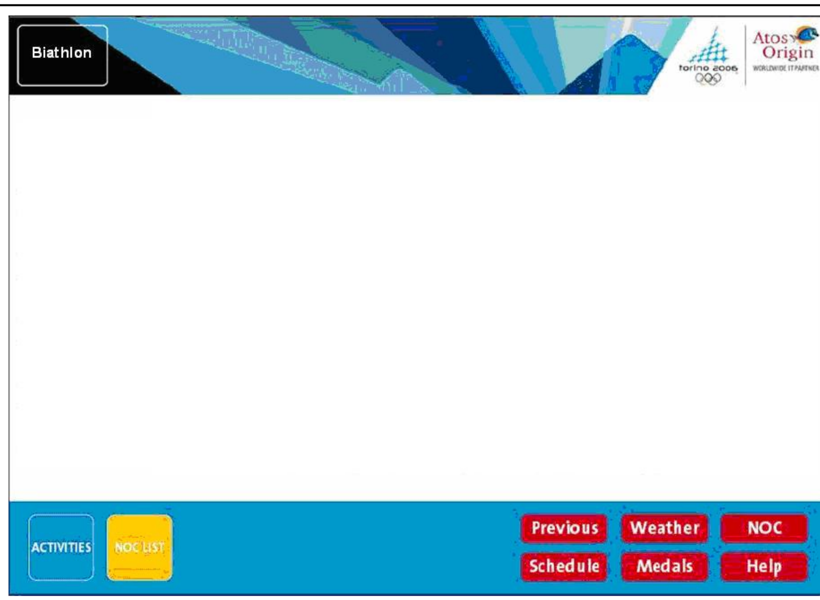


Figure 21: Main frame for the CIS mockup

At the top of it is the general header with the developer's logo in the upper right corner, the Olympic Games logo next to it and at the left end is the name of the current sport being displayed, biathlon in this example.

The footer is made of 8 navigation buttons; 2 on the left (Activities in blue and NOC list in yellow) and 6 on the right (Previous, Weather, NOC, Schedule, Medals, and Help in red). These links are recurrent for every sport screens. Once I had the main layout, I needed to customize it for each of the three disciplines.

In the case of biathlon, I needed to know how the information was organized between the header and the footer: the blank area on Figure 21 (on the previous page). I referred to the Appendix 4, specific CIS documentation for biathlon, and according to the different events I was able to organize the CIS layout. Figure 22 represent the different tables and buttons. There are three types of data on the screen: the full results (the two main tables, marked as 1), the time of the 4 last athletes (the tables at the bottom, marked as 2) and the four first leaders (the table in the upper right corner marked as 3). These tables come from (Atos-5 2005) for biathlon; using (Atos-6 2005) and (Atos-7 2005) for ice hockey and ski jumping respectively I was able to produce the other mockups for these disciplines too.

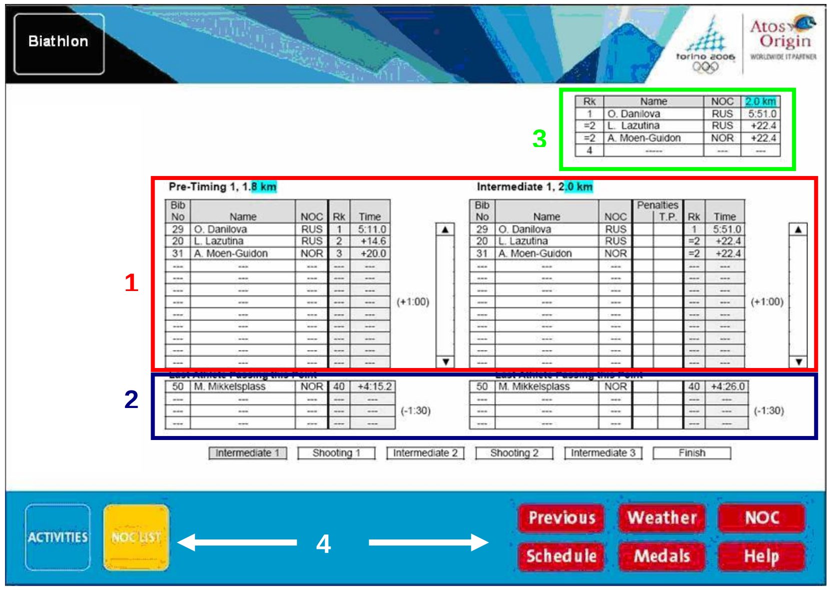


Figure 22: CIS mockup with biathlon results

I was still missing some links to go from one result screen to the start list for instance. Using the documentation, I noticed the screens were organized in categories, 5 for biathlon: Start List, Progress, Shooting, Custom View and Classification. Because no specific

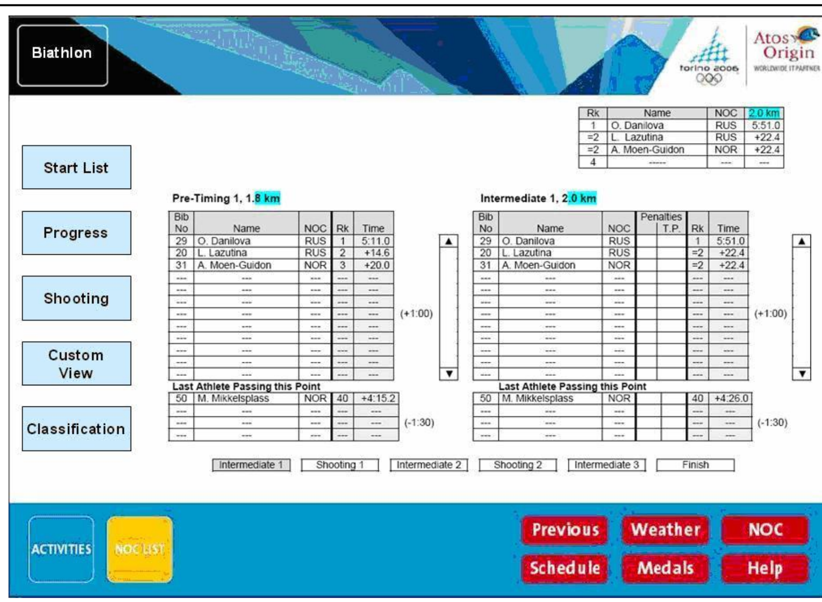


Figure 23: Final CIS mockup for biathlon

information was provided about where these buttons were supposed to be and since height buttons were already at the bottom of the screen in the footer (refer to white arrows marked as 4 in Figure 21), I made the assumption the additional buttons were on the left side of the screen. As a result, Figure 23 is the final mockup screen for biathlon.

I followed the same steps for every event for each three disciplines, and due to their different complexity, the number of screens went from 2 to 11 per screens mapping. I excluded the Home and Schedule screens in my count since they are on every sports mapping. As a result, I re-created a total of 94 screens for only 3 disciplines. Tables 4 and 5 (below) and Table 6 (on the next page) show a screen summary for biathlon, ski jumping and ice hockey respectively.

Sport / Type of event	**Biathlon**	
Team	Relay	11 screens (Appendix 5)
Individual	Individual	8 screens (Appendix 6)
	Mass Start	9 screens (Appendix 7)
	Pursuit	7 screens (Appendix 8)
	Sprint	8 screens (Appendix 9)

Table 4: Screens created for biathlon

Sport / Type of event	**Ski Jumping**		
Team	Large Hill Team Jump	Trial	4 screens (Appendix 10)
		First round	6 screens (Appendix 11)
		Final round	6 screens (Appendix 12)
Individual	Large Hill & Normal Hill	Training	2 screens (Appendix 13)
		Trial	2 screens (Appendix 14)
		Qualification round	4 screens (Appendix 15)
		Competition first round	4 screens (Appendix 16)
		Competition final round	4 screens (Appendix 17)

Table 5: Screens created for ski jumping

Type of event \ Sport	Ice Hockey	
Team	Preliminary round	9 screens (Appendix 18)
	Play-offs	10 screens (Appendix 19)

Table 6: Screens created for ice hockey

Note: Ski jumping has only two events, individual and team, whereas I stated there were 3 events total. This is because the Large Hill and Normal Hill events share the same screens. Also, these numbers are not the total number of CIS screens available for each event but only the main types of screens. For instance, if we take into account every possible screen for the biathlon relay, it goes from 11 to 48 (Home (1), Schedule (1), Start List (3), Progress (24), Shooting (8), Custom. (8), and Classification (3)). Since I followed the same procedure for each discipline, it will not affect the rest of the study on the number of screens per discipline.

The first thing that we notice is the amount of information on a screen. Although the screens are just mockups and the real CIS may slightly differ, several tables are used with many rows to display lots of data at once. When it seems a good idea at first, it can be confusing for the users. Indeed, due to an information overload, the system looses some of its efficiency in terms of scanning quickly a screen to find a specific result for instance. As a result, this makes the navigation tedious for the journalists based on the amount of data on the CIS display, and based on the number of screens some events have.

We saw the number of screens provided for each discipline. It is rich in content but difficult to read. The other concern is the navigation between all the screens. If they are so many and if on each of them is a large number of buttons, then the browsing experience of commentators might not be satisfying.

In the next section, I will focus on the CIS mapping and the different paths that exist to go from one screen to any other screens within each discipline.

5.2. Screens mapping

5.2.1. Methodology

In order to know how to reach a specific screen, how long it takes the user to go from one screen to another, if it is convenient, if it is easy, etc. I linked together every screen from each single event. To do so, I used the same documentation as mentioned above for biathlon, ice hockey, and ski jumping (Atos-5 2005; Atos-6 2005; Atos-7 2005). My goal was to answer one of my research questions about the navigation issues. With such a mapping, I would be able to see if the navigation was complex or if reaching any of the screens was straightforward.

The information I referred to (Appendix 4) indicates the links, or buttons, available to users and the screens they display. To facilitate the work I used Microsoft Visio, I was able to connect every screen and their links / buttons to any other screens.

5.2.2. Results

Using the official documentations I connected the screens in order to get a sense of the information architecture. I wanted to know what options, or different paths, the journalists would have if they wanted to go from the home screen to the second result screen for instance. Also, I wanted to know what sequence of screens they followed and on what factors their made their navigation decisions.

For a competition like the Winter Olympic Games where each of the 15 combined disciplines features an important number of events (236 total), there are a lot of distinct screens in the CIS and the number per event is very high. Already listed in the previous section, there are about 8, 16 and 9 screens per event on average for biathlon, ski jumping and ice hockey respectively. Because it was difficult to fit 16 screen mockups on the same page, I subdivided some of the ski jumping events into smaller mappings. Appendices 5 to 19 represent the CIS maps with arrows as links from one screen to another (an arrow starting from a button going to a screen).

If we study more carefully the biathlon relay mapping for example (Figure 24 on the next page) we see the different screens available for this single event. One of the most surprising findings is the flatness of the CIS page hierarchy. Obviously designed for speed of access, it is possible to navigate directly between most pages once the user reached one of the different categories (Start List, Progress, Shooting, Custom View or Classification for biathlon. Refer to the yellow areas on Figure 24).

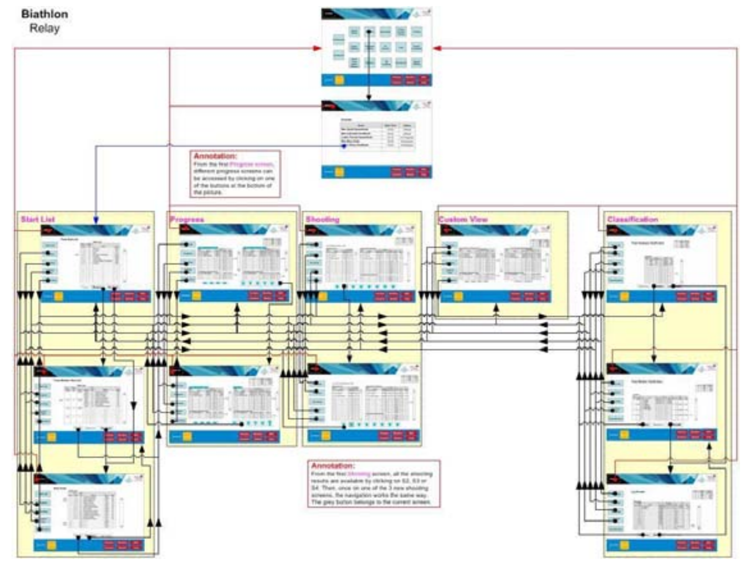


Figure 24: Mapping for a biathlon relay event

While this may initially seem like a good design decision, it may be not an ideal choice given the mental load of the user. The amount of screen clutter and available options may, in this case, outweigh any gain. Even if it is good from an efficiency perspective, the users can access about anything they want from anywhere, it is not convenient from a usability perspective, too many choices implies more time to make a final decision.

With this amount of options and possible links on a single screen, there is an information overload problem as mentioned in the previous section. Additionally, it is difficult to make the distinction between the screens, and what the most efficient path to reach them is. For biathlon for instance, the screens from each of the 5 categories look all alike, making even harder the task fore the journalists to identify what screen they reached. This is a major problem for a system that should be accessed quickly and without processing mentally any information.

I also noticed that the global overview of the CIS maps were quite similar in terms of layout for each of the three disciplines. Usually a lot of screens are accessible from the main page and only a few layers follow. This makes the browsing experience rather difficult for the journalists.

At the time of this specific analysis the Olympic Games just started and I was able to have a look at the real CIS screens used during the 2006 Turin Games. Although it did not change the results and navigation paths I found, I decided to base the rest of my study on the real screens for a matter of accuracy.

Note: The mockups based on the documentation were quite accurate. I only noticed a few differences between the mockups (Figure 25 on the next page) and the real screens (Figure 26 on the next page). The first difference was where I put the navigation buttons (Refer to the red boxes on Figures 25 and 26). When I assumed the buttons were on the left of the screen, they were actually at the bottom, in the footer area, in place of the 2 buttons that were in the left corner. The second dissimilarity was where I put the leaders table (Refer to the red circles on Figures 25 and 26). The small summary table, instead of being in the main white area, between the header and the footer, was in the header.

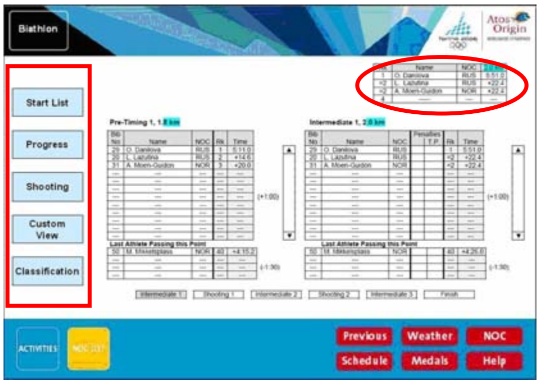


Figure 25: CIS mockup

Figure 26: Official CIS screen

After I had my mapping completed, I focused on the time required to use such a system in terms of decision making and in terms of selecting a specific screen. Indeed, I started to mention the time it takes for users to make a decision, but the time to actually select the target is also important since we are dealing with a real-time system. Thus, in the next section I am going to focus on the processing and selecting times. To do so, I used some of the predictive models suggested by (Preece, Sharp et al. 2007).

5.3. Analytical evaluation: predictive models

Once I had identified the hindrances users might have when browsing the CIS screens, or when scanning a single screen to find a specific link or detail, I wanted to know exactly how long it took them to make their mind and then how long to actually perform their action. Hick's and Fitts' laws give respectively estimations to both questions. They predict the time users spend to process information and to select a specific target based on several factors. My goal was to analyze if significant variables could influence journalists' work.

5.3.1. Hick's law

5.3.1.1. Methodology

The CIS is a real time system, which is supposed to provide information about current events in under 0.3 seconds. If the system is not reliable, too difficult to use, or if it takes users too long to find the information they need, the system is useless. To determine the time it takes users to make decisions about where to go to, what links to click on, what screens to display, I used Hick's law. This formula is designed to compute the time it takes a user to process the information and make a decision based on the number of options (links, buttons, etc.) available.

The formula is the following:

$$T = b\log_2(n+1)$$

Where: *b* is a time constant (*b* ~ 150 ms)
n is the number of options
T is the time it takes for users to make their mind

Note: The *b* constant varies from one user to another. I was not able to test journalists for this study. I therefore decided to use 150 ms for my calculus, knowing that this factor is typically between 100 ms to 200 ms. Hick's law is intended for use when users are focusing on the task and not distracted by external factors. Hence, the time found will be a lower bound.

5.3.1.2. Results

As explained above I computed the average time *T* for each screen of a specific event. I decided to focus on the most complex event, which is the relay in biathlon, since it has many athletes, several loops, intermediate times, and a lot of shooting results. The number of screens used for its mapping is the most important among the different disciplines.

I focused on screen categories: Start List, Progress, Shooting, etc. (Figure 29 to Figure 31) and I found some interesting results summarized in Table 7 (on page 43).


Figure 27: Start List screen


Figure 30: Custom screen


Figure 28: Progress screen


Figure 31: Classif. screen


Figure 29: Shooting screen

Screen category	Number of active buttons	Hick's time (sec.msec)
Start List	12	0.56
Progress	18	0.64
Shooting	17	0.63
Custom	14	0.59
Classif.	12	0.56

Table 7: Hick's law times for the biathlon relay event

I noticed that Hick's times go from 0.56 to 0.64 seconds, with the longest processing time for the Progress screen, which was expected since it has the most buttons. There results are the times it takes a journalist, when in front of one of these 5 screens, to process the information and make their decision.

Since the CIS is supposed to be a real-time system under 0.3 seconds delay, it means it takes longer to the journalists to make their decision than the system to update the results. Therefore, when the commentators are looking at a specific screen, just found the information they wanted and want to display another screen, new information arrives on the display and may disrupt them. Knowing the investment companies put into the CIS use and the efforts from the developers to have a real time system, it is probably frustrating to journalists to have such important delays in its use due to a poor interface.

Such a long processing time means there are too many options on the screens and the information overload is confirmed again. The other consequence is to make their navigation more difficult with up to 18 buttons on a single screen. To improve the CIS usability, options per screen would have to be reduced.

In addition to the processing time, I also wanted to know how long it took users to actually select the link they had chosen. Indeed, as soon as journalists have made a navigation decision, they are going to click on the link using their finger. The time it takes for them to do so depends on the distance from the user to the screen and on the size of the button. To find this type of information, I used Fitt's law.

5.3.2. Fitts' law

5.3.2.1. Methodology

Fitts' Law (Preece, Sharp et al. 2007) predicts the time it takes to select a target using a pointing device; usually the study is done starting from the center of the display. In the case of the

CIS use, it is about the time journalists are going to take to hit the right button with their finger. Like stated previously, if it takes too long because of distance issues between each buttons or between the screen and the commentators, it might affect the effectiveness of the CIS navigation and therefore its usability.

Fitts' formula is the following:

$$T = k \log_2 \left(\frac{D}{S} + 0.5 \right)$$

Where: *k* is a time constant (*k* ~ 100 ms)

D is the distance between the pointing device (hand) and the target (link on screen) in centimeters

S is the size of the target measured along the axis of motion in centimeters

T is the time it takes for users to reach the target

Note: Like for Hick's law, the time constant is determined empirically. I was not able to test the value of *k* on journalists prior the analysis either, therefore I chose an average value. Another point is about the pointing device used, which can be a mouse or hands for instance. Since Fitts' law comes from the Keystroke-Level Model (KLM) and this model takes into account the possibility of mouse or hands as pointing devices, having in the case of journalists their hands as pointing device is adequate.

5.3.2.2. Results

Fitts' law is going to give us an idea of the time journalists need to select a specific button based on its location. Before measuring the size of the target, we need to know the distance between the users and the CIS screen. By default, the assumption made for Fitts' law is that the pointing device is in the middle of the screen. Since in my case the pointing device is the journalist's finger, I am going to assume their hands are on a desk, about 30 cm (11.8 in.) from the bottom of the CIS screen, perpendicular, and in the middle. I chose this distance based on assumptions on how far from the screen journalists seat when doing their job.

Now, I need to compute the distance from their hands to the button. To do so I use the Pythagorean Theorem. Figure 32 (on the next page) represents the default setting for a journalist using the CIS. I draw 2 right triangles: the ABC triangle and the BCD triangle.

Figure 33 is a close up of Figure 32 to explain the procedure I followed to find the different distances. We have a button (in blue), at the bottom left corner; the journalist wants to select it. I need to find the distance D.

- I already know d_4 is 30cm (11.8 in.) from my previous assumptions, so I need d_3.
- To find d_3 I need d_1, which is the distance from the center of the button to the bottom of the CIS screen, and d_2, which is the distance from the center of the button to the middle of the screen.

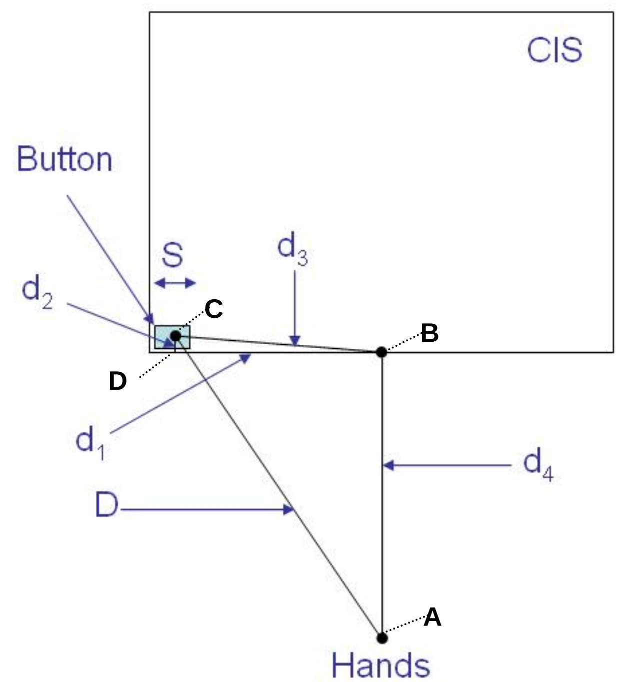


Figure 32: Right triangles for Pythagorean Theorem

S is the size of the button. By measuring d_1 and d_2 directly on the CIS display, I am able to find the final distance. I am going to take as example the Figure 32, which represents the Start List button for a biathlon relay event. Using the Pythagorean Theorem we have:

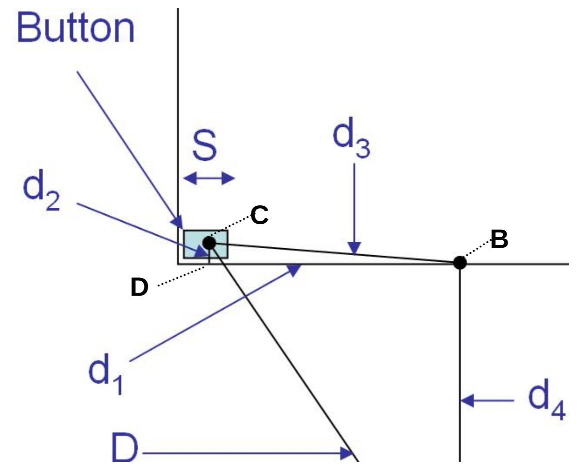


Figure 33: Close up of Figure 32

$$d_3 = \sqrt{(d_1)^2 + (d_2)^2}$$

and

$$D = \sqrt{(d_3)^2 + (d_4)^2} = \sqrt{(d_1)^2 + (d_2)^2 + (d_4)^2}$$

With $d_1 = 12.85$ cm

$d_2 = 1$ cm

$d_4 = 30$ cm

Therefore, D = 32.7 cm (12.87 in). Since S = 2.2 cm (0.87 in) and k, the time constant, is 0.1 sec, I can compute the estimated selection time based on Fitts' law, T = 0.39 seconds.

By doing the same for each button of the biathlon relay event on one of its screen, Figure 31 for instance, I have Table 8.

Button name	**D (cm)**	**S (cm)**	**Time (sec.msec)**
Start List	32.7	2.2	0.39
Progress	31.8	2.2	0.39
Shooting	31.1	2.2	0.39
Custom	30.5	2.2	0.38
Classif.	30.2	2.2	0.38
Previous	30.2	3.7	0.31
Weather	30.9	3.7	0.31
NOC	32.3	3.7	0.32
Schedule	30.2	3.7	0.31
Medals	30.9	3.7	0.31
Help	32.3	3.7	0.32
Home	38.2	2.1	0.42

Table 8: Fitts' law times for the biathlon relay event

Note: In gray is the button it takes the longest to select, it is the Home button, which refers to the one at the top left corner; it is used to going back to the very first CIS screen (list of the sports). These times do not take into account the time to actually load the selected screen, which would make the navigation even longer.

The times from Fitts' law go from 0.31 to 0.42 seconds, with the longest access time for the Home button. Again, we are over the 0.3 seconds, which is the time it takes to the system to be updated when new results come in. All the results buttons, from Start List to Classif., take also some time to select compared to the other buttons, which is not very convenient since during an event they are used a lot. The buttons at the bottom right corner take less time to select but are used less by users from my observations.

Having the Home button the most difficult to select in terms of time may seem a good idea and not an issue for the users because commentators usually focus on one sport only. On the other hand, they may want to see the results of other sports but if they feel it is going to take them too much time due to where the Home button is, they may stay on the screen they are on. Except for the Home button, the results are quite similar; it should not impact too much the way journalists use the system but we need to take into account both Hick's time and Fitts' time before drawing any conclusions.

5.3.3. Hick's law and Fitts' law combined

By adding Hick's time, Fitts' time and the users' reaction time, we would have the lower-bound time users take to select a screen. Since the reaction time is a constant, I will only focus on adding Hick's and Fitts' time. Table 9 summarizes my results. These estimates apply primarily to users who are unfamiliar with the system. As familiarity sets in, recognition (Hick) times decrease, and selection (Fitts) can occur in parallel.

Screen / Button	Start List	Progress	Shooting	Custom	Classif.
Start List		1.03	1.02	0.98	0.95
Progress	0.95		1.02	0.98	0.95
Shooting	0.95	1.03		0.98	0.95
Custom	0.94	1.02	1.01		0.94
Classif.	0.94	1.02	1.01	0.97	
Previous	0.87	0.95	0.94	0.90	0.87
Weather	0.87	0.95	0.94	0.90	0.87
NOC	0.88	0.96	0.95	0.91	0.88
Schedule	0.87	0.95	0.94	0.90	0.87
Medals	0.87	0.95	0.94	0.90	0.87
Help	0.88	0.96	0.95	0.91	0.88
Home	0.98	1.06	1.05	1.01	0.98

Table 9: Total time (sec.msec) to select information from a specific screen

For example, if a user is on the Progress screen, second column of Table 9, and wants to go to the Home screen, they are going to click on the Home button, which is listed in the last row of the Table 9. According to my results, it will take 1.06 seconds from the moment the user makes a decision to the selection of the button.

The average time from decision to clicking the button takes on average a little bit less than 1 second. It takes more than 1 second to process the information and to click on the Home button when a user is on the Progress screen though. However, it would probably take less time for an expert user who knows perfectly how the CIS works and definitely more for a novice who would have first to understand the meaning of the buttons. Because the systems change over the time and the events, such as the successive Olympic Games, and due to the short period of time the system is available prior to the start of the events, journalists are not expert at first; they need some time to adjust. Besides, due to the multitasking aspect of their job, they would not perform as efficiently as mentioned in Table 9.

For a real-time system it takes too long for users to navigate through the different screens. For journalists who have not had a chance to become familiar with the newest version of the CIS it will take them even longer. Moreover, they are working live and cannot afford to spend time learning how this complex system works; as a result, they may just stop using the CIS before they get to know its functioning.

Summary

We saw with this design analysis the global layout of the CIS screens and how they are linked to each other. A significant number of screens are available for each discipline and the information they display is quite important, which seems to imply usability issues. Therefore, after I knew there was an information overload on each screen, that there were difficulties in navigating through the CIS, and the time it actually required to select specific screens, my next step was to study the amount of information available in the CIS, what the journalists used in the system, what data they retrieved and what media they relied on. I knew the global layout of the system and the theoretical times it takes users to browse the system, I wanted to know about the CIS data. Additionally, the information on the TV screen seemed necessary since commentators have access to it during sports events too. Hence, I could compare and determine the data the journalists actually use. To know if there is enough information in the CIS, I did a content analysis divided into 3 phases: XML messages analysis, audio analysis, and video analysis.

6. Content analysis

This second part of my study was about the CIS content, I focused on determining what information was presented on what screen, and when it became available to the commentators so they could actually see them. I analyzed and gathered results that were going to lead me to new research questions and further analysis.

To know what was behind the system, I analyzed the XML messages that stored every single result that was displayed on the CIS. I focused on the way the information was organized within the XML message to know what attributes provided the data to what tables on the screen. In addition I looked at the total number of messages, per discipline, per event, and per screen.

6.1. XML data

After the end of the 2006 Olympic Games, I received the complete database used by the CIS. All the records were stored as XML messages; I had to study each different type of them to understand the information and the event they belonged to.

First, I am going to describe a record from the CIS database. Figure 34 (on the next page) is an XML message for biathlon.

- In bold are the tag names and before each equal sign is the attribute name.
- In quotes are the attribute values.

The attribute value represents the data I was interested in because it provides all the information to the system. On the Figure 34, we can see, as an example, in the **`Message`** tag the attribute `Type`. Its value is “`BTTRE_2_SP1`”, which means this is a result message (RE) for biathlon (BTT) during the second leg (2) for the first (1) shooting (S) in prone position (P), from left to right. Then, in the message, there is some information about each athlete’s results such as their rank. Indeed in the **`BT_Competitor`** tag is the attribute `Order` with the value “`1`”, this is the leading athlete, identified by their code: “`602618`”. However, the most important information in each message is the time it was sent to the CIS. At the top of each message (Figure 35 on the next page), next to `DateTime`, is the year – month – day – hours – minutes – seconds – hundred of seconds information.

Note: During a biathlon relay each team has 4 athletes skiing one after the other. When the 1st athlete is done with her or his loop, the 2nd biathlete starts and so on. A loop is called a "leg": the 1st team member competes in the 1st leg, the 2nd member in the 2nd leg, etc.


```
<row>
 <field name="ID">262127</field>
 <field name="DateTime">20060223122618852</field>
 <field name="RawMessage">
 <?xml version="1.0"?>
 <!DOCTYPE Message PUBLIC "-//IDS//CIS" "ids/oris+/cis/cis.dtd">
  <Message Category="CIS" Type="BTTRE_2_SP1" Serial="467" Origin="CSS-01SERVS-001"
Discipline="BT" Gender="W" Event="406" Phase="1" Unit="01" Format="D" Version="1"
Correction="0" Date="20060223" Time="122618852">
  <BT_Unit ID="BTW406101">
   <BT_Leg Code="2">
    <BT_Results Code="SP1">
     <BT_Last_Competitors>
      <BT_Competitor Order="1" Athlete="602618"/>
      <BT_Competitor Order="2" Athlete="601320"/>
      <BT_Competitor Order="3" Athlete="100322"/>
      <BT_Competitor Order="4" Athlete=" "/>
     </BT_Last_Competitors>
     <BT_Ranking>
      <BT_Team Code="1003117" Rank="1" Penalties="0" Spare="1" Total="0"
Total_Spare="2" Index="1" Time="25:52.1" Diff="+0.0">
       <BT_Athlete Code="100322" Rank="1" Penalties="0" Spare="1" Total="0"
Total_Spare="2" Index="1" Time="25:52.1" Diff="+0.0"/>
      </BT_Team>
      <BT_Team Code="1003125" Rank="2" Penalties="0" Spare="0" Total="0"
Total_Spare="0" Index="2" Time="26:10.6" Diff="+18.5">
       <BT_Athlete Code="601320" Rank="2" Penalties="0" Spare="0" Total="0"
Total_Spare="0" Index="2" Time="26:10.6" Diff="+18.5"/>
      </BT_Team>
      <BT_Team Code="1003118" Rank="3" Penalties="0" Spare="2" Total="0"
Total_Spare="5" Index="3" Time="26:17.4" Diff="+25.3">
       <BT_Athlete Code="602618" Rank="3" Penalties="0" Spare="2" Total="0"
Total_Spare="5" Index="3" Time="26:17.4" Diff="+25.3"/>
      </BT_Team>
     </BT_Ranking>
    </BT_Results>
   </BT_Leg>
  </BT_Unit>
  </Message>
 </field>
 <field name="Type">BTTRE_2_SP1</field>
 <field name="Discipline">BT</field>
 <field name="Gender">W</field>
 <field name="Event">406</field>
 <field name="Language"></field>
 <field name="Venue"></field>
 <field name="Origin">CSS-01SERVS-001</field>
</row>
```


Figure 34: XML message for biathlon shooting results

In Figure 35, which is the beginning of Figure 34, if we extract the information from 20060223122618852, we have "2006 02 23 12 26 18 852", which


```
<row>
 <field name="ID">262127</field>
 <field name="DateTime">20060223122618852</field>
(…)
</row>
```


Figure 35: Time information in an XML message

means the message has been sent at 12:26.18'852 on February 23, 2006. This is an essential piece of information because it is going to be the time reference when mapping, according to the time, the content of the CIS to what the journalists are saying live.

The amount of information generated during one of these events can also be truly massive. For example, the women's 4 x 6 km biathlon relay event during the Turin 2006 Games resulted in 1,267 XML messages being generated and sent to the CIS. This information is then distributed across a total of 11 CIS screens as explained previously in the section 5.2.2 (refer to Figure 24 for the mapping). During an event like the Turin 2006 Games, a total of 260,100 messages were generated over the 23 days the system was active, and an average of 14,865 XML messages per day during the actual Games. Over all sports, an average event generated 1,028 messages (Midy, Jensen et al. 2007).

Additionally, each message has a different structure depending on the disciplines and the number of messages for each of them is not similar either. Table 10 shows the breakdown of messages by disciplines. As expected, different disciplines result in different amounts of traffic, because the number of competitors, time, rounds, and measurable results vary.

	Message	**Events**	**Average**
Curling	34,985	98	357
Speed Skating	5,173	12	431
Figure Skating	2,089	4	522
Ice Hockey	36,289	58	626
Freestyle	2,619	4	655
Short Track	7,064	8	883
Snowboard	5,909	6	985
Alpine Skiing	12,564	10	1,256
Biathlon	16,176	10	1,618
Cross Country	28,359	12	2,363
Ski Jumping	12,293	3	4,098
Skeleton	10,535	2	5,268
Nordic Combined	19,498	3	6,499
Bobsleigh	23,283	3	7,761
Luge	25,667	3	8,556
Weather	1,176		
Other	16,421		
TOTAL	260,100	236	1,028

Table 10: CIS data by sport and event
Sorted by average number of messages per event.
Highlighted rows correspond to sports analyzed.

For the three sports I chose, we have per event:

- Ice hockey: 626 XML feeds
- Biathlon: 1,618 XML feeds
- Ski jumping: 4,098 XML feeds

Although it is difficult to find the exact explanation for the differences in these numbers, we can assume that if, for instance, ice hockey has fewer messages it may be due to the content of the sport itself. Indeed, most of the time there are actions and the journalists spend time commenting what they see and what is happening, not a lot of information about past records, time, score, etc. is provided to the audience. As for ski jumping, due to the short period of time it is broadcasted and because only 3 events take place during the Olympic Games, the average is higher compared to ice hockey, which actually has 58 events (games). This means journalists do not have access to the same amount of information depending on the discipline and therefore it may affect their work and the content of their commentaries.

These first results are quite interesting; we already see some significant differences in the data available per discipline. Not only the number of events vary from a few to several dozen, but also the type of information relayed by the CIS goes from score only, to wind speed, length, points, etc.

In addition, knowing the number of events per discipline, and the number of screens and XML messages per event, I was able to compute the average number of messages per screen per event. Table 11 gives a summary of these results.

	Biathlon	**Ski Jumping**	**Ice hockey**
Mockups	43	32 (48)	19
Events	5	2 (3)	2
Screens per event	8	16	9
XML messages per event (average)	1,618	4,098	626
Messages per screen per event	202	256	69

Table 11: Messages per screen per event for the three disciplines

Note: The numbers in brackets for ski jumping are if we take large hill and normal hill as 2 different events whereas they share the same screens.

These results match what I mentioned previously about the number of messages provided to the CIS, which can change significantly from one discipline to another. Obviously ice hockey has very few messages and therefore the CIS provides only little information about ice hockey games. On the other hand, ski jumping has more messages per screen. This may be due to the fact that athletes jump right one after the other and a continuous flow of data is generated. On the contrary, for ice hockey, we have to wait for a goal to be scored, an athlete to have a penalty, etc. to see new data in the CIS.

It is also interesting to notice the time effect. Indeed, when a biathlon event usually lasts for 1 hour or 1h30min, ice hockey lasts about 1h30min and ski jumping lasts from 2h30min to 3h total. This might be the main reason why there are more messages for the latter, since it lasts almost twice longer than the two other disciplines.

Once I knew the type and amount of data stored in the CIS, I focused on what the journalists were saying. Later on, I would be able to see on what kind of sources they rely on in order to make their commentaries. Finally, out of these commentaries I will look at how much data is actually stored in the CIS and could be used as source of information.

6.2. Audio analysis

Because the data journalists convey is essential, I decided to analyze their audio comments for the 15 disciplines taking place during the 2006 Winter Olympic Games.

6.2.1. Methodology

Before knowing to what extent the journalists take advantage of the CIS data and what type of information they use, I needed to know what they were saying. I focused on the content to be aware of the information they communicated to the audience. Then I could determine what they rely on.

In order to do so, I listened to 32 hours of the 2006 Winter Olympic Games from the audio track of some US Universal network videos. Since I only had to listen to the content, I was able to broaden my research and I went from the three to all the 15 Olympic disciplines. I decided to limit to 3 hours the time I would listen to each different discipline. However, some sports like skeleton are usually not aired more than half an hour; therefore I was not able to analyze the same length for each event.

I classified the commentaries into one of the 5 following categories:

- Past results (commentary about results from other races in the same or previous Olympics)
- Live results (commentary about results from same heats in the same Olympics)
- Rules / Strategy (Commentary seeking to explain the sport or the rationale for actions)
- Bio (commentary related to past achievements or personal details of athletes or coaches)
- Weather (commentary regarding meteorological or venue conditions)

I chose these different categories based on open coding strategy. I first listened to several events to have an idea of the main topics mentioned by journalists, which I wrote down. Then, knowing the different screens and information available in the CIS, I selected the categories for which I knew what CIS screens provided such information. In other words, I made sure none of the data from these categories could be found on the same screen: past and live results were on two distinct screens of the system, rules and strategy were not in the system at all, biographies had dedicated screens accessible from the athletes' name and weather was available via a pop-up window. Therefore, I would know if some screens were liable to be used more than others by the journalists based on their comments. Once I had named the categories, I listened to all the disciplines and counted the number of times journalists mentioned the selected topics.

6.2.2. Results

By analyzing what journalists were saying, it gave me an idea of the potential CIS screens they might be looking at, as well as their navigation strategy when their commentaries had different topics that could not be found on the same displays.

With the 32 hours of video feeds I listened to, I transcribed everything the journalists said during that period of time into Table 12. I counted the number of times they were referring to specific information and to what category it belonged to.

Note: As mentioned previously, the small amount of data analyzed for some sports reflects the lack of live broadcasts provided by the broadcasting companies.

	Alpine Skiing	Biathlon	Bobsleigh	Cross-Country Skiing	Curling	Figure Skating	Freestyle Skiing	Ice Hockey	Luge	Nordic Combined	Short Track	Skeleton	Ski Jumping	Snowboard	Speed Skating	**Sum**
Analysis (Min)	180	180	100	123	180	180	132	180	59	107	129	21	39	130	180	1920
Number of sporting events	6	4	3	5	3	2	4	3	3	3	7	2	2	4	9	60
Number of comments	**316**	**421**	**263**	**215**	**251**	**148**	**208**	**308**	**122**	**192**	**221**	**60**	**71**	**202**	**334**	**3332**
Past results	12%	16%	17%	20%	8%	9%	7%	12%	7%	20%	13%	12%	14%	5%	17%	13%
Live results	51%	49%	51%	46%	51%	42%	50%	53%	52%	43%	47%	62%	44%	47%	49%	49%
Rules / strategy	16%	18%	12%	16%	33%	29%	21%	19%	23%	17%	25%	12%	24%	31%	15%	20%
Biography	19%	14%	16%	13%	7%	20%	19%	17%	16%	16%	15%	15%	18%	12%	19%	16%
Weather	3%	3%	4%	5%	0%	0%	4%	0%	2%	3%	0%	0%	0%	4%	0%	2%

Table 12: Type of commentary by type of sport

My findings show some variability in the type of commentary as a function of the sport. Obviously, commentators of some sports and events have more facts and figures to report than others. Some sports are likewise more affected by weather conditions, rule changes, or have more athletes participating. However, there is a significant regularity in the data and without some specific cases, like weather information not available for indoor sports, or rules more mentioned for strategic sports, we could have a closer match.

Note: Except for Curling, which is mainly based on strategy, the two sports with the most Rules/Strategy discussion were those featuring new rules or events: Figure Skating and Snowboard. To keep viewers up-to-date, the commentators felt they had to repeat the rules many times to let the viewers be aware of those changes.

To have a better visual view of my findings from this audio analysis I created a chart to report the results for each sports (Figure 36).

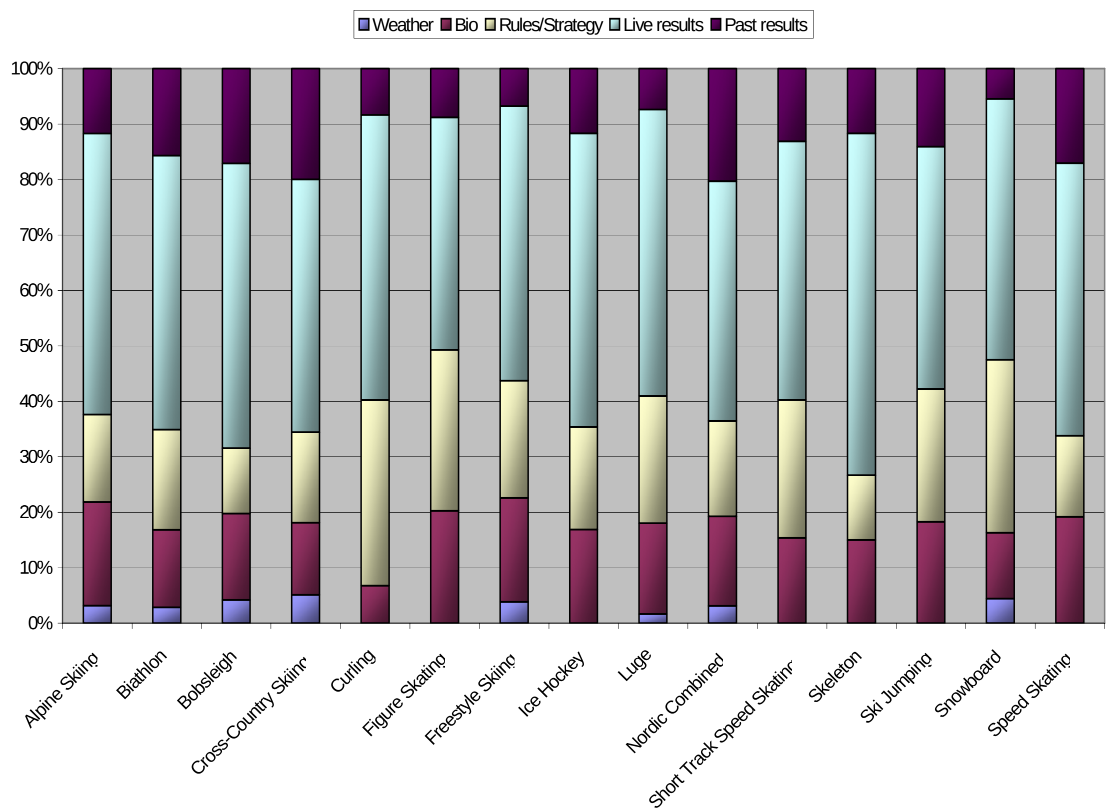


Figure 36: Content of the audio commentaries for the 15 disciplines

Notice that the overall distribution is quite homogenous, it means the type of sports does not have such an important influence; the journalists offer the same kind of information. Indeed, whatever the sports are, few comments about weather are made, I observed the same for Past

Results, Rules / Strategy, and Bio commentaries. However, there is an important part of live results, which are either available through the CIS results screens or just happening live in front of the journalists.

If we look at the average percentage for the types of comments for all the 15 disciplines we have a very distinctive subdivision (Figure 37).

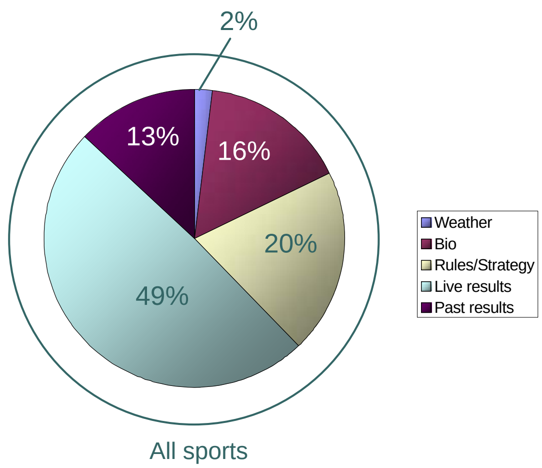


Figure 37: Content of the audio commentaries for the 15 disciplines (average)

The main result is that 49% of the journalists' commentaries are about live results, in other words, what they see happening, and what the CIS is meant to cover. This could be due to many reasons. For example, the commentators do not have enough information about the past results, the rules, the biographies, etc. in the CIS but do have information about the live results since they can just watch them in the stadium or on their TV monitor. This is probably not the case because, like mentioned previously, the system has information about athletes, weather, and past results as well as live results. Also, out of this high percentage, it would be interesting to know how much is actually available on TV or in the CIS.

The other main result it about the percentage of Rules / Strategy. Indeed, this category is not available in the CIS, but it represents 20% of the audio comments, which is the second most relayed information by the journalists. It means they have to find this data either on TV or using other resources.

Finally, according to the low percentage of commentaries about the weather, it seems this section of the system is maybe not appealing enough to the journalists or not easy to reach. Yet, no significant time difference has been noticed using Hick's law and Fitt's law during the design analysis; therefore a usability issue does not seem to be the cause of such results. Another explanation is that this window is a pop-up window and requires more steps to open it and close it, something journalists might want to avoid when doing live commentaries.

I knew, with this audio analysis, what the commentators were saying; what type of category had the most counts of commentaries. I wanted to know where the journalists found the information and especially if it was in the CIS. Indeed, I wanted to be able to map the content of their commentaries to the current data in the CIS. This is the reason why I did a video analysis as the last step of my content analysis, to know what the information on the TV screen, the actions going on, and the content of journalists' comments at the exact same time were.

6.3. Video analysis

For each of the three disciplines I did, helped by another student, an in depth analysis of two whole transmissions, 6 total. The TV coverage was randomly chosen TV broadcasts (from US Universal network) where I tried to use live coverage when possible in order to avoid video editing from broadcasting companies. In addition, if I wanted to know exactly the time the event lasted, or just some specific moments, it had to be the record of a live event. I focused on the information available to the commentators (in the CIS, on the TV screen, etc.). Then, I compared it to the content of the commentaries to analyze what resources journalists could have based their comments on. I performed this video analysis for biathlon, ski jumping, and ice hockey.

6.3.1. Methodology

For this analysis I looked at TV on-screen information (Refer to Figure 38 for a TV screen capture with countries, ranks, names and time information at the bottom of the screen) and I listened to the content of commentaries for biathlon, ski jumping and ice hockey. I did a more detailed analysis of the journalists' commentaries than for the audio analysis since I transcribed a summary of the content of what they were saying and not just classified it.

Figure 38: TV screenshot (USA 2006)

My goal was to map the topics they were talking about, the information available in the CIS (thanks to a live XML data-stream from Turin), the information on the TV screen and the action going on during the event, everything according to the time. I divided my video transcript sheet into 7 columns (Table 13):

- Information available in the CIS (from the official XML feed)
- Time on the DVD player (since the event had been recorded)
- Real time (when the event happened)
- Action
- Left TV on-screen information
- Right TV on-screen information
- Comments from journalists

Since all the different types of data were related to each other based on the time, I would be able, by just looking at my transcript, to know if the journalist's commentaries matched the information in the CIS, the information on the TV screen, the action currently going on, or none of those. This was the method I used to know the sources of their comments.

6.3.2. Results

6.3.2.1. Transcripts

This step was to try to determine what information was conveyed to the viewers and to determine the origin of said information. I created the transcripts of the six randomly selected transmissions: two biathlon, two ski jumping, and two ice hockey events; disciplines with different CIS complexity. These videos were from the US Universal network's coverage of the 2006 Winter Olympics. For each of these transmissions I tried to match the content of commentaries with the available CIS information and/or TV on-screen graphics. A total of 198 minutes of video was analyzed for this phase. In this analysis I looked at every of the three following types of events:

1) An event takes place on-screen / on site: an athlete takes the lead, a team scores, etc.
2) Relevant information is shown on screen: official clock, current score, biography, etc.
3) A commentator makes a statement

My goal was to keep track of all the data conveyed to the viewer by logging this information into Excel sheets. I wanted to know if the commentaries were related to the information on the TV screen, the actions or both. Once the on TV screen information and audio comments had been transcribed, I mapped the CIS XML messages to the official clock to compare the available data in the CIS with the journalists' comments.

Figure 39: TV screenshot of a biathlon relay event (USA 2006)

To give an example, I am going to show some of my results from this phase. Figure 39 is a screenshot taken from the TV screen; it is the information journalists, as well as TV viewers, saw when they were watching the women biathlon relay during the 2006 Winter Olympic Games. At the bottom, on the left and on the right, are pieces of visual data such as names, countries, time, time difference, etc. at a specific time during the event. I took notes of all these details and created a transcript shown in Table 13 (on the next page). The grayed line exactly matches the Figure 39; it shows the on TV screen information, the comments made by journalists, the actions of the events, and the XML messages stored in the CIS according to the time.

XML ID	Real time	Time on clock	Event	On-screen info (Left and Right side)		Comments (C: Commentator, A: Athlete)
…	…	…	…	…	…	…
	12:38:02	0:38:02.5’	RUS passing the relay		New athlete’s name, country (RUS), time, clock freezes	(C, A): description of the relay. Future race between next athletes from GER & RUS
205724(BTTRE_2_ITE), 237215(BTTLB_2_ITE)	12:38:08	5.7			Clock frozen + additional time	
	12:38:10	8.4				(C): previous records from GER athlete
16991(BTTRE_2_IT5), 45567(BTTRE_2_IT6), 77504(BTTRE_2_IT6),	12:38:25	23.2	GER close to 2nd relay	// + 1st (RUS), time	//+ athlete’s name, country (GER)	(A): links with what happened to GER in Salt Lake
109054(BTTRE_2_IT6)	12:38:34	32.2	GER passing the relay	//+2nd (GER), add. time	//+ athlete’s name, country (GER), time	(C): place and time for GER
141278(BTTRE_2_ITE), 173652(BTTLB_2_ITE)	12:38:40	37.7			Clock frozen + additional time	(C,A): NOR is back in 3rd, notice bib # are the current rank
205510(BTTRE_2_IT6)	12:39:02	+1:00.0	Friend on screen			(A): mentions who is watching
…	…	…	…	…	…	…

Table 13: Transcript for the women’s 4x6km biathlon relay live event
(Recorded on February 23, 2006)

To understand the steps I followed, we can look closer at Table 13. We see it contains several columns. Among them are the XML ID, the real time on the DVD player (for analysis purposes only), the time on the clock, the actions, the on TV screen information and the comments from journalists (from left to right). The left end column contains the references to the XML messages that match the time for each action / information / comment. I also divided the “information on the TV screen” column into 2 smaller columns, one left, and one right, based on where the information was on the TV screen in order to be more accurate in my analysis. Hence, I knew not only what information was displayed but if it was on the left or on the right of the TV screen. From this video analysis, I obtained new results detailed in the following section.

6.3.2.2. Information gaps

Examining the information the CIS provides and comparing it to what it is supposed to deliver, I started to see some of the shortcomings of this implementation of the system. Using the transcripts I created, I chose to focus on biathlon, for which I had performed 112 minutes of video analysis. I looked at when the information was available in the CIS, when it was on the TV monitor, and when the commentators when mentioning such information.

The table 14 summarizes the results from this biathlon analysis; it shows the information gaps found in the two biathlon events I watched.

Source	Number of actions		
CIS + TV	115	54.25%	
TV	64	30.19%	} ➔ 45.75%
Not CIS or TV	33	15.57%	
TOTAL	212		

Table 14: Sources for comments (112 minutes of biathlon)

This last phase of my content analysis was very useful. I realized that some important information was missing from the CIS stream. Not only is information missing for more than 15% of events (shooting results or partial times in the case of biathlon), but shooting results are only available after an athlete fires at all targets rather than after each shot, when it is directly available, live, on the TV screen. A random sampling of shooting messages showed that on average, these messages are put on the system 3.5 seconds after the final shot (in a series of 5) is taken, with some messages being delayed 30 seconds. Because the CIS is supposed to provide data in real-time, and on which journalists have to rely heavily, it is a major issue. Due to this lack of information, I asked a new research question: “How do the users deal with this issue?”

Because when the journalists are making comments, they cannot wait up to 30 seconds for the information to be available on the TV screen, they have to rely on other resources.

The other important result from Table 14 is the percentage of data that was not in the CIS yet when journalists referred to the information. Indeed, more than 45% of the results are not accessible from the system but on TV or other sources only. This means the journalists have to rely almost half the time on additional resources. Therefore, another question arises, which is: “Where do commentators find additional data when it is not available from the two displays they have on hand: TV and CIS?”

Summary

My investigation indicates there were serious problems in terms of quality of service with the Turin 2006 Olympic CIS, which is meant to work as a real-time system. Information was usually more promptly and easily available to commentators and viewers on TV monitors than through the CIS. Looking at the timing of commentary, I saw clear indications that commentators were relying more on the TV images than the CIS for live results, which accounted for almost half of all commentary. Given the shortcomings of this system, I believe it is likely that commentators at the Turin 2006 Olympic Games would have relegated the CIS as a secondary tool in favor of the live TV feed.

I have detailed the steps and decisions I took in order to analyze the Commentator Information System, its functioning and how it was used by journalists. I used this approach to find answers to my research question: Does the system meet users' needs?

The audio analysis phase helped me to answer some of the questions asked at the beginning of my study about the amount of information available too; in addition I now have some new questions. The main one was about understanding why the journalists focused 49% of the time on live results when they have such a system on hand. When fans could argue that live results are the most important pieces of information, others may like to have various kinds of data to enhance their interaction with the sports they watch.

With these different steps, I saw issues related to information overload, navigation difficulties as well as missing information in the CIS. Therefore, I was able to answer my first research questions:

- Is there an information overload?
  Yes, we saw the important amount of information per table on a single screen, the number of buttons to navigate, and the number of screens per event.
- Are there any navigation issues?
  Yes, we saw the flatness of the system the time it takes to journalists to make their decision and select specific screens.
- Is there enough information?
  No, we saw the time delay the information is available after an action occurs, and the high percentage of data no in the CIS when the journalists actually need it for their commentaries.
- Does the system meet users' needs?
  No, according to these answers and the first purpose of the CIS: providing complete information easily and quickly.

In order to see if these problems were reflected in real life, I wanted to observe the use of the CIS by journalists. To do so, I needed to do an experimental analysis in order to observe their use of the system in real conditions. Therefore, I decided first to conduct an ethnographic study during an international sports event. This was an opportunity for me to analyze journalists' behavior when working live and under pressure in a stadium with hundreds of other journalists around them. Besides, I could interview them to gather some feedback about their own experience and opinion in the CIS.

Based on those findings and observations, I decided to conduct a controlled experiment as the second step of my experimental analysis, in order to control and test very specific aspects of the system. This last phase will answer some new questions and uncertainties from the ethnographic study. These final results, after data analysis, will conclude my thesis and I will suggest some changes and improvements as well as some guidelines for further research.

7. Experimental analysis

The design and content analysis were very rich in terms of observations and results, but they also provided additional research questions. In order to confirm the observations from the previous theoretical analysis I decided to conduct an ethnographic study. This would be the occasion for me to observe the use of the CIS in a real environment and see how journalists take advantage of this essential tool when working.

The ethnographic study will give some answers to the main question about users' needs once the information overload, the navigation issues and the amount of information concerned would have been studied. Based on these results I will ask new research questions which will be answered through a controlled experiment. During this last phase, I will analyze how users behave when they have to use the CIS in difficult conditions (cognitive load, pressure, etc.), how they react to difficulties, what they find not convenient, etc.

Once the experimental analysis done, I will conclude by comparing the use of the CIS in real conditions versus during the experiment I conducted, I will list the main findings and issues found and I will finish by mentioning some interesting results for future research.

7.1. Ethnographic study

In order to answer the questions I asked during my design and content analysis, I decided to conduct an ethnographic study. My goal was to observe the use of the Commentator Information System by journalists and to interview them about their experience. I knew I wanted to know how the commentators solved the missing information issue and on what they relied. This phase of my study also allowed me to gather first-hand accounts of CIS use and any other tools or information sources used by commentators. Because waiting 2 years for the next Olympic Games to come around did not seem a reasonable course of action, I decided to study commentators interacting with the CIS used in a stadium during the 2006 European Athletics Championships in Gothenburg, Sweden.

7.1.1. The European Athletics Championships CIS

The first thing I had to do in order to understand how the journalists used the system, was to make sure the system in Sweden was close enough to the CIS used during the Olympic

Games. Indeed, my study was based on another CIS than the one I was going to ask users about. Fortunately I was able to use fully the system, browse every screen and take notes of everything I wanted prior the beginning of the event. By doing so I would be able to understand what the journalists were going to look for when browsing the system. Additionally, for the study, I had access to the press areas in the stadium used during the event. I also received the collaboration of several large European TV and radio companies whose commentators allowed me to observe them while doing live commentary of events, as well as interviewing them afterward.

In Sweden, there were about 26 disciplines (Appendix 20) and according to the developers about 450 CIS terminals were spread all over the 47 venues. While this was a different system developed by a different company (SportService 2007) for a different set of sports, the basic interface and data provided was similar enough for my purposes. The interview with the developers (refer to section 7.1.3) gave me an overview of the work they had been doing over the past years to design this new version of the system and a feeling that they did not conduct any user studies before releasing their new CIS. The details they gave me were about the system and how it was implemented. They mentioned an online CIS still in a beta version that users could rent if they were not able to come onsite, unfortunately this online resource is not available anymore. Like I said, the CIS in Sweden was close to the one used during the Olympic Games and I will describe its main characteristics next.

If we look at Figure 40, we have a basic results screen from their CIS. Even if the layout is not exactly the same, we still have the big tables full of data for the results and buttons all around to go to different screens. Based on these observations, I assumed the usability issues found for the Olympic Games CIS in the previous sections, would remain this system too.

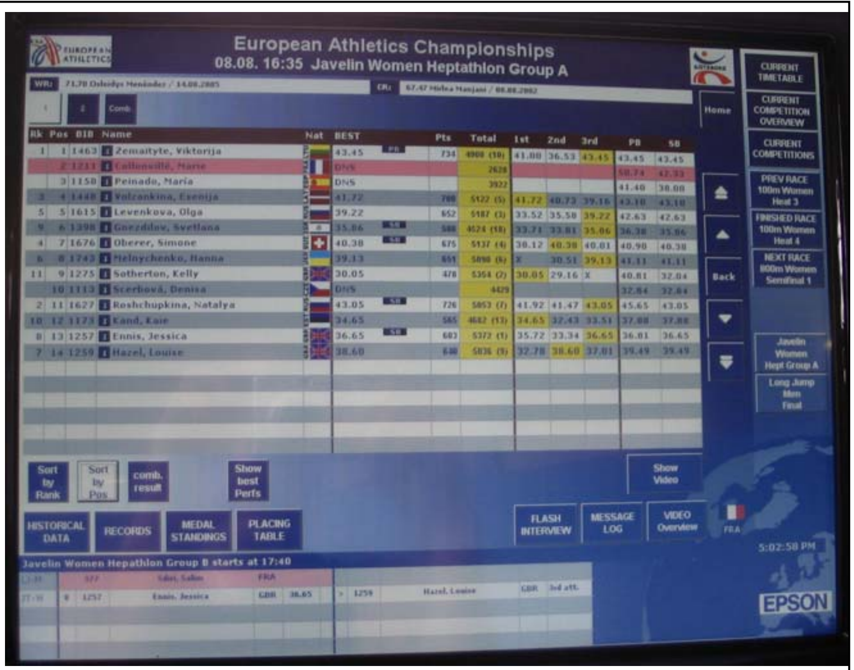


Figure 40: Results screen from the 2006 European Athletics Championships CIS

Before I observed any journalists using the system I needed to be familiar with it since I had been studying the version used for the past Winter Olympic Games. When using the CIS for the first time I noticed some additional features that were not in the Olympics version. Indeed, streaming videos were available and provided feeds from several areas of the stadium. However, since I tried to use the system when the events did not have started yet, the videos were not available and the system actually froze. I had to reboot the machine I was using. According to my contact from the European Broadcasting Union, due to the bandwidth use, this feature would be difficult to use in the future if the developers intend to increase the amount of data they want to transmit over the network. Once I knew the system I was going to go in the field and actually see if users noticed the same features and issues I previously observed. The rest of my ethnographic study was divided into two main steps based on the CIS users: The radio journalist first followed by the TV journalists whose job is to edit videos.

7.1.2. The radio journalist

This journalist was a middle age radio commentator for a Spanish radio station; he had been working for many years doing live commentaries for this broadcasting company. He was willing to help even if at first I felt he was not very comfortable about letting me observe him during his work. I got the authorization to work with him through his agent. He was seated in the stadium where the events happened, surrounded by journalists from all over the world doing the same job at the same time (Figure 41).

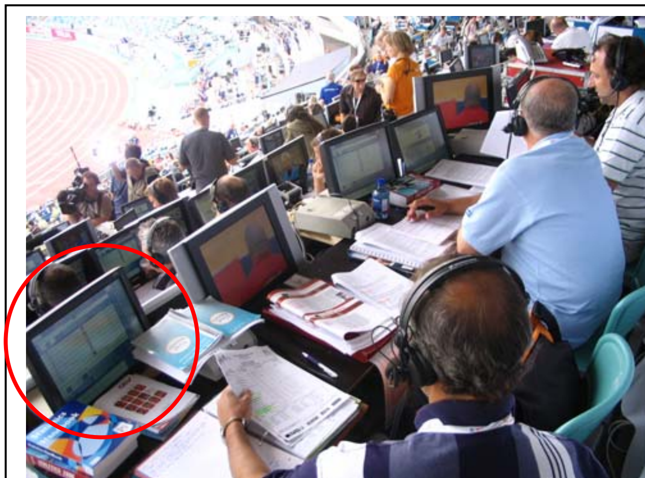


Figure 41: Journalists working in a stadium

I spent about 4 hours with him, an entire morning, standing next to his desk in the main stadium where athletics events were happening. I took notes and pictures, and I video taped him when I thought this was relevant to my study when he was using the CIS. When the morning events ended and he stopped commenting, I asked him if I could take some additional pictures of his desk and asked him some questions. He agreed to both requests.

During the time I observed him, I noticed he barely used the CIS (Figure 41 in the red circle), most of the time he left the results screen on and watched the TV monitor provided to all journalists by the organizers. Therefore, when he needed to make comments on information other than the live results he preferred referring to other resources.

For information on previous results as well as biographical data on the athletes and coaches, I observed reporters keeping extensive and detailed paper-based dossiers with their own notes (books, catalogs, binders, etc.), as well as the printed version of some of the information available in the CIS (Figure 41). This printed material, facilitated by the event organizers, offered commentators the ability to add their own notes and bookmarks, making it easier to access compared to the CIS. Usually, printed pages with updated results for each new heat and round were handed out to journalists every 10 or 15 minutes. This very interesting observation actually accounts for the 15% of non-available information either on TV or in the CIS found during the Olympics CIS study. Using their own documents is the solution journalists found to deal with the too important time delay existing between the time the action happens and the time it is available in the CIS. The main consequence was, after half a day of work, the accumulation of paper and information on a commentator's desk was significant. I noticed that journalists usually only took a quick look at the sheets of paper provided by the organizers and either stored these sheets under other documents or threw them away without further consideration. It seemed as if these papers were only of interest as a backup to CIS or TV failure.

After I spent enough time with the radio journalist, I went to a broadcasting truck to observe and interview two of the TV journalists working there.

7.1.3. The TV journalists

The 2 journalists I had the chance to interview where from a French TV channel, both younger than the radio journalist. Their job was to edit the video feeds they had received for the next live sports news using the CIS to find statistics. Due to time constraint, I was able to spend only 10 minutes with both in the truck, 20 minutes total. I asked them questions about how they used the system, what they liked, did not like, etc.

Note: Even if these journalists worked for live news editions, the broadcasts had a few minutes delay; it was not actually live. Although it could seem less stressful than the radio journalists, I observed in the truck very high tension and pressure when I was waiting to interview them.

I did not have a chance to observe the TV journalists using the CIS while doing their job because the truck was very crowded (Figure 42 on the next page) and I did not want to disturb them.

I noticed the area they were working in was very thigh; definitely less space than the journalist in the stadium. They had a couple of TV feeds on one screen and the CIS just above (red circle on Figure 43). Maybe due to the fact they were not doing their job live, they mentioned some small features they had noticed were not convenient. For instance the difference between rank and starting sorting were confusing to them. The radio journalist, doing his job live did not mention anything about this issue, maybe because he did not have time to pay attention to minor details and was too busy looking at the "big picture".

Figure 42: French TV truck

Looking back at Figure 41 and Figure 43, I noticed how far journalists were from the CIS. When I used 30 cm (11.8 in.) to compute Fitts' law, they are actually 50 cm (19.7 in.) to 1 m (3.28 ft) away from the screen, which makes the time to access the correct buttons even longer.

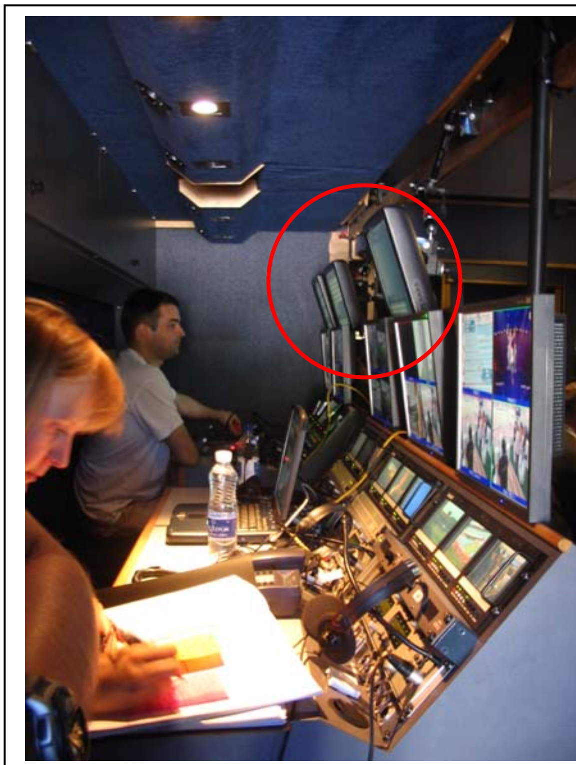


Figure 43: CIS for TV use

After I finished my interview with the TV journalists I went to talk to the CIS developers where a representative answered most of my questions. Thanks to a contact working for the European Broadcasting Union (EBU) (EBU), I was able to get in touch with the developers of the current CIS who worked for ST SportService (SportService 2007). I spent about 30 minutes with one representative from the developer team near to the central room where they monitored the main server and the network the CIS was part of. I asked him various questions about the system itself, their strategy, technical details, the future version, etc.

When I was not interviewing the users or the developers, I had the chance to walk around to see how such a big event is organized in order to have a glimpse at the stress media staff has to face, at the crowd the organizers have to deal with, at the security aspects and at all the back end part. This was very useful to understand the functioning of an international sports event.

7.1.4. Results

While this implementation of the CIS may not have had the same shortcomings as that of the 2006 Olympics CIS, I found, as predicted, its use by commentators at this event was limited. In most cases I observed reporters initially browsing the information available in the system, but quickly switching the CIS to the "Live Results" page and leaving it there for the duration of the session. With this very interesting behavior, I realized that it actually accounted for the 49% of journalists' comments, for which the content is about live results. Indeed, almost half of the time they mention the current results; maybe this is because just about all the time they leave the CIS, their source of information, on the results screen. Their use of the system matches the content of their comments found during my content analysis. I also noticed that commentators were relying heavily on the results and images presented on the TV monitors, the same the viewers see at home, more than the CIS results. However, the CIS was used extensively to compare results to those of previous heats or partial results from earlier in the same event; the only place such information was available. These observations were based on several CIS users; as mentioned previously, a radio journalist and TV journalists.

In addition to using the CIS less than expected, journalists did not notice the new features added to the system. At this event for instance, journalists were not familiar with the streaming videos, which were an innovation of the system. I learned that journalists did not know what they were for, or how to use these features, based on their feedback. Since these systems are only available in the stadium or other official venues, commentators had no opportunity to explore and familiarize themselves with the system before arrival. However, the stress associated with entertaining a live TV or radio audience meant that commentators were extremely hesitant about taking risks and exploring new technologies live. This is probably one of the main reasons why the system was not used more actively as well. The wealth of information available, together with the large number of screens available, adds to the potential for confusion. Commentators therefore seemed to prefer to switch the system to the one screen they knew they needed, and used other sources for the remaining information.

It is important to note that despite these shortcomings, commentators were uniformly positive in their evaluation of the CIS system, and considered it an important, if limited, tool for doing their job. My own experience using the system taught me that though the system contained a wealth of information, I kept returning to the “Live Results” and “Start Lists”. These two screens contain the most relevant information to enhancing the viewing experience

During the field study I saw the amount of information on a single screen and how journalists had difficulties to find what they were looking for. When they had to scroll down a table to find information, this was not convenient. First they were not even sure they would find the information at first sight when reaching the screen, second they had to press a down arrow several times until they reach the end of the table, and half of the time the arrow was not sensitive enough and nothing happened. Additionally, even if the users only browsed most of the time the heat results screens, sometimes they did not know which one to look at due to navigation issues. Finally, for long races like marathon, because the intermediate times were not frequent at all, they could wait for the information to come to the CIS but made their commentaries based on the TV screen (since the event was in the city and not in the stadium).

This concludes and answers the questions about the information overload, the navigation issues and the missing data in the CIS in real conditions:

- Is there an information overload?

  Yes, we saw the use of large tables on the CIS screens and the amount of additional information journalists bring with them on site.
- Are there any navigation issues?

  Yes, we saw journalists leaving the CIS screen on the results page instead of browsing the system for other types of statistics.
- Is there enough information?

  Yes, but using a large amount of extra resources.
- Does the system meet users’ needs?

  Yes, according to the users but no based on the developers’ goals.

We have a conflict here in the purpose of the CIS use from the journalists and developers’ points of view. In order to see if we can disambiguate this disparity I decided to focus on the users’ reactions and behavior under difficult conditions. Based on the results I obtained from the interviews and on my own observations, I decided to plan and run a controlled experiment to understand why journalists behaved such that way, why they used specific screens and not others and, as users, what is participants’ opinion on this type of system in terms of usability. Using this kind of experimental analysis would put me in control of what I want to test and what questions I need to answer.

7.2. Controlled experiment

The last phase of my experimental analysis was to conduct an experiment in a controlled environment. Being in control of the different variables would allow me to ask subjects to use the CIS the way I wanted, the way it was supposed to be used. To be ready and gather useful results, I followed a sequence of very detailed steps.

Through this study, I wanted to know how much of journalists' observed pattern of use was due to design problems and at what point users would stop using this system because of information overload or cognitive load. The participants for this study would be provided the prototype of the CIS I implemented, some hard copies of sports results, and a TV monitor showing a recorded sport event (a women biathlon relay event from the 2006 Winter Olympic Games). Once the experiment was done, I was going to analyze the kind of resources subjects used, their frequency of use, and how their patterns evolved over time and as a function of cognitive load. My goal was to use this data to suggest changes to the CIS.

7.2.1. Methodology

Before creating the CIS prototype, which would be used by the subjects, I had to make some important decisions. I needed to decide to what extent subjects would be able to browse the system, how many screens, for what sports, etc. Besides, the data available during their browsing experience should be as close as possible as in the real conditions. Based on these prerequisites, I followed the next steps.

First I had to choose one of the three disciplines since having a CIS with many of them would not reflect the real journalists' work conditions. To run my experiment I needed a CIS that subjects were going to use extensively; it had to be reliable and running correctly. I decided to re-create the one used during the 2006 Winter Olympic Games because I was familiar enough to know how it worked due to the detailed previous analysis I had performed. I decided to focus only on biathlon and chose the women relay event (one of the most complex). After I made my mind, I knew the types of screens I would need. However, I decided not to implement all of them but only the necessary screens. Table 15 (on the next page) gives a comparison between the screens I implemented and the ones actually available in the real version of the CIS.

Real Version	Start List	Progress	Shooting	Custom View	Classif.
Prototype	Start List	Progress	Shooting		

Table 15: Screens kept for the prototype version

Additionally, I came to the decision to create a system updated at the same time the events were happening. Hence, it would be transparent to the users and they would think they are using the CIS live, the same way journalists do. To do so, I needed to store the data for the entire event in advance. The only option I had was to parse every single XML message containing all the data sent to the CIS, belonging to the relay event, and received during the 2006 Olympics. Like mentioned previously, different tables in the CIS means different types of data, this means different types of messages. For each of them, I created a PHP parser (Refer to Appendix 21 for the “upper right table data” parser) and stored the data into a dedicated database. Prior to retrieving the information, I looked carefully at every single screens of the biathlon relay event to understand what data from the XML feeds was stored in the tables, in the rows, and in each cell. I hade made sure to design the database such that when I would be running queries to populate the tables, through the PHP code in the parser, it would be very straightforward and no many data splits would be necessary. Although the tables had many attributes for an efficient ER diagram, it was easier for me in the CIS implementation.

Once I had the data stored, I focused on re-creating the CIS interface so that it looked similar to the real system in terms of colors, layout, size, etc. I also used the PHP web language to have active pages that were going to retrieve data from the database as stated above. Using the official documentation and the pictures received from the 2006 Winter Olympics in Turin, I designed and programmed the 39 screens needed for the CIS interface. Table 16 is the list of these screens.

Number of screens	**Type of screen**	
1	Home	(Appendix 22)
1	Schedule	(Appendix 23)
3	Start List	(“Team”, Appendix 24)
	Progress	(“Leg 1 – Intermediate points 1 and 2”, Appendix 25)
8	Shooting	(“Leg 1 – Shooting 1”, Appendix 26)
1	Weather	(Appendix 27)
1	Medals	(Appendix 28)

Table 16: Experiment CIS screens

Because the results were supposed to appear on the CIS screens when events occurred, I had to simulate a clock that would start at the exact same time as the real event. Here the biathlon event started on February 23rd, 2006 at 12pm, so when subjects were going to start using my prototype, a script would simulate the same start date and time. Then, my CIS would use this time to display the information on time.

Once the design was completed and I was close to the final version of the prototype, I decided to start recruiting subjects, to organize the experimental room and the tools I would use to record subjects' experience.

7.2.2. Set up

Being at school implied I was going to recruit mostly students. Because I wanted them to act like journalists, I tried to recruit students who had a background in journalism and / or in biathlon. I stopped recruiting once I had 18 subjects; I made sure to have enough US subjects and non-US subjects for my data analysis. Among those 18 volunteers I excluded 4 of them. One subject was not able to repeat the commentaries; he did not seem willing to put any efforts even though he knew ahead of time what the experiment would be. He probably assumed the tasks would be easier. Besides, the subject spent almost twice the time other subjects spent for the training session and to fill out the first questionnaire, as a result not enough time was left to run the entire experiment. The second subject I decided not to include was not repeating the commentaries either but just using the CIS. The third and fourth subjects had difficulties repeating and did not try to find any of the athlete's information asked. Therefore my data analysis is based on the behaviors and answers of 14 subjects.

I decided to focus on a specific independent variable: the country of origin of the subjects (from the USA or not). The first reason for choosing this set was because the CIS is used during international events by both English and non-English speaking journalists. I wanted to see if the language factor had any impacts on the performance of end users. Besides, even though the non-US subjects understood and spoke English well, I assumed it would be more difficult for them to perform the experiment tasks since repeating every word of the journalists' comments in English seemed to me more difficult for them. Indeed, they would have to process more information due to the language issue. Therefore even if the difficulty in the questions asked were the same for US subjects and non-US subjects, the latter would already have a higher cognitive load. This state is interesting because it foresees how the US subjects would behave in the next tasks when the work load increases. Table 17 (on the next page) represents my set of subjects. Even though not my primary interest in this study, I identified the gender factor as another possible interesting set. I will give some details of my finding in the future work chapter.

	US subjects	Non-US subjects	TOTAL
Males	5	3	8
Females	2	4	6
TOTAL	7	7	14

Table 17: Sets of subjects for my experiment

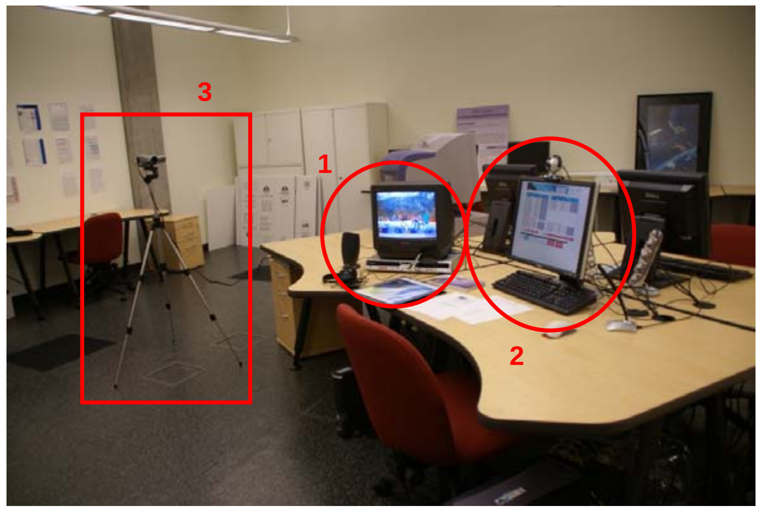


Figure 44: Set up for the experiment

The experiment took place in the Oregon State University (OSU) usability lab (Figure 44), which was equipped with monitoring and recording programs. I added to the environment a TV (marked as 1 in Figure 44) to display the biathlon event in order to simulate the real work conditions of journalists. The CIS (marked as 2 in Figure 44), which the subjects would be using, was running on a regular Windows machine. I also put in the room a camcorder (marked as 3 in Figure 44) to record subjects' reactions and their interaction with the system during the experiment. With this video camera I was able to tape the user and the CIS screen. I put it far enough to have a large view of the scene. Since the camera was next to the TV speaker, I had on the audio track of the tape both subjects and commentator's commentaries. After each subject had completed their experiment, I had a 1h30 tape with their every move. The webcam on the top of the CIS screen was the tool I used to record the visual expression of the subjects. Then, I could study this file to see how they reacted during specific phase of the experiment. At the end of the experiment, I had audio and video tracks from each subject, which helped a lot during the data analysis. After the experiment, I transferred the 18 video tapes onto 18 DVDs. I saved the webcam media files on a separate DVD. On both video feeds, from the camcorder and from the computer used for the CIS, I had an audio track.

In addition to the CIS and the TV I was going to hand out to participants some additional documentation, like during real sports events, which I chose carefully to be relevant to the biathlon event. If they wanted, subjects could refer to a paper (Appendix 29) which explained the 2006 biathlon rules for those who were not familiar enough with this discipline. Another paper resource (Appendix 30) was the biathlon results from the 2002 Winter Olympic Games which could be useful to them if they needed additional information about previous events.

Finally, subjects also had two different guides, one for the 2006 Winter Games (IOC-5 2006) and one for the 2002 Olympics (IOC-3 2002). When the 2006 guide was more for general information, I bookmarked the 2002 guide to refer only to biathlon, which had more details about the rules and the events, and had some figures.

The set up described in this section was the starting point to my experiment. To have some answers to my research questions, I needed to design the right set of tasks, questionnaires, and questions. In the next section I will be presenting the tools I used and their sequence over the experiment.

7.2.3. Procedure

I had planed a duration of 2 hours per subject to finish the experiment and it actually lasted 1 hour and 40 minutes on average. The successive experimental sections were the following:

- First, the volunteers went through and signed the consent form and filled out a pre questionnaire (Appendix 31) about their experience with computers, their knowledge of winter sports, and specifically biathlon, as well as their background in broadcasting if any.
- During the first 15 minutes, participants took a short training session during which I gave them some reminders about biathlon rules (Appendix 32), I presented them the paper resources they had, I showed them two short clips of the video they were going to watch on TV (the beginning and a section where journalists explained the rules). Then, I taught them how the CIS and its main features worked. I always made sure to let them ask me any questions during the training. The subjects were able to browse the CIS at leisure for a couple of minutes afterward to become familiar with it.
- At that point, the participants filled out a mid questionnaire (Appendix 33) in order for me to gather some information on their first experience with the CIS.
- Then, I explained to them how the experiment was going to be conducted, what the tasks they would have to perform were and what I expected from them. I told them what they would have to write down, time differences, leg numbers, shooting results and intermediate times on the sheets of paper, called Note Cards, I would gave them (Appendix 34) between each phase. Each participant had the same athletes to keep track of. I explained to them the Bonus Questions concept and the rewards they would earn when answering correctly. These were aim to test subjects' work-load, by asking

additional questions, called Bonus Questions (Appendix 35), during the experiment (only 1 minute was allowed to suggest an answer). They were meant to probe the subjects' willingness and ability to answer, serving as an indicator of cognitive load. The Bonus Questions were designed such that the participants needed to use the CIS, paper resources or the TV monitor to find the correct answer. Each participant received the same set of questions at the exact same time. A total of 7 Bonus Questions were asked to each participant (6 when not enough time toward the end of the experiment) and no hints were given to them about what resource to use to find the correct answer. This was a way for me to analyze what was the first kind of resource they used, if they were willing to answer, if they felt comfortable browsing the CIS when not sure the answer would be there, etc. After each session I counted the number of correct answers they gave and I rewarded them with snacks based on their performances.

- During the experiment, users were video and audio taped; I took notes of their behaviors and interaction with the system as well. The CIS recorded into log files the screens the users accessed and at what time. As soon as the video started on TV, the CIS simulated real conditions synchronized with the TV images; on the CIS was the information available at the time specified. The experiment had five different phases:

    - The first phase lasted 12 minutes and 14 seconds (8:10 of live video and 4:04 of commercial breaks). During this period of time participants watched the biathlon event video, listened to the audio comments from the journalists and repeated out loud every word they heard emulating commentators. In the meantime, I handed out 2 Bonus Questions to see how efficient they were without too much work-load and when being interrupted. The second commercial break indicated the end of this first phase.
    - Then, during 11 minutes and 4 seconds (8:54 of live video and 2:10 of commercial breaks) subjects kept repeating what they were hearing, but in addition they had to keep track of what was going on during the event for one specific athlete. While writing down on-going results and repeating out loud journalists' commentaries, I handed out two other Bonus Questions.
    - The third phase started after the third commercial break. It was shorter due to the time between each commercial break; it lasted about 6 minutes and 20 seconds (4:27 of live video and 1:53 of commercial breaks). Participants had to repeat journalists' comments, keep track of information about three athletes and I handed out one Bonus Question .
    - After the fourth commercial break, it was the fourth phase. That time, still repeating, participants kept track of information about five athletes over 11

minutes and 32 seconds (8min of live video and 3:32 of commercial breaks), or 7 minutes (4:43 of live video and 2:17 of commercial breaks) depending on the time constraint. I handed out two, or one, Bonus Questions depending on the remaining time.

Note: The use of the CIS ended after the fourth phase, it means its use lasted about 40 minutes. The different stages were designed to gradually increase subjects' work load.

- Then, I asked the participants some questions about their practice with the CIS, what they would improve, what they think was difficult, easy, or any other comments they had, and I asked them to fill out a last questionnaire more thorough about their experience (Appendix 36).
- Finally, before they left the room, I gave them their rewards and the $10 compensation for having completed the study.

I intended to focus my analysis on how long subjects were able to keep up with the audio comments by repeating them out loud, how long the gaps were between stops, etc. By analyzing the Note Cards I gave them to keep track of the results, I saw how accurate they were in their answers and this gave me an idea of their performance. In addition, I analyzed the path they followed through the CIS using the log files recorded during the experiment. I used the video and audio records to study the way they found the correct answers to my Bonus Questions, how their work strategy evolved over time and with load, or if in specific conditions they decided not to use the CIS on purpose. All these results would help me to understand what I saw in Sweden as well as the results I found when analyzing the CIS during the design and content studies.

The experiment helped me to answer some of the new research questions asked during the theoretical analysis of the CIS and after I analyzed my first findings. Knowing when and why users made mistakes, if they did, and how they dealt with them seemed essential. In addition, I wanted to suggest design ideas for a new interface and look at differences in terms of performances depending on the users (US subjects vs. non-US subjects).

7.2.4. Results

The data transcription started after all my subjects participated in the experiment. Using the video from the camcorder I transcribed the exact time subjects filled out the Note Cards and the Bonus Questions. I used the same feed to know what CIS screen was displayed at that time so I was able to know if their answers came from the TV, from other resources, or from the CIS and if from the latter I indicated what specific screen they used. By doing so I would have some hints about why they made mistakes, if they did, or where they found a specific answer when it is available on multiple screens.

By knowing the exact time, I could compute the time difference with the moment the information was available on the CIS or on TV. I used this data for the delay analysis described in the next section. I listened to the subject's comments to see if there were any gaps. I mean by gaps, the time between a statement made by a journalist and the time the subjects repeated it. When audio gaps occurred I recorded their length and the how many of them happened per subject.

Once I had everything transcribed, I started to analyze using statistical tools and set comparison methodologies. I computed the total number of answers subjects replied to, their correctness, the sources they used, the data delay (how many and how long), if any, they had when writing them, the audio gaps (how many and how long), if any, they had, what fields they left empty on the Note Cards, etc. Then I computed some percentages for comparison purposes.

In the next sections I will detail my data analysis, my main findings, and I will give some of the reasons and assumptions for such results.

7.2.4.1. Overview

Because of the small number of subjects I had, I was not sure if the assumption of a normal distribution, a Gaussian shape, would be a correct hypothesis. Therefore, rather than using parametric statistical tests such as the ANOVA test, I decided to perform non-parametric tests. I used the Wilcoxon rank-sum test to find the p-values. The advantage for this kind of test is that it does not make any supposition about the population being tested; however the drawback is that it is less powerful: it is more difficult to detect significant differences. Nevertheless, I was able to find enough major differences to report them in the following data analysis results section.

For each statistical result, I will state the Wilcoxon Z value of the test, which is the statistical difference between the two sets (US subjects and non-US subjects), and the p-value when significant (when $p < 0.05$). Table 18 (on the next page) is a summary of my results.

				US subjects	Non-US subjects	Causes
Answers provided	Phase 1	BQ	answered	**36%**	**79%**	Cognitive overload
			correct	100%	79%	
	Phase 2	BQ	answered	50%	71%	Cognitive overload
			correct	100%	100%	
		NC	answered	91%	54%	
			correct	87%	96%	
	Phase 3	BQ	answered	29%	57%	Cognitive overload
			correct	100%	50%	
		NC	answered	**59%**	**47%**	
			correctly	98%	85%	
	Phase 4	BQ	answered	43%	57%	Cognitive overload
			correct	100%	100%	
		NC	answered	75%	61%	
			correct	88%	84%	
Gaps	Phases 1 to 4	Data delay (min:sec)		1:16	2:18	Cognitive overload
Screens used	1st questionnaire			34	61	Uncertainty
	2nd questionnaire			17	23	More familiar

Table 18: Results overview after statistical analysis

Legend:
NC: Note Cards
BQ: Bonus Questions
Marginal results
Significant results

7.2.4.2. Subjects' efficiency

As mentioned previously I divided my experiment into 4 phases, each increasing the work over load over the time. During these periods I asked subjects to keep track of information about specific athletes (intermediate times, shooting results, etc.) when at the same time I asked them random questions. For the latter, they had limited time and were not allowed to answer after 1 minute elapsed. When keeping track of the athlete's information I asked them to use Note Cards I provided. At the same time, during the entire experiment, when the biathlon event was occurring, not during the commercial breaks, I asked subjects to repeat everything the journalists were saying. Next is my analysis of how the subjects performed to both the additional questions and the information they had to find in the CIS about the athletes.

It is important to remember that every subject, prior repeating the commentaries and looking for specific information in the CIS, had a training section where they were able to ask questions and could browse the CIS on their own until they felt comfortable enough.

During the phase 1, subjects had to repeat the audio comments from the commentators and had to answer 2 questions handed out without notice. The US subjects answered on average only 36% of the questions when the non-US subjects did 79% which is a significant difference ($Z = -2.3702$, $p = 0.0178$).

In order to explain this difference, I looked at how the subjects behaved during this first phase. The US subjects were really into repeating commentaries, they did not pay too much attention to what was going on around them, and they wanted to get used to the task. On the other hand, the non-US subjects had difficulties from the very beginning and due to a higher cognitive load. They preferred to answer the additional questions, Bonus Questions, task that seemed to be easier for them at that time.

This explanation is confirmed by the audio gaps I noticed during that phase. Non-US subjects tended to have a marginal difference in terms of number of audio gaps (2 for US subjects vs. 4 for non-US subjects, $Z = -1.7662$, p = n.s.) and a significant difference in terms of length of gaps compared to US subjects (0:12 for US vs. 0:39 for non-US, $Z = -2.305$, $p = 0.0212$). It means, instead of repeating, non-US subjects were looking for the answers to the Bonus Questions.

During the second phase of the experiment, subjects had to repeat what they were hearing as well as keep track of the information of one athlete; this was to increase the work load and cognitive load. US subjects tended to do better than non-US subjects with 91% of information filled out vs. 54% for non-US subjects, which is only a marginal difference ($Z = 1.6405$, p = n.s.).

US subjects had fewer and shorter audio gaps than non-US subjects, even if this difference is not statistically significant, it means US subjects were able to handle both tasks when non-US subjects had difficulties to keep up with them.

When in the previous phase US subjects focused on getting used to the audio comments and did not pay too much attention to the questions, on the contrary to non-US subjects, during this phase US subjects were used to the task of repeating commentaries and were able to focus more on the questions. Non-US subjects tried to get used to the audio task and therefore lost track with the information they had to keep track of, they had already reached a high cognitive load.

During the phase 3, subjects had to keep track of the information of 3 athletes at the same time when still repeating the commentaries. By doing so, the work load had more than doubled. I noticed that there was a significant difference in the percentage of correctly information filled out. US subjects had 98% of correct information when non-US subjects only had 85% (Z = 2.0546, p = 0.0399). This result confirms what I observed in the previous phase. On the other hand, the difference between the amount of information filled out had no marginal difference anymore, however, when US subjects and non-US subjects provided on average about the same percentage of answers (59% vs. 47%, Z = 1.0933, p = n.s.), non-US subjects encountered a higher cognitive load and made more mistakes (2% for US subjects vs. 15% for non-US subjects).

As expected, the task for non-US subjects is perceived more difficult by them than US subjects since English is not their native language, therefore the current struggling state for non-US subjects can be seen as the future state of US subjects when the work load will increase even more: with high cognitive load, number of mistakes is more important.

This result was confirmed during the 4th phase where the percentage of answers stayed low for both US subjects and non-US subjects (75% and 61% respectively, Z = 0.9594, p = n.s.). However, there was no significant or marginal difference between these two sets of subjects. Their percentage of correct answers remained very high for both US subjects and non-US subjects (88% and 84% respectively, Z = 0.5134, p = n.s.). It seems that their strategy was to spend more time finding the correct answers, even if they ended up not filling out the entire Note Cards, rather than finding all the athletes' information. This assumption about their strategy is actually confirmed with the delay there was between the time the information was available on the CIS screen and the time they actually used it and wrote it down. The next paragraph is going to detail this last statement.

Over the 3 phases were subjects had to keep track of athletes' information, we saw that even though non-US subjects were less efficient than US subjects, the amount of answers provided has the same pattern. Indeed, during the second phase both sets found a lot of information but were not used to the task yet. Therefore, in the 3rd phase they were performing better because they knew where to find the information and how to handle repeating and tracking information at the same time. However, in the 4th and last phase, after increasing significantly the subjects' cognitive load, subjects did not succeed as well as they did during phase 4. Table 19 (on the next page) gives a summary over the 3 phases and shows the negative impact cognitive load had on the CIS users' performances.

	US subjects	Non-US subjects
Phase 2 (Keep track of 1 athlete)	91%	54%
Phase 3 (Keep track of 3 athletes)	98%	85%
Phase 4 (Keep track of 4 athletes)	75%	61%

Table 19: Information filled out

Note: Another explanation for a better score during phase 3 could be linked to the number of interruptions subjects had. Indeed, due to time constraint, I only asked 1 additional question during this period of time versus 2 during phase 1. In phase 4 I asked 2 extra questions to 10 subjects and only one question to the 4 remaining subjects due to time constraint too. Clearly, subjects were less disrupted during the 3rd phase, which could explain their better results.

I also noticed a statistical marginal difference between the time the information was available and the time it was actually recorded by the subjects. Indeed, US subjects tended to have on average a 1 minute and 16 seconds delay over the 4 phases when non-US subjects had a 2:18 delay (Z = -1.5333, p = n.s.). Again, this is due to the work overload they underwent. Table 20 represents the delay evolution over the 4 phases for both US subjects and non-US subjects (these are the means).

	US subjects	Non-US subjects
Phase 2	1:03	1:19
Phase 3	1:08	1:44
Phase 4	1:38	3:11

Table 20: Time delays (min:sec)

The time 3:11 in phase 4 for non-US subjects seems a big difference from the delay times in the other phases. This is due to one subject who reached their limit very early in the experiment and kept accumulating delays. Actually 3 subjects significantly increased their total delay from phase 3 to phase 4 to more than double. Refer to Table 21 (on the next page) for a summary of their results.

Note: In Table 20 there is no data for phase 1 because they just had to repeat what they were listening to; during that phase I did not ask to keep track of information of any athletes.

	Phase 3	**Phase 4**
Subject A	1:29	8:53
Subject B	1:22	3:09
Subject C	0:30	2:47

Table 21: Total delay accumulated in phases 3 and 4 (min:sec)

These subjects had a high total delay over the experiment; they reached their limit early in the experiment. I decided not to exclude any of them since they behaved the same as other subjects for the other tasks.

Note: In Table 21, I did not give the results for the second phase since 2 of these subjects did not answer any of the questions, therefore no delay can be computed. The third subject did not have a significant delay difference between the phase 2 and 3, for this reason I did think the data was relevant to this table.

With these first results, we see that cognitive load is clearly higher for non-US subjects. The fact that non-US subjects make more mistakes than US subjects can be linked to their behavior when they had to fill out a first questionnaire. Indeed, in this questionnaire they had to find specific information in the CIS and there was a marginal difference in the number of screens they used: 34 for US subjects vs. 61 for non-US subjects ($Z = -1.9209$, p = n.s.). Since they also browsed the system longer (on average 6:41 for US subjects vs. 8:29 for non-US subjects $Z = -1.0222$, p = n.s.), it means they were not sure or confused where to find the answers to my questions.

On the other hand, when asked if they felt some information was more difficult to find than other, there are some interesting differences in their ratings. When we could think that non-US subjects find it harder, it is actually US subjects who had more difficulties finding information such as the prone shooting results, the age of an athlete or the names of some team members ($Z = 1.8224$, p = n.s.; $Z = 2.1757$, $p = 0.0296$; $Z = 1.7817$, p = n.s. respectively). These answers, gathered from a questionnaire handed out right after the training session, were slightly different from those provided in the last questionnaire, once the main task was over, but with the same set of questions. Indeed, there was now a marginal difference with US subjects finding more difficult to locate the age of an athlete. The other marginal difference was when they had to look for the athlete's rank. In addition, after they were used to the system, I noticed a significant difference in the difficulty US subjects had to find the athlete's country of origin ($Z = 1.986$, $p = 0.047$)

compared to non-US subjects. It seems some types of information are more difficult to locate for US subjects than non-US subjects.

As seen in this section, some major differences appeared in the use of the CIS based on the end users. Overall, US subjects performed more efficiently than non-US subjects did even though the latter found the CIS easier to learn ($Z = 2.3274$, $p = 0.0199$). We saw that they did not make a lot of mistakes when filling out with information the Note Cards I gave them. Instead, they chose not to answer when they were not sure.

7.2.4.3. Sources of errors

In the previous section we found clear evidence subjects experienced a high cognitive load. We saw that few mistakes were made due to the subjects' strategy, which was to leave fields unanswered rather than making mistakes when they were not sure about their answers. Now that we saw when they make mistake, I am going to detail at the type of mistakes users make. I looked at all the mistakes made for which I could attribute a source. Table 22 is the summary of my findings.

Source of error	**Number of errors**	
Spare bullets left when used	23	42%
Incorrect screen	13	24%
Total penalties when Prone or Standing	12	22%
Wrong row	4	7%
Confusion on sheet	3	5%
TOTAL	55	

Table 22: Sources for the mistakes subjects made

The more typical mistake made was to get confused with the number of spare bullets used or left. Indeed, on the CIS screen the information provided to the users only says if it is the first or second shooting range. For the first one, the Prone position, this is only indicated with a (P) on screen. In the second position, the Standing is indicated with a (S) (refer to the red boxes on Figure 45, on the next page). First of all, several times during the training session, subjects asked me to repeat what these letters stand for. In addition, no information is provided about the two numbers display in this column: $0^{(1)} + 0^{(2)}$. Again, subjects asked to be reminded what these numbers were for (the left number, $^{(1)}$, is the number of penalty loops the athletes went through; the right number, $^{(2)}$, is the number of spare bullets they used). This last confusing information was the source of almost half the mistakes (refer to Table 22). Subjects got confused and believed it was the number of bullets left the athlete's rifle. This design misled the users and made them process more information than they should.

Bib No	Name	NOC	Penalties (P)	Penalties (S)	Penalties T.P.	Rk	Time	Diff
8-1	O. Khvostenko	UKR	0+0	0+0	0+0	9	14:02.0	+31.9

Figure 45: Screenshot of the shooting information on the CIS

To solve this issue, the initials should be explained or put in a legend so users can refer to it if they forget what the letters and numbers stand for. Having the same format for both penalty loops and used spare bullets may be not very convenient either since these are two different types of penalties but they are referenced the same way. This would probably need to be changed to give more feedback to the users about the information on the CIS screen.

Another common error was when subjects got confused by the meaning of T.P. (Total Penalties) next to (S) and (P) (refer to the red box on Figure 46). Again, I had to repeat the meaning of this data after many subjects asked me during the experiment. It seems that this column, which is the sum of all the penalty loops (left number) and the sum of all the used spare bullets (right number), was more distracting than useful. Instead of using the information like initially defined, they used the right number of (P), or (S), and the right number of T.P. as the number of penalty loops and the number of used spare bullets respectively. Like for the issue encountered with the meaning of the data under (P) and (S), not having any definition of what the letters "T" and "P" stand for confused the subjects a lot.

Bib No	Name	NOC	Penalties (P)	Penalties (S)	Penalties T.P.	Rk	Time	Diff
8-1	O. Khvostenko	UKR	0+0	0+0	0+0	9	14:02.0	+31.9

Figure 46: Total Penalties for the shooting results

To solve this recurrent problem, the same ideas as for the (P) and (S) mistakes suggested above can be used.

The second main source of mistake was when subjects thought they were on the correct screen when they were not. This happened only on the Progress screens. Some users looked at the left table results when the information asked was on the right table and vice versa. This was probably due to a lack of concentration since they were multitasking. I also noticed some of the subjects not paying attention to the title of the table, which indicated what intermediate point or shooting range it was about. Indeed, since the sequence of the screens alternates between intermediate points (Int 1, Int 2, Int 3, etc.) and shooting ranges (S1 and S2) (Figure 47 on the next page), some users used the first screen, Int 1 / Int 2, to record correctly the information for these two intermediate points and then went to the second screen, Int 2 / S1, thinking it was Int 3 / Int 4. This mistake represented about a fourth of the different types of errors subjects made. The first type of errors was related to cognitive load, this one is related to the way users navigated through the interface and also linked to the subjects' cognitive state. Indeed, because they did not have time to pay attention to little details such as those mentioned they made more mistakes than if they were fully focused on the CIS.

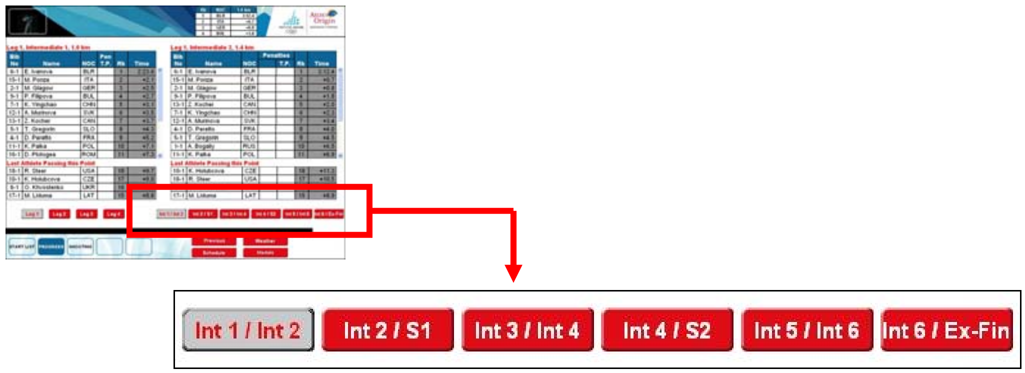


Figure 47: Sequence of buttons for the Progress screens

To fix this type of mistake, the sequence of screens has to be convenient to users. Having shooting results with intermediate times may be confusing. It seems more suitable to have a continuous flow rather than different kind of data on a single screen. Besides, the shooting results are also available in a more detailed version on the Shooting screens so they do not need to be on the Progress screens too. One of the possibilities to fix this problem would be to keep the sequence as well as sending in parallel some indicators to the users to let them know they are looking at shooting results. Another solution would be to differentiate the shooting and time results by having specific screens for both.

Another common error, which did not lead to many errors but more to a waste of time, was choosing the wrong Leg. I will discuss these findings in details in the section 7.2.4.5.

An additional interesting source of error, even though not significant, was when users transcribed the information from the previous or next row. This problem happened when they had to write down the intermediate time of a specific athlete. Some subjects transcribed the complete wrong time and some wrote the correct minutes but the wrong seconds. The latter was usually due to a first look at the CIS to transcribe the correct minutes, but when looking back at the screen to take notes of the seconds, the subjects used the result time of the athlete on the previous or next row. Those who had difficulties to stay on the correct row ended up using their finger or pen as a place-holder (Figure 48). This issue is due to the large amount of information displayed on a single screen, which subjects complained a lot about.

Figure 48: Subject using his pen to locate the correct time

This is a recurrent problem that occurs in spreadsheets as well. The difficult task is to go from one end of a row to the other especially when the height of the row is small and it is surrounded by many other rows. A solution could be to highlight the specific row the users are interested in when they touch any information from this row (athlete's name, rank, bib number, country, etc.). As a result the row is in contrast and easy to follow. To un-highlight it, users would have to touch it again, which makes the procedure very easy to remember and to execute.

The last most common error was made by subjects when they wrote the results of an athlete at the wrong places. Since on a single page there were blank fields for two athletes, it happened that they wrote down the information in the other athlete's area. This is another sign of distraction due to the high work load they had to face.

We saw here many errors due to several factors. It is obvious that the interface does not provide enough information to the users and therefore they make mistakes easily (spare bullets left / used, current leg, T.P., etc.). At the same time, subjects had to deal with large amount of information on screen such as big results tables. This led them to make mistakes when they had to locate a very specific piece of information. Finally, due to the tense environment they had to deal with, little time was available if they wanted to keep up with events going on. The cognitive load, the interface as well as the navigation implementation did not seem to be efficient enough for such conditions. I mentioned some ideas that could be used to avoid these situations, in the next section I will give more details about how subjects dealt with their mistake as well as their strategy when using the CIS.

7.2.4.4. Approaches to dealing with errors

We know what kind of mistakes subjects made and their sources errors, thus having an idea of the different solutions they used to deal with them would be interesting. In order to do so, I looked at subjects' behavior, at their questionnaires and at their answers on the forms. Table 23 (on the next page) is a summary of my findings based on my observations during the experiment and the post-analysis.

Response / Source of error	Stop repeating	Crossed out	Double check	Go back and forth between screens	Scroll up and down
Spare bullets left when used		X	X		
Incorrect screen	X			X	X
Total penalties when Prone or Standing					
Wrong row	X	X	X		
Confusion on sheet	X	X	X		

Table 23: Consequences to mistakes / uncertainty

Confusing the number of spare bullets left with the number of bullets used was very common. This mistake was when the subjects mixed how many bullets the athlete just used with the actual number of bullets left in the rifle. Most of the time subjects were not sure about the correct number to give; therefore they double check until they write down their answer. Some, still not sure about the figures they wrote, crossed out their answer to change it (from used to left bullets or vice versa, changing a correct into an incorrect answer and vice versa).

The incorrect screen as source of error is when the subjects are not on the screen where they should find the correct information; they notice it by not finding the athlete at all. Therefore, they usually spend a lot of time scrolling up and down the big results tables to find the athlete’s name but vainly. They end up having to go back to the start list where the information about the athlete’s leg is, another reason why they loose time and get delayed. Finally, if they really do not know why they cannot find the athlete, they stop repeating the commentaries and take a closer look at the tables one more time. As an observer, I know when they realize they did not pay attention to the leg when they should have because many of them say it out loud or make a gesture that mimes they should have thought about it earlier.

The “total penalties when Prone or Standing” source of error is when subjects used the total number of penalties when they should have been looking at either the Prone or Standing results. In that case, nothing happened since they did not notice their mistake. Usually, this is due to subjects who did not understand the meaning of the letters and did not want to spend time looking for the correct answer. Therefore they wrote randomly what they thought had the most chances to be correct.

Sometimes users made mistakes because they looked at the information on the wrong row. Because there are 18 rows per table, and 2 tables per screen (I do not take into account the “Last athlete passing that point” table with only 4 records because hardly used by subjects) a lot of information is on one screen and separated by a few inches. Users are multitasking when reading and writing down the answer on their sheet, and as a result they could not remember at once the answer and had to look back at the row. This was a difficult task; they had to be very accurate and needed to pay a lot of attention. Some subjects just stopped repeating until they had the correct information written down, others doubled check several times and if they realized they made a mistake, they corrected it. We saw, in one of the previous section, the use of pen or finger to locate the result on a row.

The confusions on sheet had similar consequences as when the row was not correct. Subjects usually wrote the time of an athlete in another athlete’s text field or wrote an intermediate time at the wrong place. Some realized their mistake but others did not, which accounted as errors at the end of the experiment.

We saw some basic mistakes due to a poor interface design and a heavy data interface overload. The user’s experience suffers from those by loosing a lot of time, getting delayed or worst, making mistakes. Many subjects mentioned it when I asked them what they thought was not convenient when using the CIS.

In the next section I will focus more on the interface and navigation implementation in order to link them to common subjects’ mistakes.

7.2.4.5. Navigation observations

During my analysis, when I looked at the Note Cards the subjects gave back to me after the experiment, I noticed some recurrent empty fields on many forms. It turned out some did not transcribe any information at all for one specific athlete. Indeed, I asked them on purpose to keep track of the last athlete who was far behind. Out of the 14 subjects, one did not have even time to look at the athlete since he already had difficulties with the other athletes; 6 transcribed some or all the information, but 7 did not fill out anything for this last athlete thinking it was a mistake and they would not find this biathlete. This means they did not rely on the system even if it was clearly stated in the Team Members list that this athlete was part of the race. It also implies that the system does not provide any information about late athletes who are not in the same time range as the leaders. Indeed, between the two intermediate points where the athlete’s time is recorded and appears on screen, the athlete virtually disappears from the CIS. According to those who found the athlete and saw that she was running late, they mentioned how difficult it was to go back and forth between the screens to find her late time or late shooting results, while they had to keep writing down the time of the leaders at the same time. As a conclusion, the navigation tends to be an issue when an athlete is far behind.

Yet some visual clues exist to let the users know who crossed a specific intermediate point in last position (Figure 49). Additionally, since the rank number is mentioned (refer to the red vertical box on Figure 49) and they are able to know how many athletes are competing, they know when athletes are still missing a check point. However, based on my observations and subjects' use of the interface, they did not pay attention to this small table and some did not even understand what it was for. It seems this additional data on the CIS could be removed if it only adds information overload.

Figure 49: Information about the 4 last athletes at an intermediate point

This situation happens often during sport events, athletes can be running very late or be well ahead of time. In both cases the journalists should be aware of the situation and have a global overview of the game, race, heat, etc. For sports with a limited number of athletes, an option like a pop up window to display on the screen a small picture of the current state of the race for instance could be considered. The users would be able to see live where the athletes are at that present time.

The results of this experiment clearly indicate that there are issues with the users' navigation experience. Indeed, when they should reach a screen quickly and without any hesitation, they sometimes need several intermediate screens, or use longer path than those initially designed.

If we take a closer look at the number of screens displayed by each subject for the entire experiment, we see that on average they display about 51 screens (50 for subjects vs. 53 for non-US subjects, Z = -0.5111, p = n.s.). Among the 14 subjects, 723 screens were displayed. The most frequent ones are in Table 24 (on the next page). We can see that only 6 different screens represent more than 50% of the total displayed screens. The three grayed screens are the “transition” screens. This means when a user clicks on the “Start List”, “Progress”, or “Shooting” button the screen displayed by default is respectively the “Team”, “Leg 1 Int 1 / Int 2”, and “Leg 1 S1” screen. This data tells us that they clicked more often on the “Progress” button than any other buttons and that going through each of these screens is necessary when looking for any kind of information. Depending on what information they had to look for, they used more screens than others (Leg 1 Int 5 / Int 6 and Leg 2 Int 1 / Int 2 for instance).

Screen	Times displayed			
Progress: Leg 1 Int 1 / Int 2	110	=385	15%	=53%
Start List: Team	76		11%	
Start List: Team Members	53		7%	
Progress: Leg 1 Int 5 / Int 6	53		7%	
Progress: Leg 2 Int 1 / Int 2	49		7%	
Shooting: Leg 1 S1	45		6%	
Other (33 screens total)	338		47%	
TOTAL	723			

Table 24: Number of times for the most displayed screens

On Figure 50 is the overview of the screens reached during the entire experiment. The transition screens are clearly in majority. Additionally, for legs 1 and 2, the subjects used extensively the screens necessary to find the information asked.

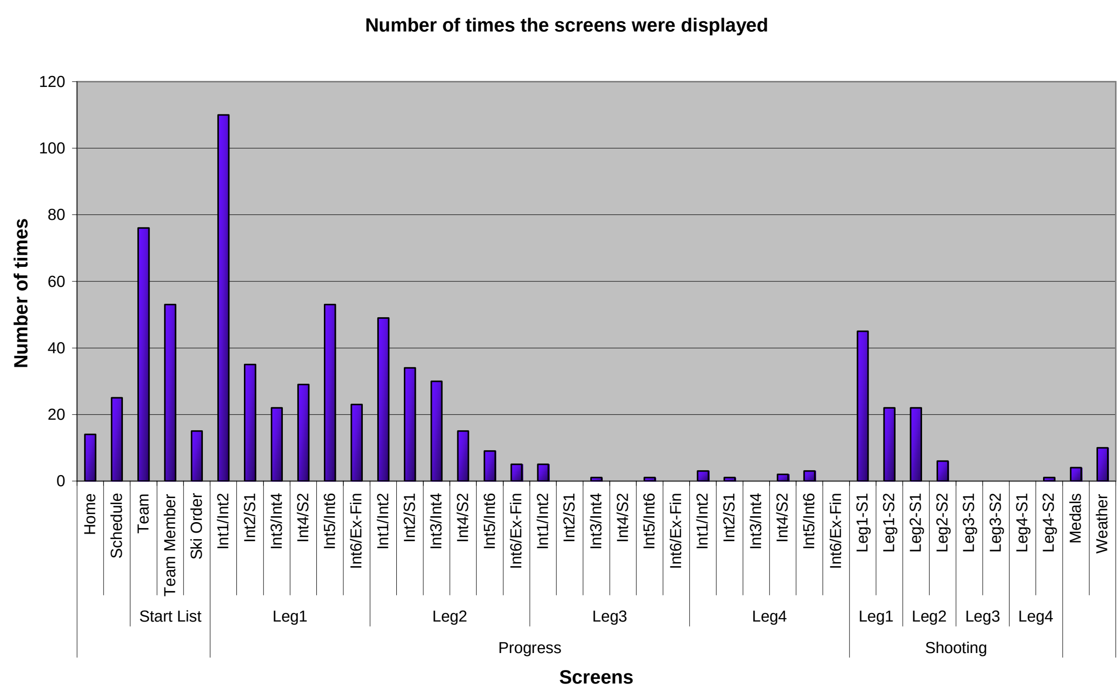


Figure 50: Number of times subjects reached any of the available screens

Now that we have an idea of the screens subjects used, the next question is to know if they displayed the screens because it was part of the path to reach a specific target or because they found useful the information on that screen. For that purpose I asked at the end of the experiment: “Which screens seemed the most useful to you?” – Q1. Users were able to cite any screens and as many as they wanted. Table 25 gives a summary of their answers.

Screen	**Times mentioned**	
Progress	14	54%
Shooting	5	19%
Team Members	5	19%
Start List	2	8%
TOTAL	26	

Table 25: Answers to Q1 provided in the post experiment questionnaire

Not only is the Progress screen extensively used as a transition screen but it seems subjects liked the information it provided (all the 14 subjects mentioned it). Indeed, this type of screen contains the data for intermediate times as well as shooting results. I noticed that they answered in a general form their preferences for Progress, Shooting and Start List screens (each regroups several sub categories), but specific screens in the Start List category which is the Team Members screen. They clearly identified this display to be useful to their experience. It is confirmed on Figure 50 (on the previous page) by the high number of times it has been displayed, which is very relevant in this case since it is not a transition screen.

Although the number of times screens were displayed was useful information, it has to be linked to the time it actually stays on screen. Indeed, depending on this variable, it can be either a transition screen or a target screen. Figure 51 (on the next page) provides the total time each screen was displayed on the CIS.

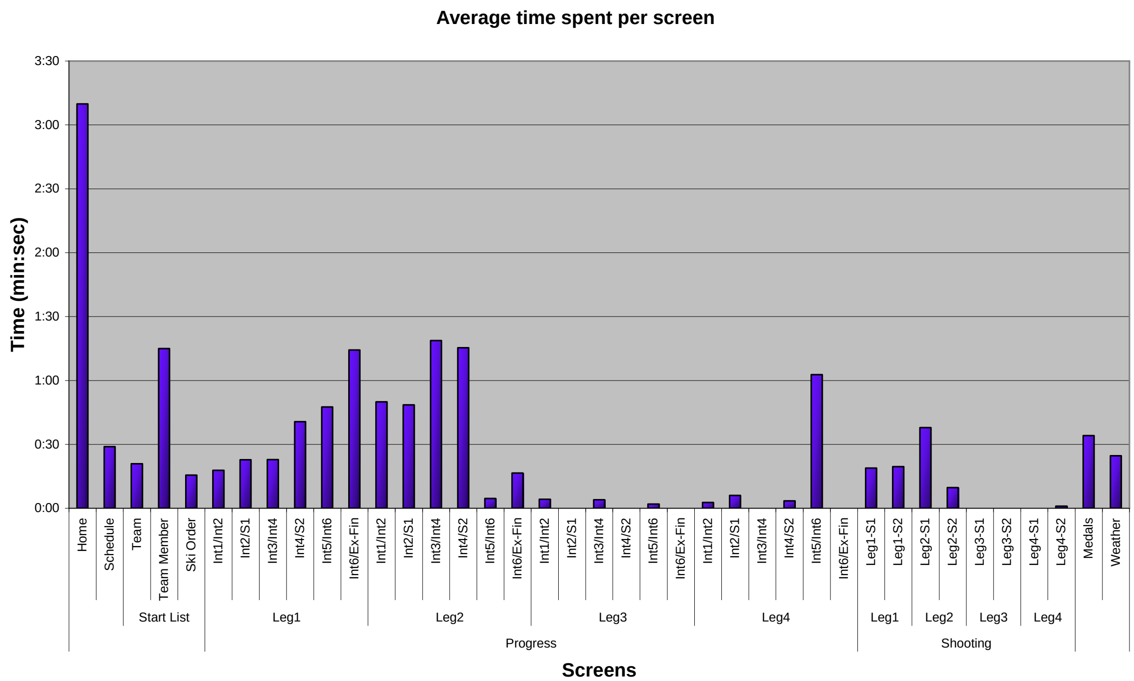


Figure 51: Average time spent on each screen

We see here a large amount of time spent on the last screens of Leg 1 (Int4/S2, Int5/Int6, and Int6/Ex-Fin) and on the first screens of Leg 2 (Int1/Int2, Int2/S1, Int3/Int4, Int4/S2). Indeed, a lot of information I asked the subjects to find was on those screens. Three exceptions occur though.

The first one is the Home screen. It stayed longer than the others because at the beginning of the experiment the subjects did not have to use the system but just had to repeat the commentaries for a dozen of minutes. A few browsed the system but most of them left the home page on since I did not ask them to answer questions that would have required to browse the CIS. The second exception is the Team Member page. Like mentioned previously, it was very useful to the subjects since they could find the athletes of every team as well as the leg they were going to compete in. During Leg 4, there is a very long time during which progress screen Int 5 / Int 6 is on. This is due to a specific user. Indeed, during the second phase the subjects had to find information that was on the progress screen Int 5 / Int 6 of the first leg. This subject went successively from leg 1 to leg 4 looking for the information required since in leg 1 nothing had appeared yet. The subject did not understand that the times were going to pop up on the screen as soon as the athletes crossed the intermediate point but not before obviously. Instead of waiting on the correct screen, **Leg 1** Int 5 / Int 6, the subject made the error to stay on **Leg 4** Int 5 / Int 6. Since nothing appeared on the screen, it was left on until the subject realized their mistake.

To see if there are differences in navigation strategy, I will now compare how long US subjects and non-US subjects spent on average on each of the CIS screens (Figure 52).

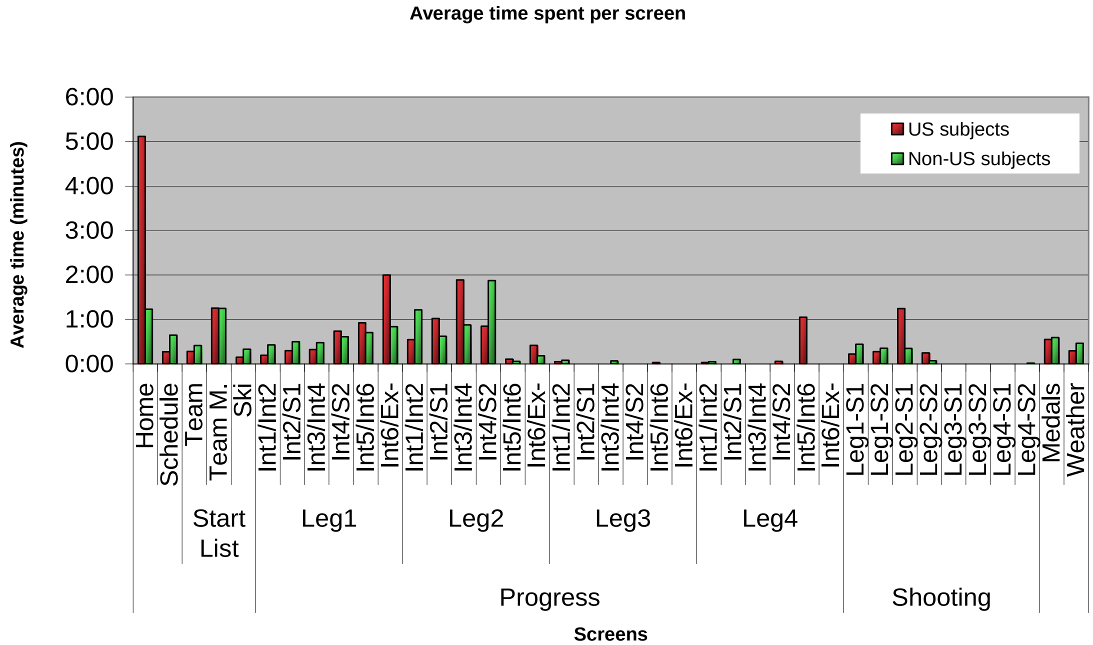


Figure 52: Time spent on each screen by US subjects vs. Non-US subjects

Since I wanted to compare the behavior of subjects, I did not focus on the significant differences (Leg 1 Int6/Ex-Fin, Leg 4 Int5/Int6, Leg2-S1, etc.) which were mainly the results of isolate subjects. Instead, I want to point out the transition screens. Those are Schedule, Team, Leg 1 Int 1 / Int 2, Leg 2 Int 1 / Int 2, and Leg 1 S1. Non-US subjects spent on average more time on each of these screens because it took them longer to find where to go next, which is synonym of a higher cognitive load. This was very time consuming for them; because they had to go through those screens and spend time looking at the information provided to see if it was the correct screen, they lost several seconds when US subjects had already reached the screen they wanted because they interacted better with the CIS.

This leads us to the sequences the subjects had to go through before they could display a correct screen. I recorded the successive screens for which there were less than 3 seconds before the next screen was displayed. Indeed, this meant it was just a transition screen. For the 14 subjects I transcribed my findings in Table 26 (on the next page).

Number of intermediate screens	Number of chains
1	115
2	21
3	3
4	1
5	1
TOTAL	141

Table 26: Chains of successive screens

With 141 chains of screens (a succession of more than 2 screens), subjects followed on average 10 chains during the experiment to reach the screen they wanted. Some of those chains were necessary to get from one CIS screen, to another but other chains were due to navigation difficulties with users looking for the correct path. In the case of the 4 and 5 intermediate screens, a subject took some time to randomly browse the CIS; therefore the time between each screen was very short and under the 3 second threshold. More important, out of these 141 chains, three occurred more than three times (Table 27).

Number of times	Sequence
11	Home → Schedule → Start List Team
4	Progress Leg 1 Int 2 / S1 → Progress Leg 2 Int 2 / S1 → Progress Leg 1 Int 2 / S1
4	Progress Leg 1 Int 5 / Int 6 → Progress Leg 1 Int 4 / S2 → Progress Leg 1 Int 5 / Int 6

Table 27: Most common sequences

The first chain is the path users had to follow when they went from the Home screen to any result screens. This was not convenient for users since they had to go through the Schedule screen every time they started from the home page. When there were not any events going on other than the one they were watching, there was no point having such a screen.

The second chain, which was generated by the same subject the four times, was due to an uncertainty on where was located the information. The user went back and forth from the first leg to the second leg. I noticed this mistake occurred regularly. Instead of focusing on where to find the correct information, users chose to navigate randomly until they found what they were looking for.

The last chain seems to be a navigation pattern since it happened four times and was generated by three different subjects. Indeed, the button “Int 4 / S2” led to the results page that is just before “Int 5 / Int 6”. When subjects were waiting on the Int 5 / Int 6 screen for the information to come up (we saw in Table 24 this display was used a lot) and realized that nothing was happening, they made sure it was normal and quickly went back to the previous results to check if all the athletes already passed that point. If so, they knew they had been on the correct page and went back to Int 5 / Int 6 waiting for the leaders to pass the next intermediate point. This problem was recurrent during the experiment, no information was provided to the user to let them know what was going on, where the athletes were. The reason why this chain was more frequent than others was because it was during the first phase; subjects did not have too much to do yet and were able to be ahead of time, waiting on the correct screen. Later on, some got behind and when they displayed the correct screen, the information was already available.

To know if the high number of chains was voluntary I decided to analyzed what the subjects’ strategies were in term of switching from one results screen during a specific leg to another for a different leg (especially on the Progress screens). Did they change the leg first or did they change the intermediate point first? Based on my observations it was obvious that they changed the leg first when using the CIS. This means, when the subjects were on the Progress screen with the results of the 1^{st} and 2^{nd} intermediate points during the 1^{st} leg and they wanted to have the results of the 5^{th} and 6^{th} intermediate points during the 2^{nd} leg for instance, they followed the pattern on Figure 53.

Progress **Leg 1** Int 1 / Int 2 → Progress **Leg 2** <u>Int 1 / Int 2</u> → Progress Leg 1 <u>Int 5 / Int 6</u>
① ② ③

Figure 53: Transition with modifying the leg first

First they changed the leg (in bold) then the intermediate points (underlined).

The 14 subjects changed 111 times total from one progress screen to another, which was in a a different leg. Below, in Table 28, is their navigation pattern:

Change preference	**Count**	
Leg	84	76%
Intermediate points	27	24%
TOTAL	111	

Table 28: Decisions in changing screens

We see there are 24% of changes due to a different strategy, which is changing the intermediate points first. When this could be seen as a different choice from some subjects, I observed it was not actually due to their own decision. Indeed, they changed the intermediate points first because they thought they already were on the correct leg (Figure 54).

Progress Leg 1 **Int 1 / Int 2** → Progress Leg 1 **Int 5 / Int 6** → Progress Leg 2 Int 5 / Int 6
❶ ❷ ❸

Figure 54: Transition with modifying the intermediate points first

By looking at the time they spent on the transition screens for both chains (② and ❷) it confirmed what I observed. Indeed, the time spent on the screens ❷ (from 10 seconds to a minute) was much longer than the time spent on ② (from 1 to 3 seconds). This was due to the fact that subjects thought they were looking at the correct screen in ❷, spent a lot of time scrolling up and down the tables looking for an athlete who was not there because she was in a different leg. When they realized their mistake they change the screen. The feedback provided to the CIS users about the current leg displayed versus the one going on during the event, was very poor turned out to be a source for navigation mistakes.

This design problem is related to another observation I made. Indeed, a key navigation issue that slowed down and disturbed the users was to go from the Shooting to the Progress screens. There are 24 Progress screens (Leg 1 – Int 1 / Int 2, Leg 1 – Int 2 S1, …, Leg 1 – Int 6 / Ex - Fin, Leg 2 – …, Leg 3 – …, Leg 4 – …) and 8 Shooting screens (Leg 1 – S1, Leg 1 – S2, Leg 2 – …, Leg 3 – …, Leg 4 – …). Usually it took some time to the subjects to find the correct Progress screen (say **P**) from the list above; then, when they decided to go to a Shooting screen (say **S**) to find other information and then to finally come back to **P**, they waste a lot of time. Although a “Previous” button was available, the subjects hardly ever used it and ended up on the default Progress screen page, which was Leg 1 – Int 1 / Int 2 (say $\mathbf{P_0}$). Assuming **P** is different from $\mathbf{P_0}$, subjects had to browse the CIS interface again to go to the on-going screen **P**, which they may not remembered anymore. Some subjects wasted time looking for athletes but could not find them since they were not competing in the 1st leg, those who remembered to change the default leg did not like it either and mentioned that it was not convenient at all.

It is clear that the possible paths from one screen to another are numerous and give probably more options to the users than they really need. Having to go through screens to reach the interesting ones is a drawback of the system as well as having to browse the CIS all over again just because they changed of screen for a few seconds. Being able to set specific screens by default depending on what is going on during an event could be a solution to this navigation problem. For instance, if the leg 2 is the current leg, when clicking on Progress or Shooting the users could be automatically redirected to the correct screen belonging to the second leg. That way, they would not waste time finding the correct path, looking around and finally going through several screens to reach it.

7.2.4.6. Experimental vs. real environment

During my field study I observed and interviewed two kinds of journalists: radio and TV journalists. Although the CIS was different from the one used during the experiment I will focus on the recurrent patterns, behaviors and feedback I gathered.

For the radio journalist, I saw that he used the CIS only a few times, leaving mostly the system on the results screen. When it was not on this screen, it was because he was browsing the start list.

As for the subjects during my experiment, I asked them specifically to keep track of the athletes' times therefore they had to use the system. They could not rely only on the TV since almost all the information was in the CIS. However, I noticed the same behavior as the journalists': they left the results screen on, waiting for the information to come up when they could have been browsing the interface in the mean time. This was maybe due to the fact they were not confident enough in coming back easily to the current results screen. We saw that they also used the Team Member list screen a lot. When it was expected, since I asked them to find athletes' information, more than a third of the subjects really liked using it (refer to Table 25).

When the radio journalist was commenting the live events, he was watching the TV a lot, probably because it felt more "natural" to him to watch the images of the live feed than the CIS. In addition, knowing that the audience is seeing the same images at the same time, it would add some relevant descriptions.

During my experiment, I asked subjects to repeat what they were hearing; I did not ask them to watch the TV. However, they were all watching the TV at least during the first phase when they did not have to find information in the CIS. Beginning with the phase 2, they were having difficulties to keep track of the information. Indeed, they were repeating the commentaries, browsing the CIS for information but they were watching the TV too. I observed many of the subjects looking back and forth at the TV and the CIS when they could have just been looking at the CIS. Some subjects' body was completely toward the TV. The subjects' strategy, for the most efficient ones, was to look only at the CIS. I think this was due to the fact that knowing what was happening on the TV helped them to repeat the comments to understand the context of their statements. Still, both subjects and journalists watched the TV.

When asking the TV journalists their opinion about the CIS, they said it was a good system; however they would have liked it better if a "rank sorting" option was available. During the experiment I gathered the same feedback from the subjects. I saw them scrolling up and down to find someone and when I asked them their opinion about the system some told me they wished they could sort the athletes by name, country, rank, etc.

Another negative aspect of the CIS mentioned by the radio journalists was the language of the system. The only available is English and the journalists told me they would like to have a version of the CIS in their native language.

The results from this study showed that some foreign subjects had more difficulties than US subjects. We can assume it was due to the language the system is in, foreign subjects had to process more information to translate and it took them more time to understand.

This phase of my experimental analysis provides answers to my last research questions about the potential mistakes users make and improvements for future CIS versions:

- When do users make mistakes?

  Under high cognitive load because they cannot pay attention to minor details any longer.
- How do they deal with these mistakes?

  They stop using the CIS because they are not sure where to find the correct information anymore.
- How to customize the interface for a better usability?

  By providing more visual feedback to the users and using less amount of information at once.

These answers confirm that the CIS has usability issues and need improvements in order to meet journalists' needs.

Summary

Through this experimental analysis we saw major issues in the CIS use. Based on the observations I made during the ethnographic study, I realized early on that there were navigation and information load issues with the CIS. Having journalists using only a few screens of the system seemed inappropriate when we know the amount of information available and the data they need to make appealing commentaries. With the controlled experiment, we confirmed the high cognitive load the users undergo when using such a system and how it affects their capacities to produce good results. We saw the navigation issues related to the interface and the impact missing feedback can have on the users. I analyzed performances for US users and non-US users and we saw that with a high work load, the use of the system is definitely more complex. We also confirmed the flatness of the system by detailing the different possible paths users are able to follow. This last observation has for consequences to confuse the users, to make them made mistakes, and to waste their time. Hence, knowing that during the different phases I asked the subjects to keep track of the same information for different athletes, they should not have had to browse so many screens as presented in my findings. The right, current and useful information needs to be accessible very quickly, without any doubts and users should be able to reach it at any time. I suggested ideas to improve the usability of the Commentator

Information System and I pointed out some of the bad design implementations developers need to fix. These outcomes are for US users as well as non-US users, thus they are meaningful.

8. Future work

I mentioned previously that I also looked at the gender factor during my study. Indeed, since a very few women work in the broadcasting field (less than 10% of sports journalists in Great Britain and 12.6% of newspapers sports staff in the US are women (SportsJournalists'Association)), I thought it would be interesting to see if the CIS had been implemented to match their use as well.

Studies about gender factors have already been conducted in different areas. Some papers have been published on what impact gender has in end-user programming (Beckwith and Burnett 2004), especially within spreadsheet environments (Beckwith 2007), with some interesting results on how different males and females behave. However, few results are available on how females react to complex and high-cognitive load multitasking tasks compare to males. Even though the Corpus Callosum is said to be 20% larger in women's brain (DeLacoste-Utamsing 1982) (the two hemispheres are supposed to better interact together; so the person is better at multitasking), as of today, I did not find any studies with significant results that confirm women, or men, were better at multitasking within computer environments, which are my experiment conditions.

Due to the small sample of subjects I had and the fact that most of the female subjects were non-US subjects (we saw non-US subjects tend to perform less efficiently than US subjects) I will not draw any conclusions but I will list some of my findings related to the gender effect when multitasking as a start for further research.

During my experiment males and females behaved on average about the same. Their results when keeping track of information, or answering additional questions, were similar. Females seemed to have more difficulty keeping up with the commentaries, especially during the first phase of the experiment. Possible explanations could be due to the "good citizen effect" where female subjects were trying harder to answer questions correctly while male subjects focused on the commentaries and were more selective about what questions they chose to answer. As a result, females may have experienced a higher cognitive load than males.

To confirm this observation and make sure females' behavior can be explained the way I did, a study with more subjects, with a more homogenous distribution in terms of country of origin, should be conducted, which could lead to interesting research questions and future studies.

9. Conclusions

9.1. Discussion

I posed several research questions at the beginning of my study, which led to more questions once I found my first results. I used the theoretical and experimental methodologies to gather data, make some observations and present my findings. In this section I will summarize what I found and what will be the future steps to complete this work. First I will answer the main questions of this study. Then I will compare them with my assumptions and expectations. Finally I will suggest changes and ideas to improve the CIS.

Questions:

9.1.1. Is the system really needed?

According to the organizers, to the broadcasting companies, to journalists, the Commentator Information System is a fundamental tool when covering a live sports event. Companies are willing to invest a large amount of money to have their journalists use the system. Although there are documentations available with the past records, the past results, or the athletes' biography, the big boards in stadium are not enough as source of commentaries for the journalists to convey appealing comments to the audience. Clearly, during the ethnographic study, the journalists were using extensively other resources; however, for detailed live results, they had to use the CIS. Based on this fact, what about the system itself?

9.1.2. Is the system used as much as it should?

The CIS is necessary in journalists' daily work. However, when they could come to the stadium, or the commentary booth, with nothing else than their pass, they use to carry an important volume of additional information: official guides, official results books, printed out papers, personal computer, etc. Moreover, they use extensively these documentations to the prejudice of the CIS. This latter is almost never used and is left on one or two different screens (results and start lists). I constrained the number of screens for my experiment to those needed to find the useful information but still, 1 or 2 users browsed the system randomly to see what screens were available. The same for journalists, they know the screens they need to use and are not aware of the extra features available (e.g. video streaming) in the CIS.

To this question I would answer that the system is not used as much as it could be in terms of number of screens and different types of features.

9.1.3. Does the system meet users' needs?

Based on the observations made during my study and the answers provided to the three next questions, I would say that it depends on the users: from a journalist's or developer's point of view, the needs are different. Indeed, commentators do not complain about the CIS but its use does not meet developers' expectations.

9.1.3.1. Is there an information overload?

During my design, content and experimental studies, I realized the amount of information presented on screen. There is a large number of buttons to go from almost anywhere to everywhere, besides the data displayed is very important (lots of tables, lots of records, etc.). As a result the users get confused easily because they have too many options. I observed during my experiment what hindrance the overload information was for the subjects when looking for the correct information.

9.1.3.2. Is there enough information?

From the research I did on the content of the system and when the events actually happened, I noticed important gaps where the CIS was missing this data. I noticed similar issues during the experiment when not enough feedback was provided to the users and they made wrong assumptions (e.g. late athletes). Based on these facts, there is definitely a problem with the amount of data matching the live results.

9.1.3.3. Are there any navigation issues?

This is one of the main findings; the flatness of the system. Developers added many and many buttons to let the users be in complete control about where to go. Instead of providing quick access to the CIS screens, it is time consuming. Indeed, the users need to find the correct path and keep looking for data, browsing pages, scrolling tables, or clicking on the buttons they see. Furthermore, the feedback provided to users on the screen they have in front of them is very low since they all look the same. As a result, the navigation is not easy and turns out to slow down users' browsing experience when it should be very fast.

9.1.4. When do users make mistakes?

Usually several reasons are responsible for users' mistakes. It can be due to the interface design, the information overload, the stressful environment, the uncertainty in navigation, etc. Unfortunately this question does not have a clear answer because we saw that the subject's strategy during the experiment was either to answer correctly or not answer at all. This is exactly what journalists do since they cannot afford to make mistakes. During the data analysis of my controlled experiment I focused more on the origin of these mistakes (meaning of initials not explained to users, too many information in a single table, not enough feedback to users, all the screens look alike, etc.) than when they actually happened.

9.1.5. How do users deal with these mistakes?

When users make mistakes, which happens rarely as mentioned above, they try to fix it very quickly. When we could think they are going to change their navigation habits (e.g. use the "Previous" button instead of going again through all the screens from the beginning) they actually behave the same. I observed during the experiment that subjects had difficulties to remember the reason of their mistakes and sometimes it happened again. One common behavior I noticed was when the subjects double or triple checked before writing down their final answers.

I think in such difficult work conditions, they just discard mistakes; they do not have time to focus on those but only on the correct information and do not want probably to improve their browsing experience due to the number of tasks they already have to perform.

9.1.6. How to customize the interface for a better usability?

Based on the reasons why users make mistakes I suggested a couple of changes to improve the CIS. Due to the information overload, some recurring data needs to be removed; what is not used by the users too (e.g. "last athletes passing that point" table). Tools to highlight specific information chosen by the users put them in control of what they want to see and what is important to them. Also, the ways to navigate through the different screens have to be consistent and convenient (e.g. sequence of similar screens in Shooting but not in Progress). The users need meaningful feedback about their current screen and should be able to go backward if they realized they made a mistake.

Basically, the improvements that need to be done have to follow Nielsen's heuristic evaluation (Nielsen 1990) but especially in the case of websites (Preece, Sharp et al. 2007).

Indeed, the CIS is a web application and it lacks a lot of usability principles in its design and implementation.

9.2. Conclusion

Before starting this study I had been told the design of the CIS was poor and using it was not at all convenient. I realized it when I first started to study how the screens were linked to each others and how complex the mapping was. The way it had been designed did not make sense, it was more like all the screens of the system put together assuming that would be the best layout.

By looking at the use of the CIS by journalists I understood what their alternative to this design was: large amount of additional information on their desks. I assume other journalists behave the same but probably younger commentators working in this field use laptops instead. However, I was surprised that the journalists told me almost only good things about the CIS. Looking at their use and how few screens they needed, I thought they were going to give bad reviews about it. At that point I was kind of concerned about the reasons and meanings of such feedback and observations. Hence, I was expecting a lot of answers and new results from my experiment that would lighten me on these facts. The data analysis gave me some clues about the type of mistakes users make, even though the tasks and environment was different from the one in a stadium. However, the changes that need to be done are pretty clear and I actually realized that the system has not been developed from a user's point of view but from a developer's, which opens a broad range of possibilities for improvement in the future.

Summary

The Commentator Information System is known by only a few people and most of them are working in the broadcasting business. Doing a study on such a private system was very appealing to me since I did not know anything about it and it seemed to have design issues. Going through the whole process of design, content and experimental studies and analysis taught me a lot and I was able to find significant results and changes to make for future versions. As a first acknowledgement of this work and the stakes it implies, one of my papers have been published (Midy, Jensen et al. 2007), confirmation that this problem has been understood by the HCI community.

To conclude about the CIS, we can say that it is a very important tool, it is fundamental for journalists' work since they have to rely on it extensively. However, the system needs drastic changes to match its end users' habits and capacities. Moreover, it seems the implementation of the system did not take into account the external environment the commentators have to deal with, its ambient stress and noise. By focusing more on the users and their work conditions, I believe improvements can be made to the system to better its usability.

Bibliography

Apple. (2006, October 19). "Nike + iPod Frequently Asked Questions (Technical)." Retrieved October 4, 2007, from http://docs.info.apple.com/article.html?artnum=303934.

Atos-1. "Atos Origin Global Homepage." Retrieved October 4, 2007, from http://www.atosorigin.com.

Atos-2. "Major Events - Information Diffusion." Retrieved October 4, 2007, from http://www.atosorigin.com/en-us/Services/Industries/Major_Events/Services_Solutions/Information_Diffusion/default.htm.

Atos-3. (2004, June 15). "Commentator Information System Screen Definitions: Ceremonies."

Atos-4. (2005, August 3). "Commentator Information System General Screen Descriptions."

Atos-5. (2005, August 31). "Commentator Information System Screen Definitions: Biathlon."

Atos-6. (2005, October 6). "Commentator Information System Screen Definitions: Ice Hockey."

Atos-7. (2005, August 31). "Commentator Information System Screen Definitions: Ski Jumping."

Atos-8. (2006). "Olympic Images." Retrieved October 4, 2007, from http://www.atosorigin.com/en-us/Services/Industries/Major_Events/Multimedia/Images/default.htm.

Auto-Ref. "Auto-Ref Inc." Retrieved October 4, 2007, from http://www.auto-ref.com.

Bassin, K., S. Biyani, et al. (2002). "Metrics to evaluate vendor-developed software based on test case execution results." IBM Systems Journal **41**(1): 13 - 30.

BBC. "BBC SPORT | Football | FA Cup | Virtual Replay." Retrieved October 4, 2007, from http://www.bbc.co.uk/virtualreplay/premiership/index.shtml?1040.

Beckwith, L. and M. Burnett (2004). "Gender: An Important Factor in End-User Programming Environments?" IEEE Symposium on Visual Languages and Human Centric Computing: 107-114.

Beckwith, L., Inman, D., Rector, K., and Burnett, M. (2007). "On to the Real World: Gender and Self-Efficacy in Excel." IEEE Conference on Visual Languages and Human-Centric Computing: (to appear).

Cavallaro, R. (1997). "The FoxTrax Hockey Puck Tracking System." IEEE Computer Graphics and Applications **17**(2): 6-12.

Chi, E. H. (2005). Acceptance of UbiComp Technology in Sports. UbiComp2005 conference workshop on Sports in Technology, Tokyo, Japan.

Chi, E. H., G. Borriello, et al. (2005). "Pervasive Computing in Sports Technologies." IEEE Pervasive Computing **4**(3): 22-25.

Cromley, J. (2006, October 19, 2006). "Nike and iPod team up for run." The Herald, from http://www.bradenton.com/mld/bradenton/living/health/15520059.htm.

DeLacoste-Utamsing, C., and Holloway, RL. (1982). "Sexual dimorphism in the human corpus callosum." Science **216**(4553): 1431-1432.

EBU. (October 2, 2007). "Official website of the European Broadcasting Union." Retrieved October 4, 2007, from http://www.ebu.ch.

Gibbs, S., M. Hoch, et al. (2001). Broadcast Games and Digital Television. Sixth international conference on 3D Web technology, Paderbon, Germany, ACM Press.

Hallberg, J., S. Svensson, et al. (2004). Enriched media-experience of sport events. Workshop on Mobile Computing Systems and Applications, English Lake District, UK.

Hawk-Eye. "Hawk-Eye Innovations." Retrieved October 4, 2007, from http://www.hawkeyeinnovations.co.uk/.

Huayong, L. and Z. Hui (2005). A Content-Based Broadcasted Sports Video Retrieval System Using Multiple Modalities: SportBR The Fifth International Conference on Computer and Information Technology (CIT'05) Shanghai, CHINA.

Hunter, J. (2001). "Telecommunications delivery in the Sydney 2000 Olympic Games." Communications Magazine, IEEE **39**(7): 86 - 92.

IBM. (2007). "PointTracker." Retrieved October 4, 2007, from http://www-05.ibm.com/e-business/uk/rolandgarros/techtour/website.html.

IOC-1. "Broadcast Rights: Global broadcast revenue." Retrieved October 4, 2007, from http://www.olympic.org/uk/organisation/facts/revenue/broadcast_uk.asp.

IOC-2. "Official website of the Olympic Movement." Retrieved October 4, 2007, from http://www.olympic.org.

IOC-3 (2002). Salt Lake 2002 - Official Spectator Guide. Salt Lake City, SLOC.

IOC-4. "Sports on the Olympic programme." Retrieved July 18, 2007, from http://www.olympic.org/uk/sports/index_uk.asp.

IOC-5. (2006). "Torino 2006 - Official Spectator Guide." Retrieved July 20, 2007, from http://www.torino2006.org/ENG/OlympicGames/vieni_a_torino2006/guide.html.

IOC-6. (2004, December). "Athens 2004 Olympic Games: Global Television Report." Retrieved July 20, 2007, from http://multimedia.olympic.org/pdf/en_report_1086.pdf.

ITF, I. T. F. (2004). Serve Speed Validation Report, ITF.

Johnson, H. (2004). "EDH South Africa gives you the first service!" from www.edhsport.com.

Koulouris, J. (2001). "Planning telecommunications for the Athens 2004 Olympic Games." Communications Magazine, IEEE **39**(7): 100 - 104.

Midy, M.-A., C. Jensen, et al. (2007). The commentator information system: a usability evaluation of a real-time sport information service. Proceedings of the international conference on Advances in Computer Entertainment technology Salzburg, Austria, ACM Press.

motionbased. (2004). "Motionbased launches GPS performance tracking for athletes." from http://www.motionbased.com.

Nextel. "NASCAR NEXTEL FanView™." Retrieved July 13, 2007, from http://www.nextel.com/en/promotions/racing/fanview.shtml.

Nielsen, J., Molich, R. (1990). Heuristic evaluation of user interfaces. Human factors in computing systems: Empowering people, Seattle, Washington, United States, ACM Press.

Page, M. and A. V. Moere (2006). Towards Classifying Visualization in Team Sports. International Conference on Computer Graphics, Imaging and Visualization Sydney, AUSTRALIA.

Pingali, G. S., Y. Jean, et al. (1998). Real time tracking for enhanced tennis broadcasts. Computer Society Conference on Computer Vision and Pattern Recognition, Santa Barbara, CA, USA.

PollingReport.com. (2001). "What is your favorite sport?" from http://www.pollingreport.com/sports.htm.

PollingReport.com. (2003). "What is your favorite sport to watch?" from http://www.pollingreport.com/sports.htm.

Preece, J., H. Sharp, et al. (2007). Fitts' law. Interaction Design. Wiley. West Sussex, England. **1:** 713 - 715.

Preece, J., H. Sharp, et al. (2007). Heuristis evaluation for websites. Interaction Design. Wiley. West Sussex, England. **1:** 689 - 696.

Sargent, S. L., D. Zillmann, et al. (1998). "The gender gap in the enjoyment of televised sports." Journal of Sport & Social Issues **22**(1): 46-64.

Singer, R. and E. Hanapole. (2006, October 06). "IBM and the Future of Sports." from http://www.ibm.com/investor/viewpoint/podcast/27-01-06-1.phtml.

SportService. (2007). "ST SportService official website." Retrieved January 11, 2007, from http://www.st-sportservice.com/index_eng.html.

SportsJournalists'Association. (2006 July 16). "Sports journalism - women's final frontier?" Retrieved July 16, 2006, from http://www.sportsjournalists.co.uk/blog/?p=155.

Sportvision. "Sportvision - Changing The Game." Retrieved July 11, 2007, from http://www.sportvision.com/.

Takizawa, Y. (2001). "Telecommunications at the Nagano 1998 Winter Olympic Games." Communications Magazine, IEEE **39**(7): 76 - 84.

theage.com.au. (2006, July 13). "Wired for speed." The Age, from http://www.theage.com.au/news/technology/wired-for-speed/2006/09/26/1159036543281.html.

Tjondronegoro, D., Y.-P. P. Chen, et al. (2004). "Integrating Highlights for More Complete Sports Video Summarization." IEEE Multimedia **11**(4): 22-37.
Toftemo, O. and R. Ekholdt (2001). "Telecommunications in the 1994 Winter Olympic Games." Communications Magazine, IEEE **39**(7): 72 - 75.
USA. (2006). "USA Network official website." Retrieved September 20, 2007, from http://www.usanetwork.com/.
Vicon. "Sports Performance." Retrieved July 12, 2007, from http://www.vicon.com/applications/sports.html.
Wang, J. R. and N. Parameswaran (2004). Survey of sports video analysis: research issues and applications. Pan-Sydney area workshop on Visual information processing, Sydney, Australia, Australian Computer Society, Inc. Darlinghurst, Australia, Australia.
zol.com.cn. "zol.com.cn website." Retrieved September 18, 2007, from http://pc.zol.com.cn/25/255310.html.

Appendices

Appendix 1: Disciplines and sports for the 2006 Winter Olympic Games

Sports	Disciplines
Biathlon	Biathlon
Bobsleigh	Bobsleigh
	Skeleton
Curling	Curling
Ice Hockey	Ice Hockey
Luge	Luge
Skating	Figure Skating
	Short Track Speed Skating
	Speed Skating
Skiing	Alpine Skiing
	Cross Country Skiing
	Freestyle Skiing
	Nordic Combined
	Ski Jumping
	Snowboard

Appendix 2: Page extracted from the official CIS documentation: Header for general screens

3 Screen Header

The final layout of the screen header is defined in the TOROC CIS 2006 Look and Feel document. The layout is expected to be similar to the following:

The screen is divided into three sections, left, middle, and right.

Left section

- Sport pictogram or Olympic rings or "cis2006"
- Sport (discipline) name or "Commentator Information System"
- Event name, where applicable
- Venue name
- Date

Middle Section

- Reserved for leader board, where applicable

Right section

- Torino 2006 and Atos Origin combined logo

See sample below.

Main Header Background

Sport Header Background

Appendix 3: Pages extracted from the official CIS documentation: Buttons for general screens

4 Navigation Buttons

All sports and screens will use some standard navigation concepts. Button appearance will be defined in the TOROC CIS Look and Feel Document.

4.1 Sport Pictogram

In all screens the sport icon (top left corner) returns the user to the menu page of all sports.

4.2 Lower Right Navigation

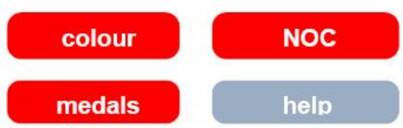
The navigation in the lower right corner will be standard with different button options.

4.2.1 Main Screen

On the Main Screen the following options are visible:

- colour
- NOC
- medals
- help

These will be displayed in this layout (actual buttons are described in the Look and Feel Document):



4.2.2 Schedule Screens (GES1 and GES2)

On schedule screen GES1 and GES2 (refer to Section 5.1) the following options are

- previous
- weather
- NOC
- home
- medals
- help

Appendix 3: Pages extracted from the official CIS documentation: Buttons for general screens (Continued)

These will be displayed in this layout:

4.2.3 Schedule Screen All Sports (GES3)

On schedule screen GES3 (refer to Section 5.1) the following options are visible:

- previous
- colour
- NOC
- home
- medals
- help

These will be displayed in this layout:

4.2.4 All other screens

On all other screens the following options are visible:

- previous
- weather
- NOC
- schedule
- medals
- help

These will be displayed in this layout:

4.3 Availability

Appendix 3: Pages extracted from the official CIS documentation: Buttons for general screens (Continued)

If any menu options are not available, then the button will be "greyed out" to indicate the option is not available.

Appendix 4: Pages extracted from the official biathlon CIS documentation: Biathlon relay

2.2.6.3 Relay Events

The progress screens for the Relay events are essentially the same as the screens for the individual events, except that the Leader Board for the Relay events displays team, not athlete, names.

2.2.6.3.1 Relay, No Pre-Timing, Progress (BTP45)

This screen format is the progress screen used for all shooting points.

Distance Buttons

Because there are so many intermediate options, there should be two sets of buttons, one for the Legs, one for the Intermediate points within the selected leg.

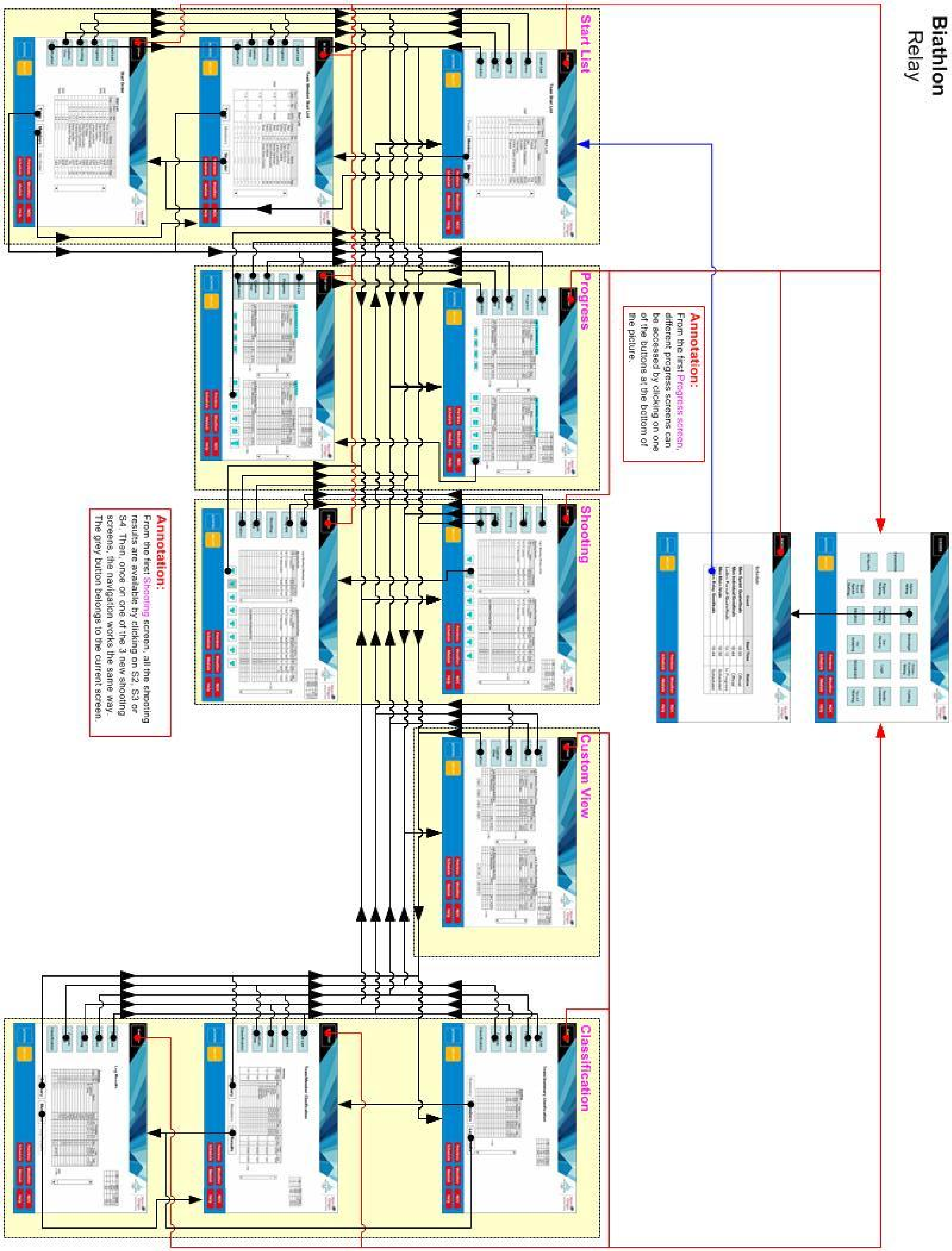
Leg 1	Leg 2	Leg 3	Leg 4	Int 1 Int 2	Int 2 S1	Int 3 Int 4	Int 4 S2	Int 5 Int 6	Int 6 Ex-Fin

where Int 1 = Intermediate timing point 1
Int 2 = Intermediate timing point 2
S1 = Shooting 1
Int 3 = Intermediate timing point 3
Int 4 = Intermediate timing point 4
S2 = Shooting 2 or Ex = Exchange
Int 5 = Intermediate timing point 5
Int 6 = Intermediate timing point 6
Ex-Fin = Exchange/Finish.

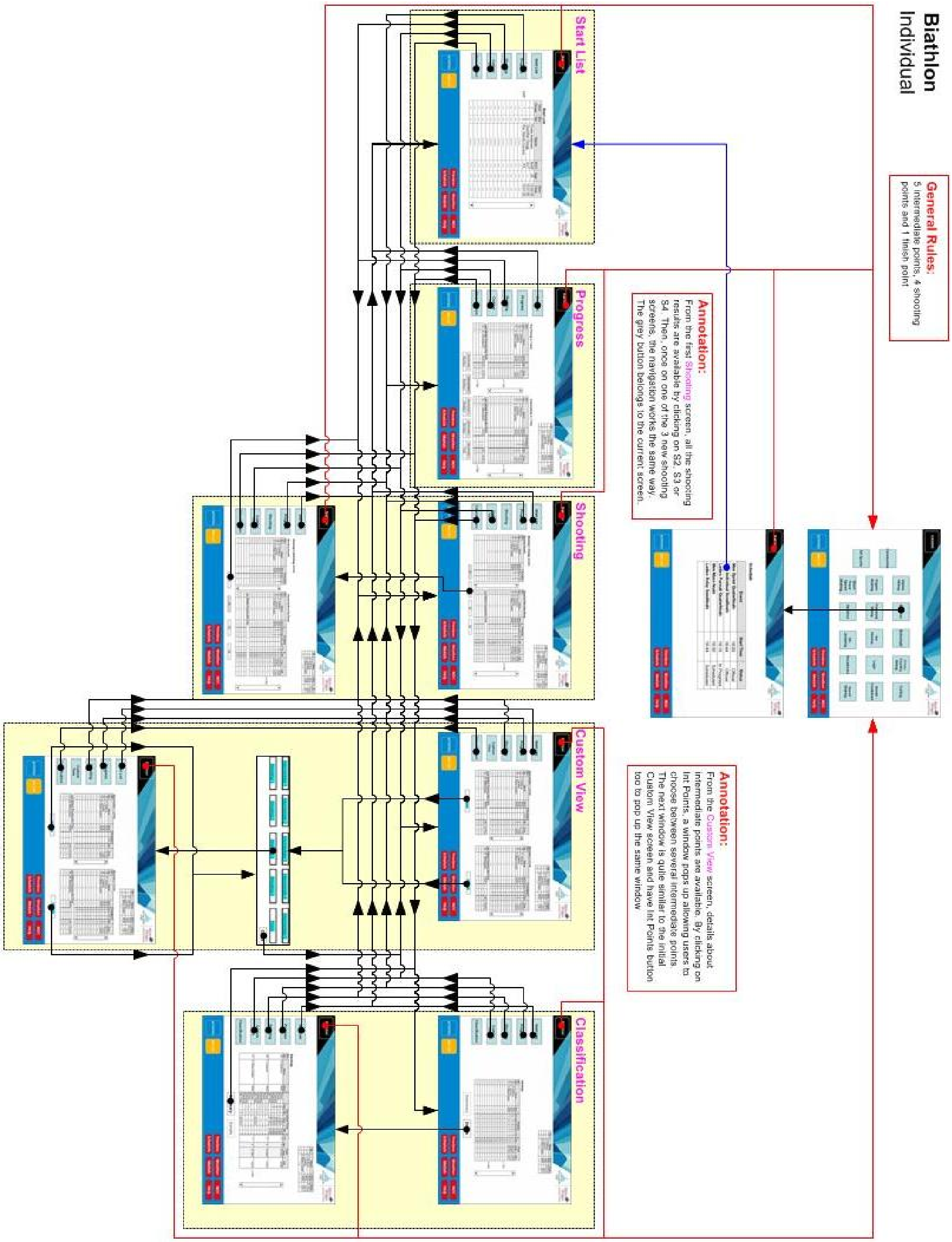
The buttons should work as follows:

User Presses Button	System Displays
Leg 1	Leg 1, Int 1/Int2
Leg 2	Leg 2, Int 1/Int2
Leg 3	Leg 3, Int 1/Int2
Leg 4	Leg 4, Int 1/Int2
Int 1 / Int 2	Current Leg, Int 1 and Int 2
Int 2/ S1	Current Leg, Int 2 and S1
Int 3 / Int 4	Current Leg, Int 3 and Int 4
Int 4/ S2	Current Leg, Int 4 and S2
Int 5 / Int 6	Current Leg, Int 5 and Int 6
Int 6 / Ex-Fin	Current Leg, Int 6 and Exchange or Finish

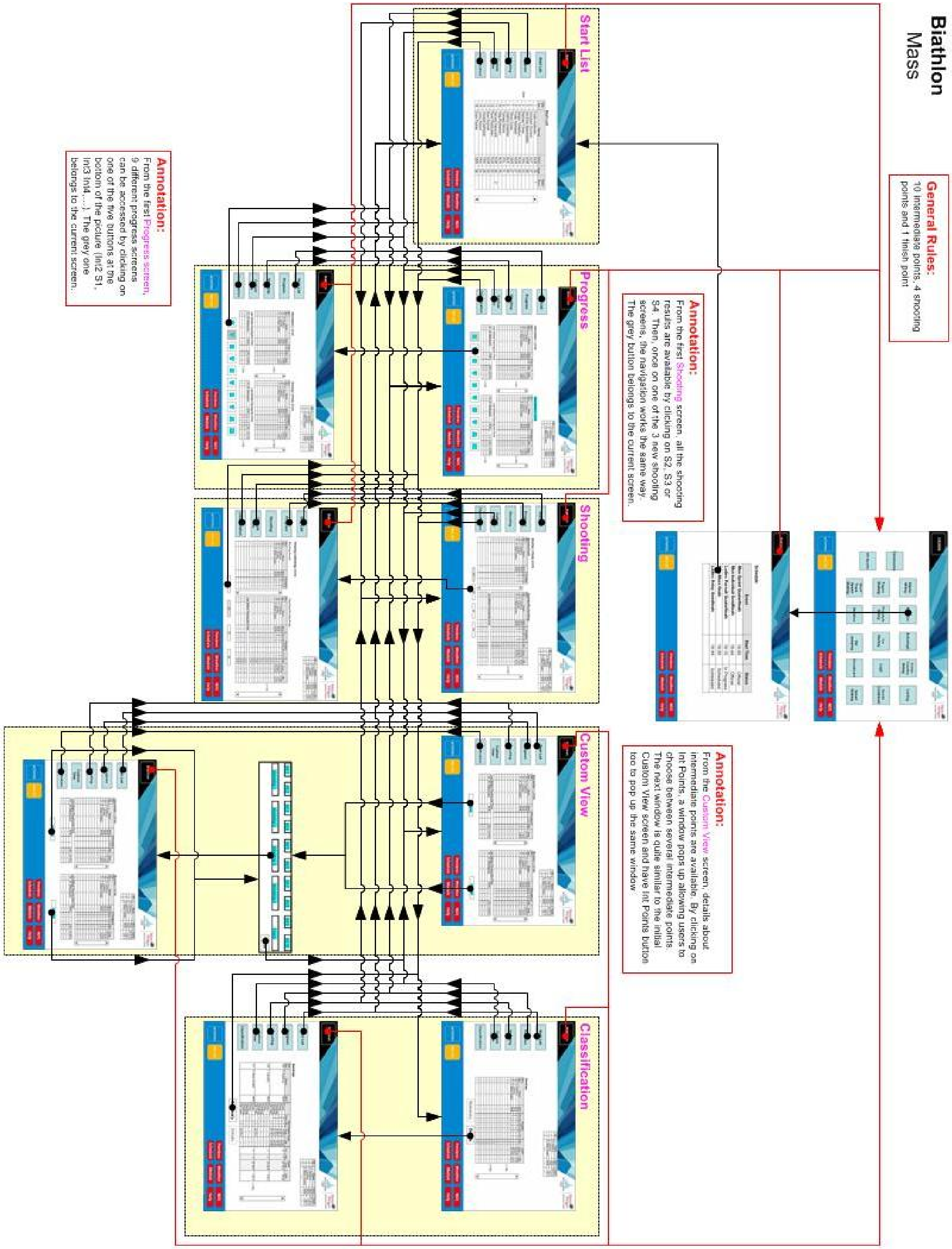
Appendix 5: Biathlon mapping (Relay)



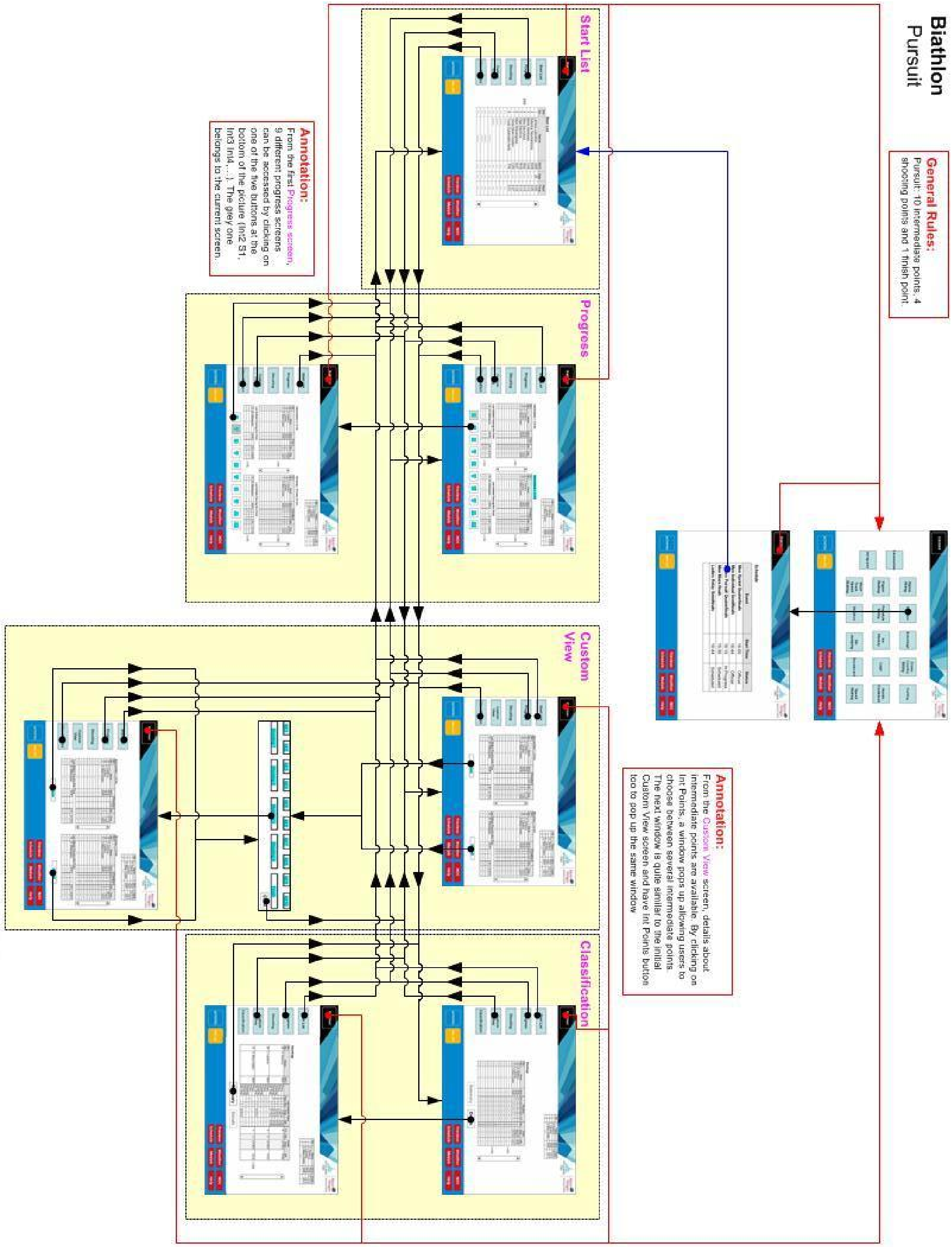
Appendix 6: Biathlon mapping (Individual)



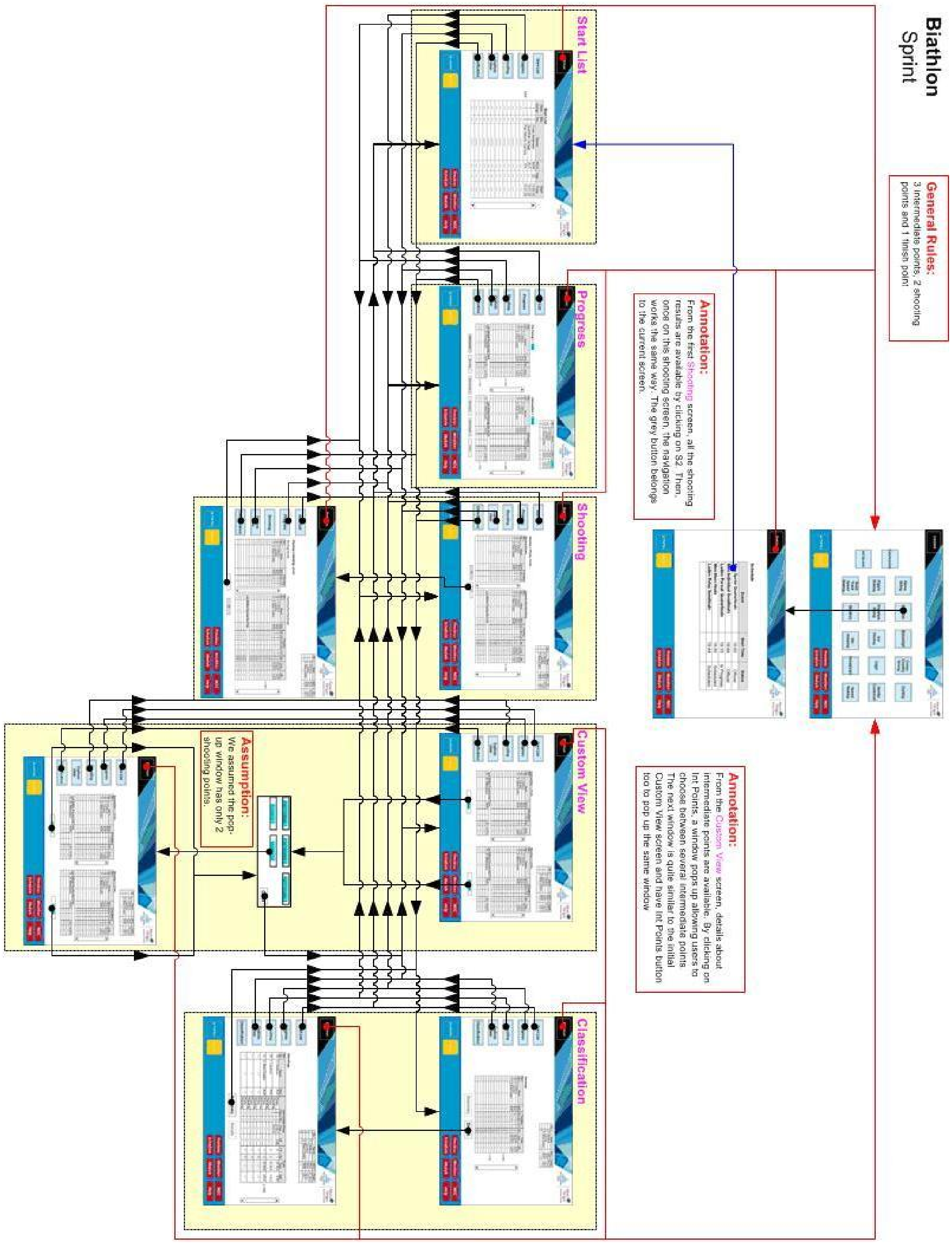
Appendix 7: Biathlon mapping (Mass Start)



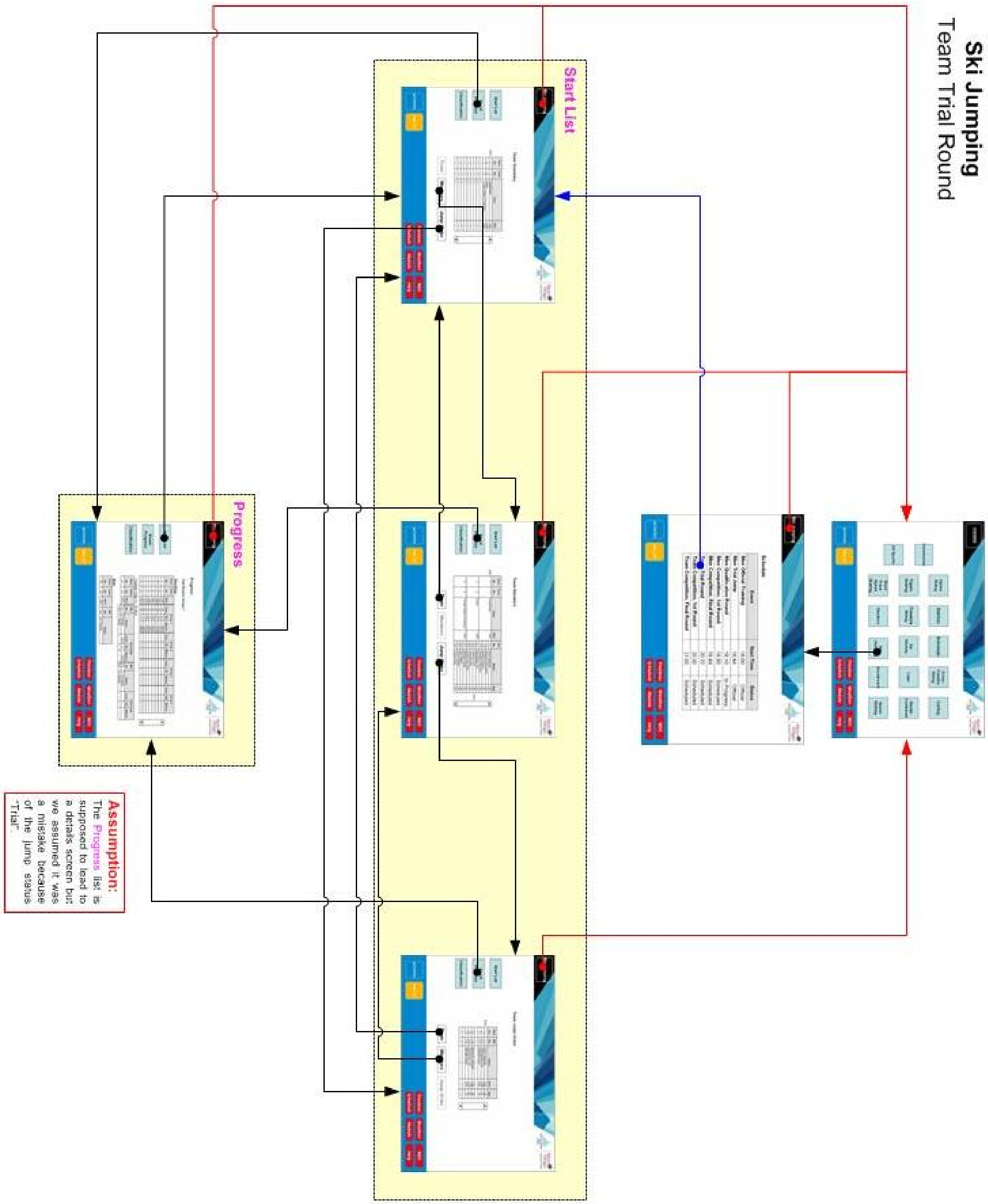
Appendix 8: Biathlon mapping (Pursuit)



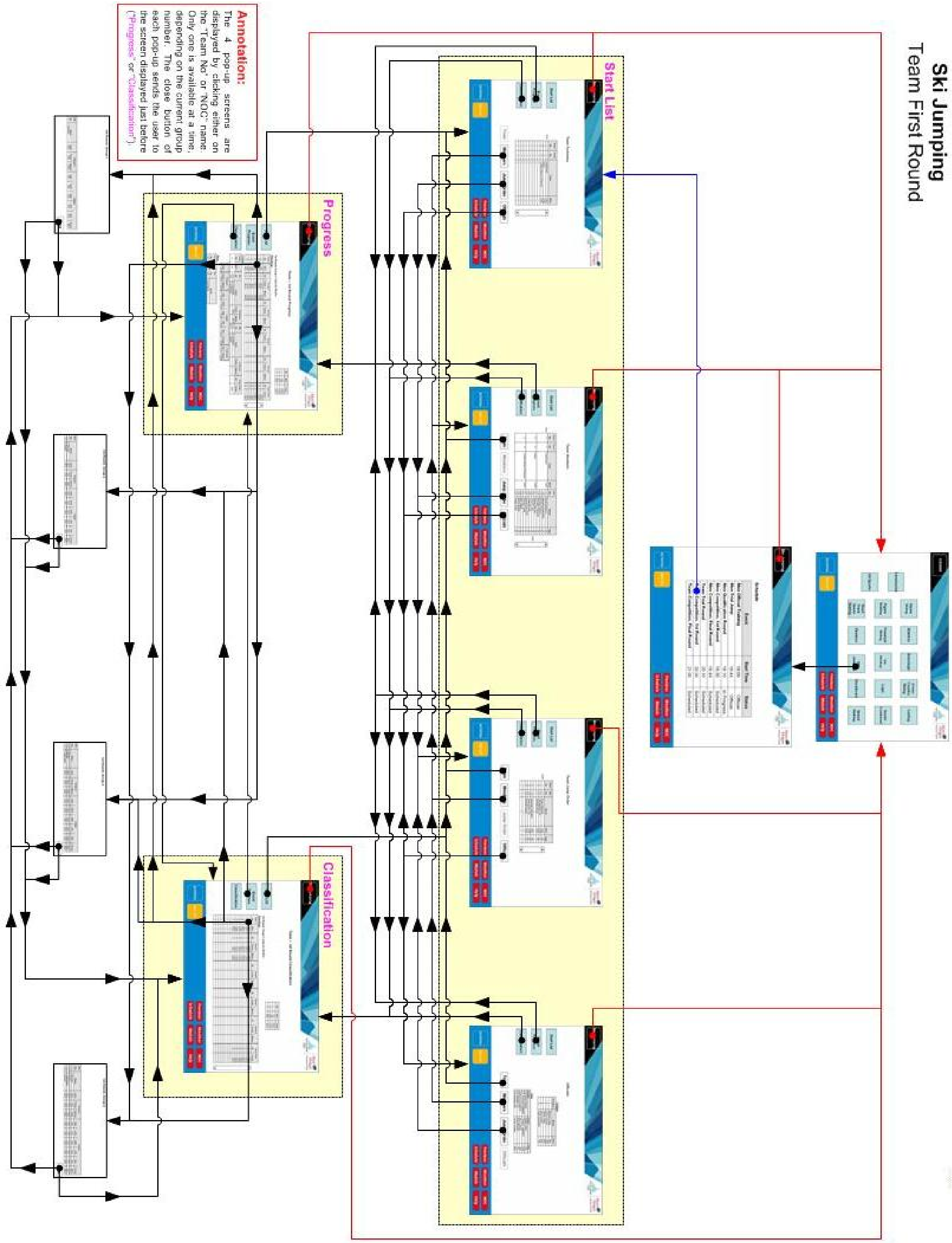
Appendix 9: Biathlon mapping (Sprint)



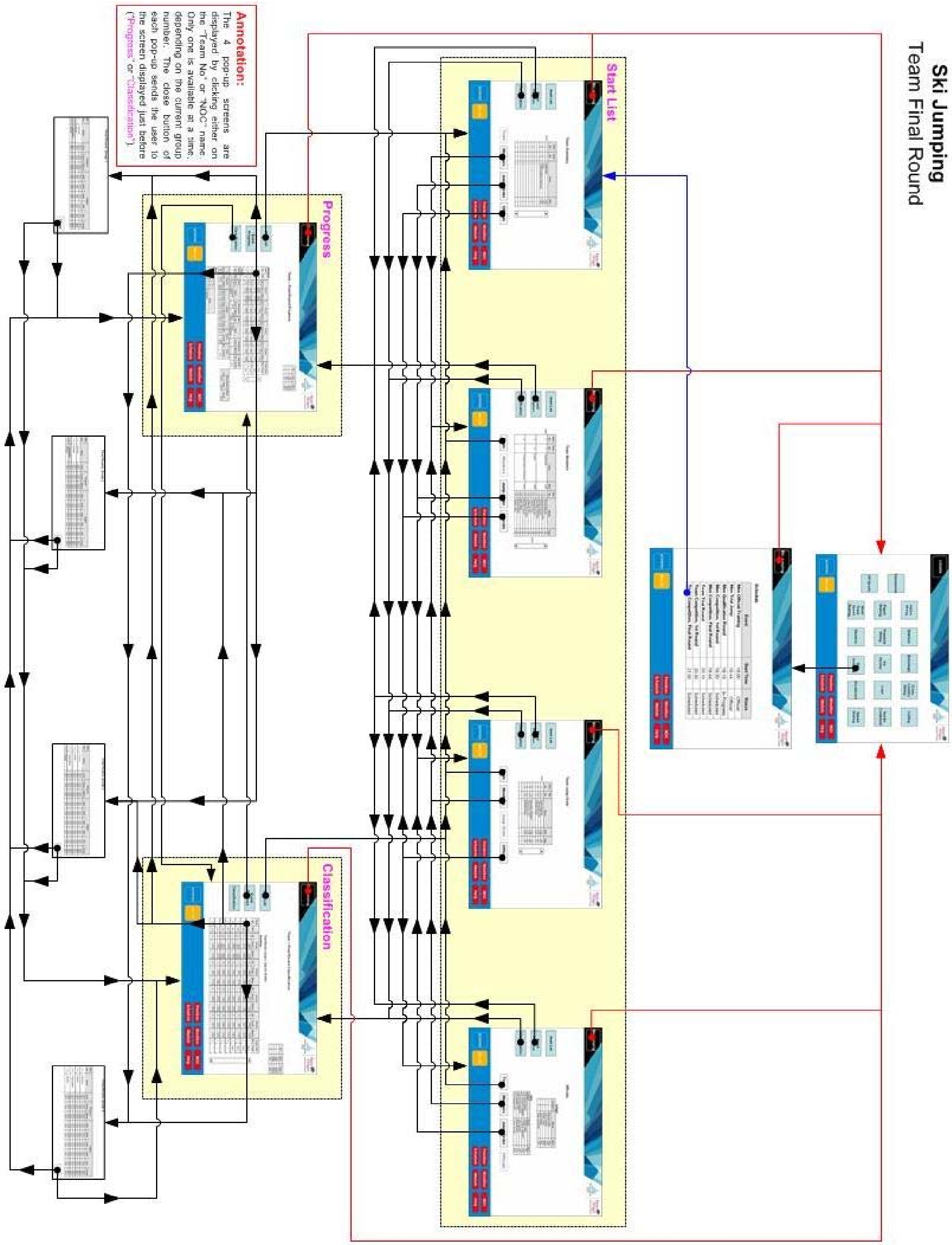
Appendix 10: Ski jumping mapping (Team Trial)



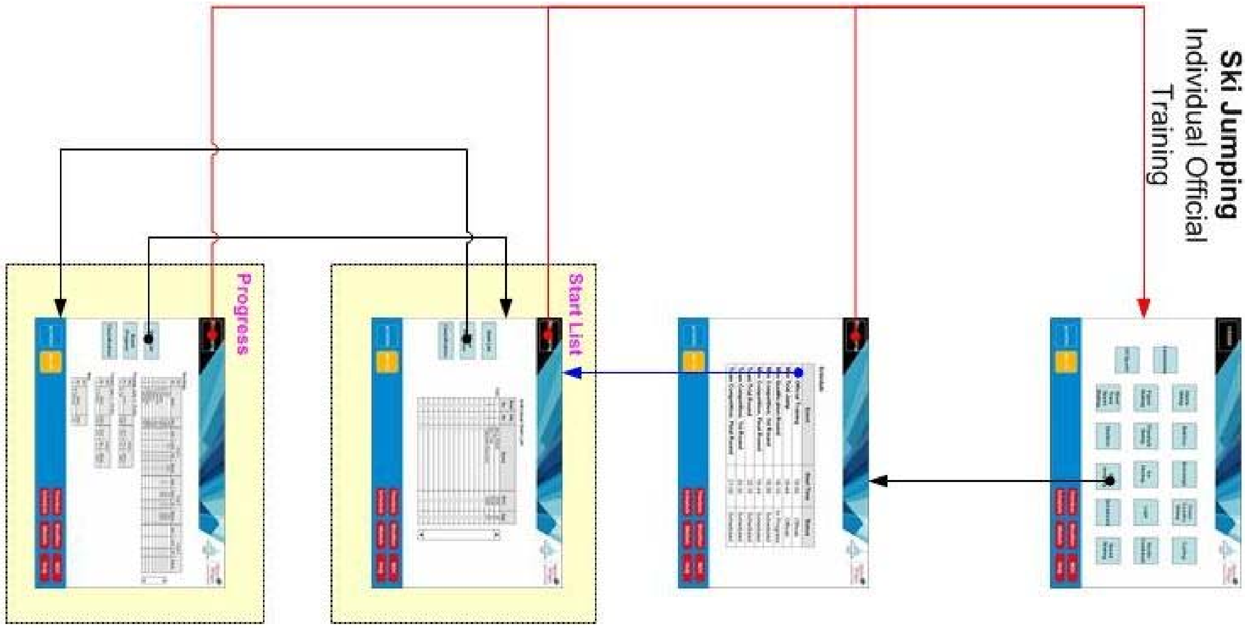
Appendix 11: Ski jumping mapping (Team First Round)



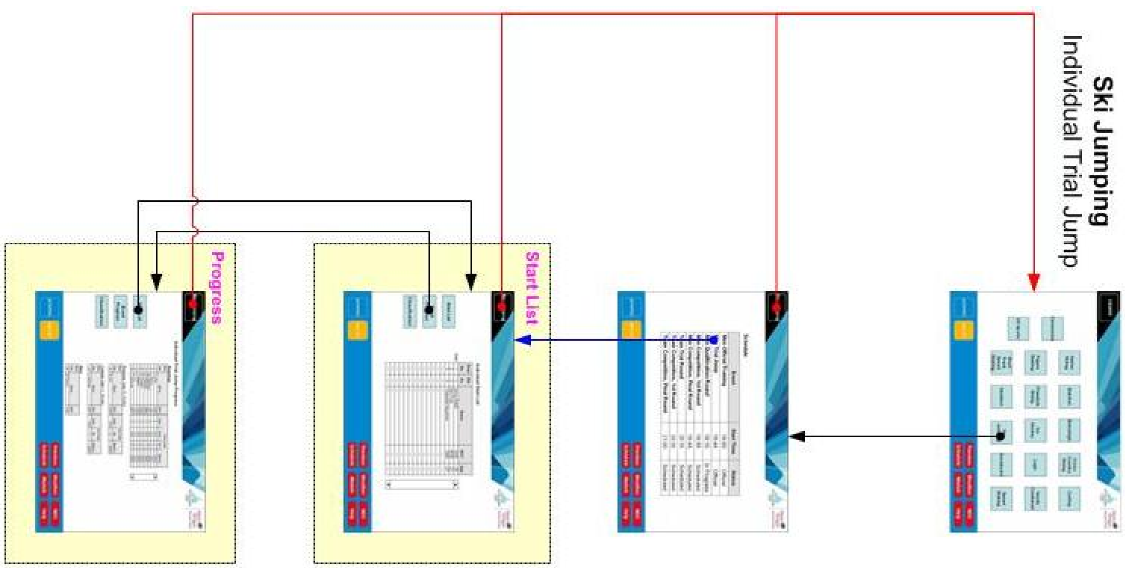
Appendix 12: Ski jumping mapping (Team Final Round)



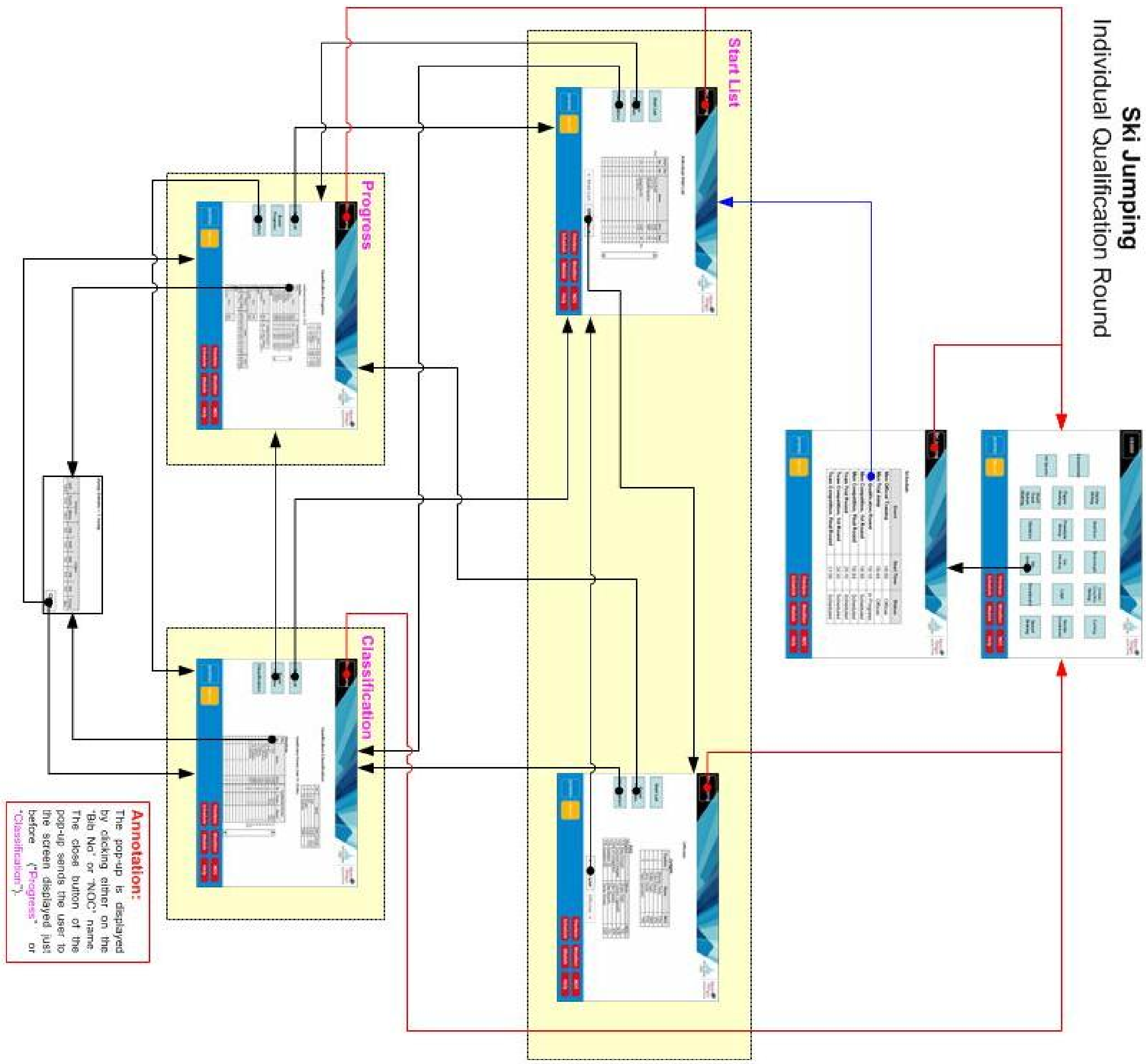
Appendix 13: Ski jumping mapping (Individual Training)



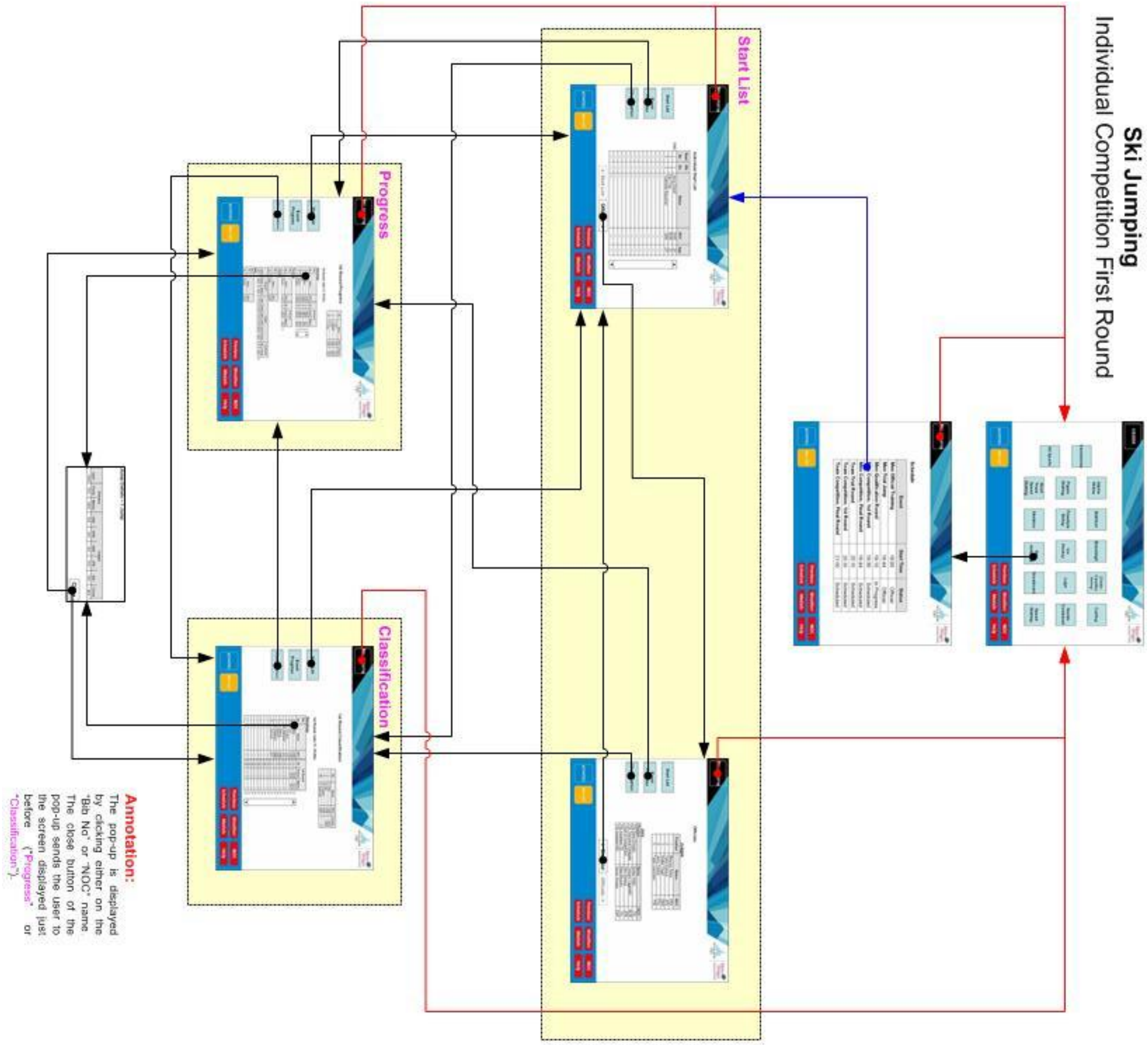
Appendix 14: Ski jumping mapping (Individual Trial)



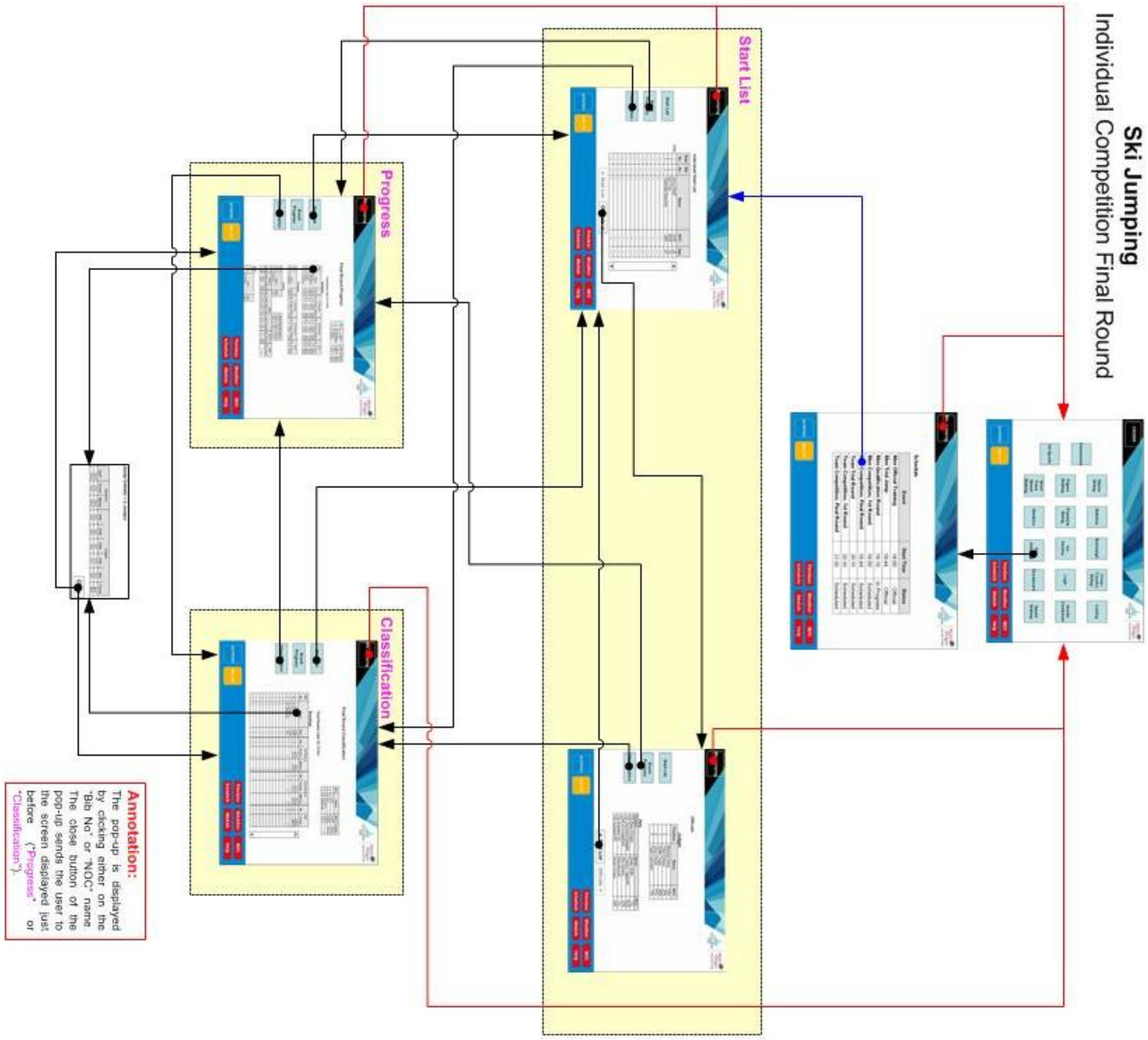
Appendix 15: Ski jumping mapping (Individual Qualification Round)



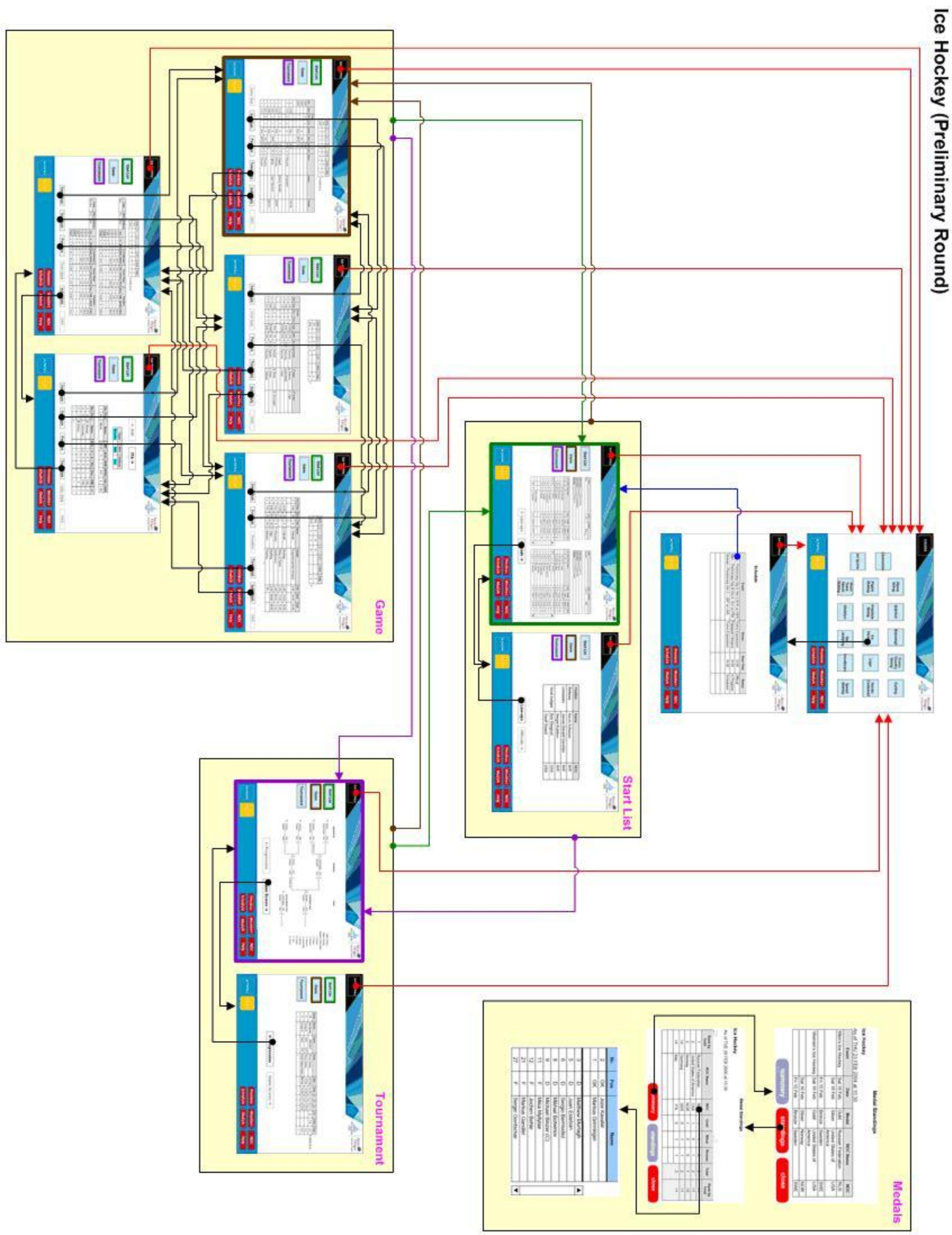
Appendix 16: Ski jumping mapping (Individual Competition First Round)



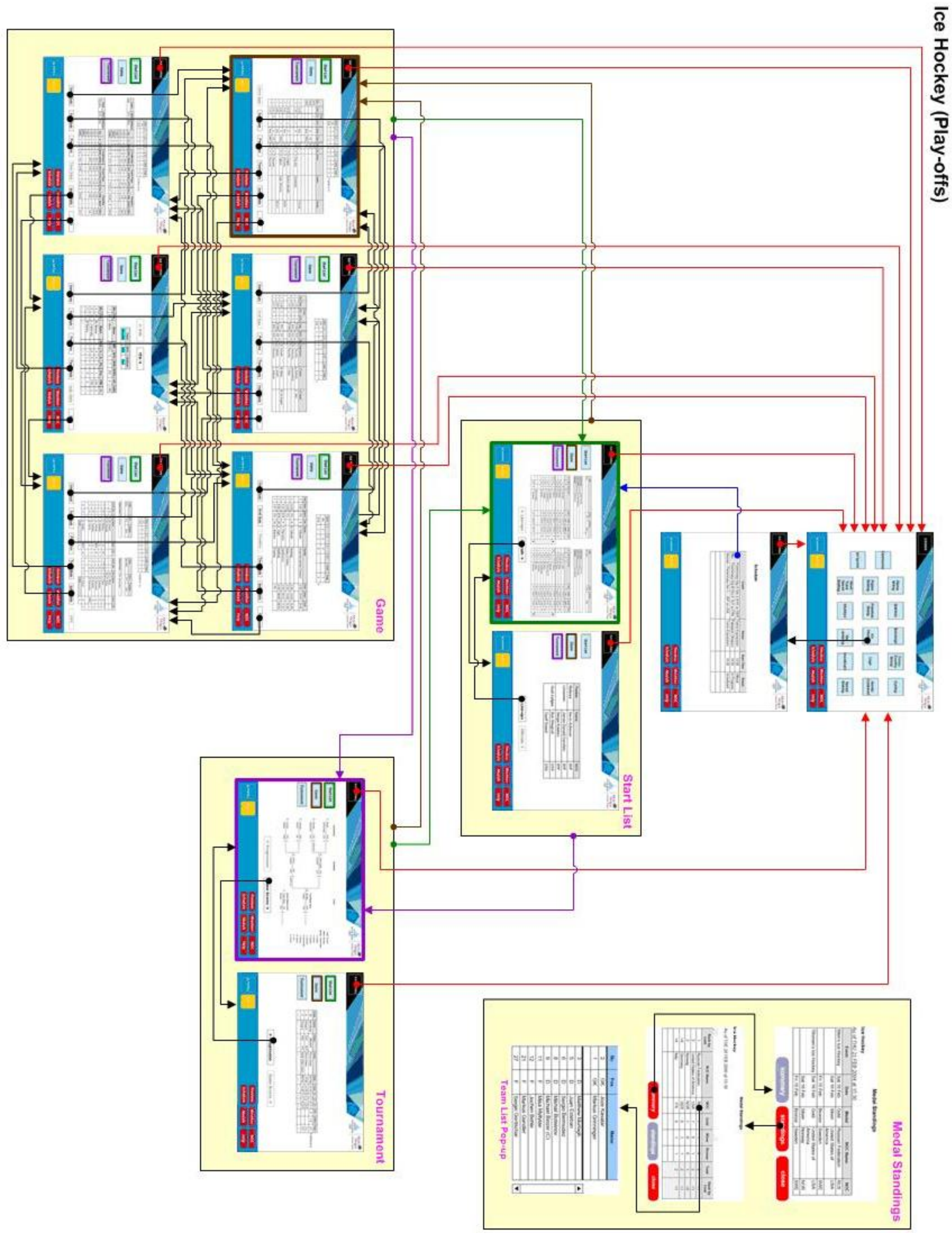
Appendix 17: Ski jumping mapping (Individual Competition Final Round)



Appendix 18: Ice hockey mapping (Preliminary Round)



Appendix 19: Ice hockey mapping (Play-offs)



Appendix 20: 2006 European Athletics Championships disciplines

Disciplines		Men	Women
Track	100 m	**X**	**X**
	200 m	**X**	**X**
	400 m	**X**	**X**
	800 m	**X**	**X**
	1500 m	**X**	**X**
	5000 m	**X**	**X**
	10,000 m	**X**	**X**
	Marathon	**X**	**X**
	100 m Hurdles		**X**
	110 m Hurdles	**X**	
	400 m Hurdles	**X**	**X**
	3,000 m Steeplechase	**X**	**X**
	20 km Walk	**X**	**X**
	50 km Walk	**X**	
	4 x 100 m	**X**	**X**
	4 x 400 m	**X**	**X**
Field	High Jump	**X**	**X**
	Long Jump	**X**	**X**
	Pole Vault	**X**	**X**
	Triple Jump	**X**	**X**
	Shot Put	**X**	**X**
	Discus	**X**	**X**
	Javelin	**X**	**X**
	Hammer	**X**	**X**
	Decathlon	**X**	
	Heptathlon		**X**

Appendix 21: XML parser for the leader board results

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1" />
<title>ParserSAX: BTTLB</title>
</head>
<body>
<?
include("connection.php");
$file = "files/ToParse.xml";
//$file = "files/BTTLB_2_ITE.xml";
/* Enter after the page url, after .php, ?fileURL=BTTRE_1_SP1.xml
   which is the name of the xml file saved into the files dir */
//$file = "files/".$fileURL;
/* Start element handler function */
function startElement($parser, $start_element_name, $attribs)
{
  print "Tag Name: $start_element_name\n";
  echo "<br/>";
  global $timeValue;
  global $legValue;
  global $typeValue;
  /* Variables for Team */
  global $codeT;
  global $rankT;
  global $clockT;
  foreach ($attribs as $att_name => $att_value)
  {
        $tag = $att_name;//name of the tag, "Code" here
        $value = $att_value;//value of the ta, code # here
        print "   Atribute: $att_name = $att_value\n";
        echo "<br/>";
        if ($start_element_name == "Message")
        {
              if ($att_name == "Time")
              {
                    $timeValue = $att_value;
              }
        }
        if ($start_element_name == "BT_Leg")
        {
              if ($att_name == "Code")
              {
                    $legValue = $att_value;
              }
        }
        if ($start_element_name == "BT_Leader_Board")
        {
              if ($att_name == "Code")
              {
                    $typeValue = $att_value;
              }
        }
        /* To populate the last_competitor table */
        if ($start_element_name == "BT_Team")
        {
              if ($att_name == "Code")
              {
```

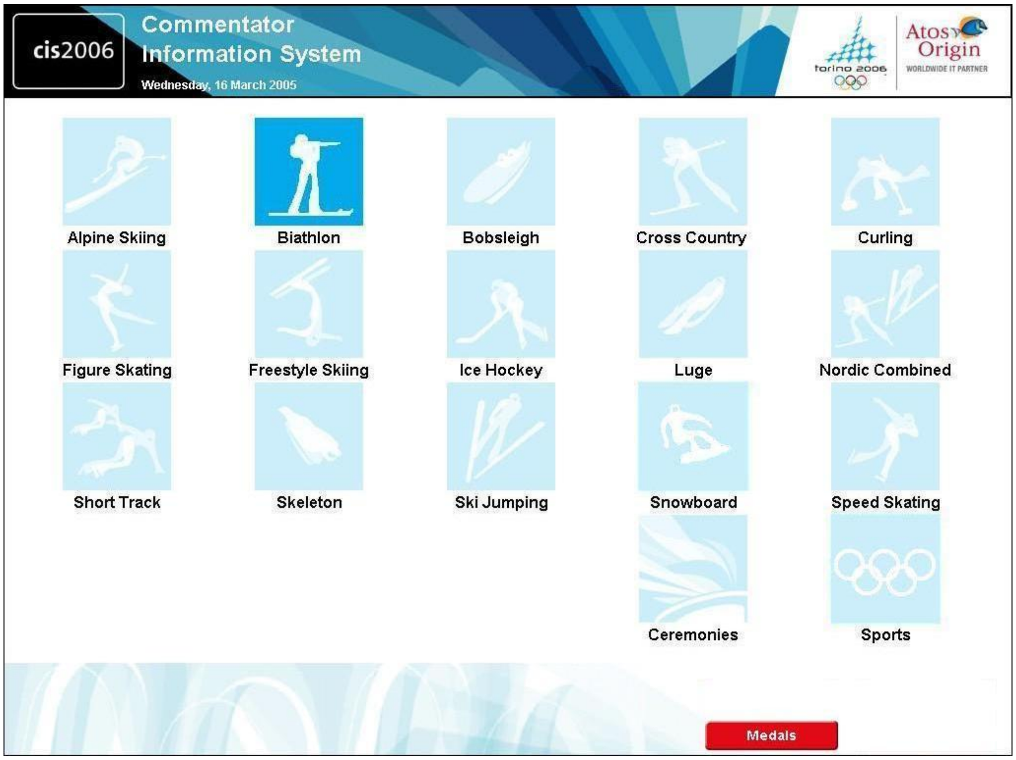
Appendix 21: XML parser for the leader board results (Continued)

```
                        $codeT = $att_value;
                }
                if ($att_name == "Rank")
                {
                        $rankT = $att_value;
                }
                if ($att_name == "Time")
                {
                        $clockT = $att_value;
                }
                if (strlen ($codeT) != 0)
                {
                        $result_check_leader = mysql_query ("SELECT time, code_team FROM leader_board")
                                or exit();
                        /* Initiate the variable to 0 => code not already in the database*/
                        /* Check if time already in, if so: check if code already in */
                        /* Not possible to have same code twice or more for same time */
                        $already_in = 0;
                        while ($row = mysql_fetch_row ($result_check_leader))
                        {
                                // Look for same time
                                if ( strcmp($row[0], $timeValue) == 0)
                                {
                                        // Look for same team
                                        if ( strcmp($row[1], $codeT) == 0)
                                        {
                                                $already_in = 1;
                                        }
                                }
                        }
                        /* Insert only if code not already in the table*/
                        if ($already_in == 0)
                        {
                                $result_insert = mysql_query ("INSERT INTO leader_board
                                          (time, code_team)
                                          VALUES
                                          ('$timeValue', '$codeT')")
                                        or exit();
                        }
                }
                $result_update = mysql_query ("UPDATE leader_board SET
                                                type  = '$typeValue',
                                                leg   = '$legValue',
                                                rank  = '$rankT',
                                                clock = '$clockT'
                                        WHERE code_team = '$codeT'
                                        AND   time      = '$timeValue'")
                        or exit();
        }
  }
print "Time tag Name: $timeValue\n";
echo "<br/>";
print "Leg #: $legValue\n";
echo "<br/>";
print "Type of progress: $typeValue\n";
echo "<br/>";

}

/* End element handler function */
```

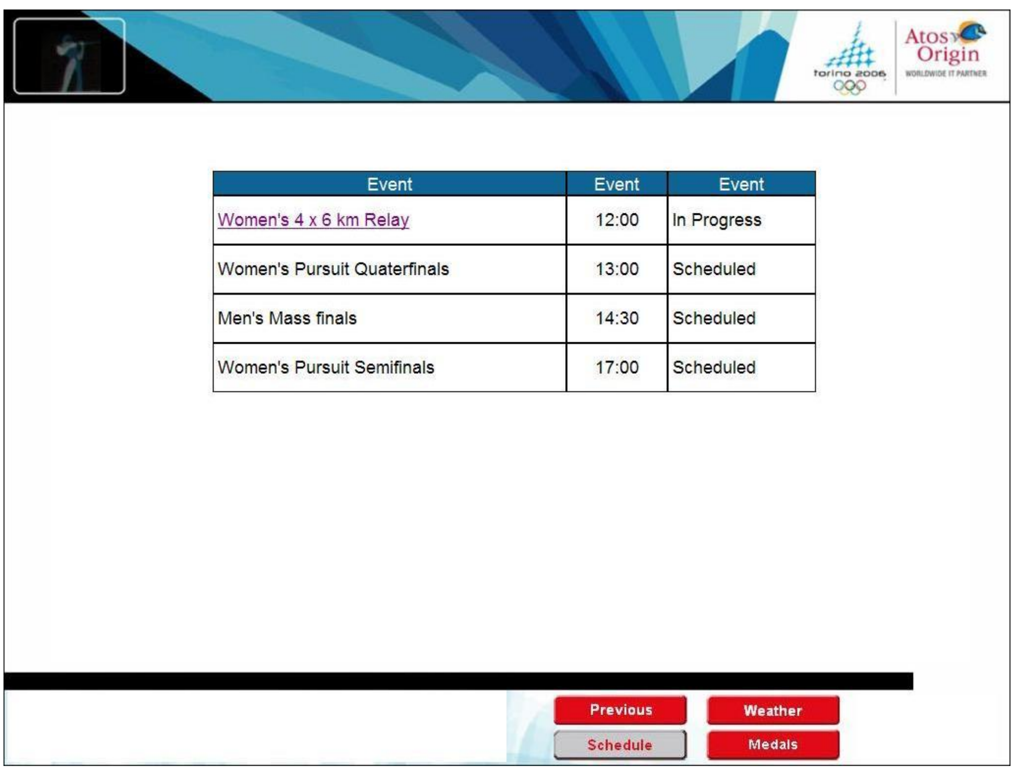
Appendix 21: XML parser for the leader board results (Continued)

```
function endElement($parser, $end_element_name)
{
  print "END Tag Name: $end_element_name\n";
  echo "<br/>";
}

/* Data handler function */
function characterData($parser, $data) {
}

/* Create parser */
$xml_parser = xml_parser_create();

/* Set parser options */
  /* Leave tag names' case like how they are */
xml_parser_set_option ($xml_parser, XML_OPTION_CASE_FOLDING, 0);

/* Register Handler */
xml_set_element_handler($xml_parser, "startElement", "endElement");
xml_set_character_data_handler($xml_parser, "characterData");


/* Parse XML */
if (!($fp = fopen($file, "r")))
  {
         die("could not open XML input");
  }
while ($data = fread($fp, 4096)) {
if (!xml_parse($xml_parser, $data, feof($fp))) {
  /* Gather Error information */
  die(sprintf("XML error: %s at line %d",
         xml_error_string(xml_get_error_code($xml_parser)),
         xml_get_current_line_number($xml_parser)));
}
}




/* Free parser */
xml_parser_free($xml_parser);

mysql_free_result ($result_check_code);
mysql_free_result ($result_insert);
mysql_free_result ($result_update);
mysql_close ($conn_id);
?>

</body>
</html>
```

Appendix 22: Prototype of the 2006 CIS: Home screen



Appendix 23: Prototype of the 2006 CIS: Schedule screen



Appendix 24: Prototype of the 2006 CIS: Start List screen

Appendix 25: Prototype of the 2006 CIS: Progress screen

Appendix 26: Prototype of the 2006 CIS: Shooting screen

Rk	NOC	S1
1	BUL	6:47.3
2	RUS	+4.6
3	SVK	+5.9
4	GER	+7.2

Leg 1, Shooting 1 (Prone), 2.0 km

Shooting Results

Bib No	Name	NOC	Penalties (P)	T.P.
9-1	P. Filipova	BUL	0+0	0+0
1-1	A. Bogaliy	RUS	0+0	0+0
12-1	A. Murinova	SVK	0+0	0+0
2-1	M. Glagow	GER	0+1	0+1
15-1	M. Ponza	ITA	0+1	0+1
8-1	O. Khvostenko	UKR	0+0	0+0
7-1	K. Yingchao	CHN	0+0	0+0
13-1	Z. Kocher	CAN	0+0	0+0
5-1	T. Gregorin	SLO	0+0	0+0
17-1	M. Liduma	LAT	0+1	0+1
11-1	K. Palka	POL	0+2	0+2
18-1	R. Steer	USA	0+1	0+1
10-1	K. Holubcova	CZE	0+1	0+1
6-1	E. Ivanova	BLR	0+2	0+2
4-1	D. Peretto	FRA	0+2	0+2

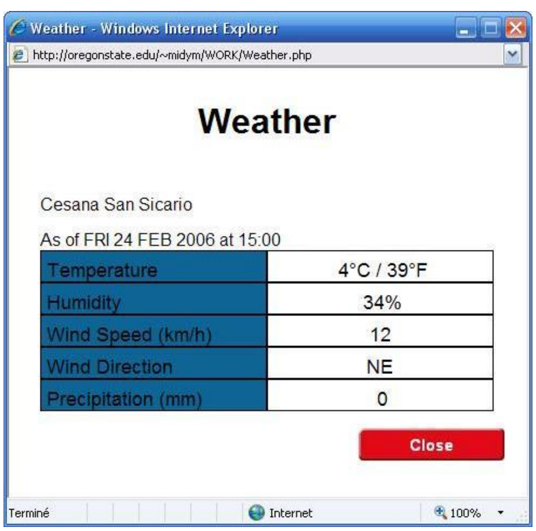
Departing Shooting Range

Bib No	Name	NOC	Penalties (P)	(S)	T.P.	Rk	Time	Diff
9-1	P. Filipova	BUL	0+0		0+0	1	6:47.3	+0.0
1-1	A. Bogaliy	RUS	0+0		0+0	2	6:51.9	+4.6
12-1	A. Murinova	SVK	0+0		0+0	3	6:53.2	+5.9
2-1	M. Glagow	GER	0+1		0+1	4	6:54.5	+7.2
15-1	M. Ponza	ITA	0+1		0+1	5	6:57.8	+10.5
8-1	O. Khvostenko	UKR	0+0		0+0	6	7:00.9	+13.6
7-1	K. Yingchao	CHN	0+0		0+0	7	7:01.4	+14.1
13-1	Z. Kocher	CAN	0+0		0+0	8	7:02.2	+14.9
5-1	T. Gregorin	SLO	0+0		0+0	9	7:03.1	+15.8
17-1	M. Liduma	LAT	0+1		0+1	10	7:06.5	+19.2

Last Athlete Passing this Point

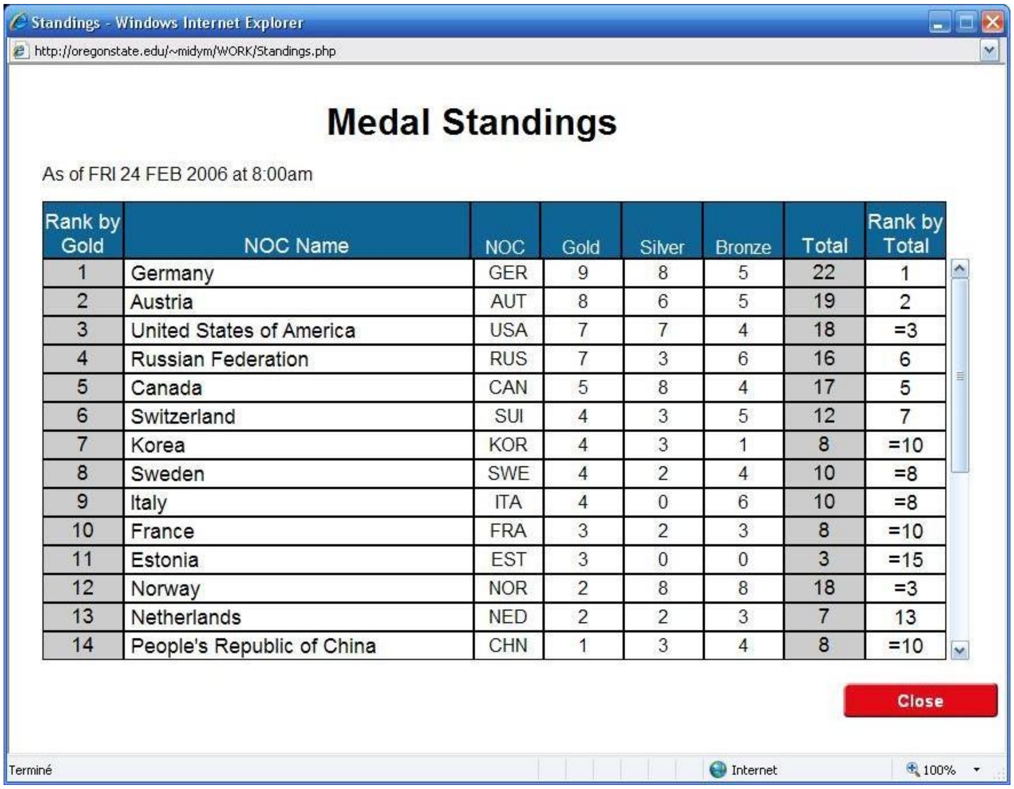
Bib No	Name	NOC	Penalties (P)	(S)	T.P.	Rk	Time	Diff
3-1	T. Berger	NOR	1+3		1+3	18	7:47.8	+1:00.5
14-1	T. Otaka	JPN	0+2		0+2	17	7:34.9	+47.6
16-1	D. Plotogea	ROM	0+3		0+3	16	7:31.4	+44.1
4-1	D. Peretto	FRA	0+2		0+2	15	7:23.4	+36.1

Appendix 27: Prototype of the 2006 CIS: Weather screen



Temperature	4°C / 39°F
Humidity	34%
Wind Speed (km/h)	12
Wind Direction	NE
Precipitation (mm)	0

Appendix 28: Prototype of the 2006 CIS: Medals screen



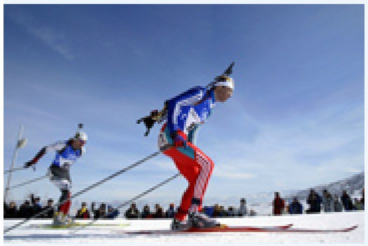
Medal Standings

As of FRI 24 FEB 2006 at 8:00am

Rank by Gold	NOC Name	NOC	Gold	Silver	Bronze	Total	Rank by Total
1	Germany	GER	9	8	5	22	1
2	Austria	AUT	8	6	5	19	2
3	United States of America	USA	7	7	4	18	=3
4	Russian Federation	RUS	7	3	6	16	6
5	Canada	CAN	5	8	4	17	5
6	Switzerland	SUI	4	3	5	12	7
7	Korea	KOR	4	3	1	8	=10
8	Sweden	SWE	4	2	4	10	=8
9	Italy	ITA	4	0	6	10	=8
10	France	FRA	3	2	3	8	=10
11	Estonia	EST	3	0	0	3	=15
12	Norway	NOR	2	8	8	18	=3
13	Netherlands	NED	2	2	3	7	13
14	People's Republic of China	CHN	1	3	4	8	=10

Appendix 29: Biathlon rules available during the experiment

Biathlon rules



A competition phase

The biathlon is an Olympic Winter sport that combines **freestyle cross-country skiing** and small bore **rifle shooting.** This discipline requires **strength and endurance,** as well as the ability to concentrate and technical skills.

The events take place on **circuits of various lengths** (2 km, 2.5 km, 3 km, 4 km) depending on the specialty. After each circuit, the athletes have to complete a shooting session at the rifle range, each one consisting of five shots.

The **penalties** are deducted by having to cover an additional 150 m circuit for each target missed, or with the addition of one minute to the total time for each target missed in the individual events. The time taken for the four shooting sections is deducted, therefore each athlete tries to reduce their time in the rifle range to a minimum: the best arrive at 30 seconds, and are able to hit the five targets in approximately 15 seconds from the first shot. **The winner** is the one that manages to complete the entire circuit in **the best time** (including the time taken for shooting) with the addition of possible penalties.

There are ten events in the Olympic Sport Programme, five men's and five women's.

Type of competition	Men's Events	Women's Events
Individual	20 km	15 km
Sprint	10 km	7,5 km
Pursuit	12,5 km	10 km
Relay	4 x 7,5 km	4 x 6 km
Mass Start	15 km	12,5 km

Relay

Each of the four athletes that make up the team must cover the entire race distance before changing over to their teammate and must complete two shooting series of five targets each: **from the ground, then standing.**

The athletes have available, in addition to their five shots, another three in reserve, which have to be loaded individually for security reason. After the first shooting phase the athletes line up at the shooting range on the basis of their position in the race, the first in lane one and so on. If, despite the three reserve shots, they fail to hit all the targets, they must enter the penalty round on the basis of the missed targets.

From: http://www.torino2006.org/ENG/OlympicGames/sport_ed_atleti/bt_regole.html

Appendix 30: Past biathlon results available during the experiment

Biathlon at the 2002 Winter Olympics

From Wikipedia, the free encyclopedia

• *Interested in contributing to Wikipedia?* •

Jump to: navigation, search

2002 Winter Olympic Games Biathlon

The Biathlon events were held at Soldier Hollow.

Contents

Men

10 km Sprint

Medal	Athlete	Time (missed targets)
Gold	Ole Einar Bjørndalen (NOR)	24:51.3 (0)
Silver	Sven Fischer (GER)	25:20.2 (1)
Bronze	Wolfgang Perner (AUT)	25:44.4 (0)

Without any misses with the shooting, Bjørndalen wins his second gold of the Games.

Appendix 30: Past biathlon results available during the experiment (Continued)

12.5 km Pursuit

Medal	Athlete	Time (missed targets)
Gold	Ole Einar Bjørndalen (NOR)	32:34.67 (2)
Silver	Raphaël Poirée (FRA)	33:17.7 (1)
Bronze	Ricco Gross (GER)	33:33.7 (2)

Bjørndalen wins his third gold of the Games to equal Aleksandr Tikhonov as the most successful biathlete at the Olympics.

20 km Individual

Medal	Athlete	Adjusted Time (penalty minutes)
Gold	Ole Einar Bjørndalen (NOR)	51:03.3 (2)
Silver	Frank Luck (GER)	51:39.4 (0)
Bronze	Viktor Maigurov (RUS)	51:40.6 (1)

After finishing 6th in the 30 km cross country, Bjørndalen wins the gold in the biathlon, where he is by far the best skier.

4 x 7.5 km Relay

Medal	Team	Time (missed targets)
Gold	Norway (Halvard Hanevold, Frode Andresen, Egil Gjelland, Ole Einar Bjørndalen)	1:24:42.31 (0)
Silver	Germany (Ricco Gross, Peter Sendel, Sven Fischer, Frank Luck)	1:25:27.6 (1)
Bronze	France (Gilles Marguet, Vincent Defrasne, Julien Robert, Raphaël Poirée)	1:25:36.6 (1)

Appendix 30: Past biathlon results available during the experiment (Continued)

Women

7.5 km Sprint

Medal	Athlete	Time (missed targets)
Gold	Kati Wilhelm (GER)	20:41.4 (0)
Silver	Uschi Disl (GER)	20:57.0 (1)
Bronze	Magdalena Forsberg (SWE)	21:20.4 (1)

Another surprise from Germany, which takes first and second. Forsberg seals a second bronze with a late sprint towards the finish.

10 km Pursuit

Medal	Athlete	Time (missed targets)
Gold	Olga Pyleva (RUS)	31:07.77 (1)
Silver	Kati Wilhelm (GER)	31:13.1 (4)
Bronze	Irina Nikulchina (BUL)	31:15.9 (2)

After leaders Poirée and Forsberg fail at the last shooting, Pyleva grabs the opportunity to take her first international victory.

15 km Individual

Medal	Athlete	Adjusted Time (penalty minutes)
Gold	Andrea Henkel (GER)	47:29.1 (1)
Silver	Liv Grete Skjelbreid Poirée (NOR)	47:37.0 (1)
Bronze	Magdalena Forsberg (SWE)	48:08.3 (2)

Henkel surprises, while hot favorite Forsberg misses two shots in the last round but wins her first medal.

Appendix 30: Past biathlon results available during the experiment (Continued)

4 x 7.5 km Relay

Medal	Team	Time (missed targets)
Gold	Germany (Katrin Apel, Uschi Disl, Andrea Henkel, Kati Wilhelm)	1:27:55.8 (1)
Silver	Norway (Ann-Elen Skjelbreid, Linda Tjørhom, Gunn Margit Andreassen, Liv Grete Skjelbreid Poirée)	1:28:26.4 (0)
Bronze	Russia (Olga Pyleva, Galina Kukleva, Svetlana Ishmouratova, Albina Akhatova)	1:29:20.5 (2)

Defending champions and major favorites Germany come from behind after the first leg to take the gold medal. Katrin Apel and Uschi Disl also were on the winning 1998 team.

Retrieved from "http://en.wikipedia.org/wiki/Biathlon_at_the_2002_Winter_Olympics"

Categories: 2002 Winter Olympics | 2002 Winter Olympics events | Biathlon at the Olympics

Appendix 31: Pre-questionnaire for the experiment

Subject number:
(Assigned by the Principal Investigator)

Condition: 1st ☒ 2nd ☐
(Assigned by the Principal Investigator)

Please fill in the following fields:

1. Have you ever used a Commentator Information System?........................ Yes: ☐ …………………... No: ☐

If yes, when and under what circumstances? …………………….…….…. ____________________________

____

____

2. Have you ever watched biathlon?... Yes: ☐ …………………... No: ☐

If yes, when was the last time? ………………………………….……….. ____________________________

____

____

3. What is your familiarity with biathlon? (Check one)………….…………… Unfamiliar: ☐ Novice: ☐ Intermediate: ☐ Expert: ☐

4. Do you know most of the rules of biathlon?... Yes: ☐ …………………... No: ☐

5. Did you watch some of the 2006 Winter Olympic Games on TV?.............. Yes: ☐ …………………... No: ☐

6. Did you listen to some of the 2006 Winter Olympic Games on radio?...... Yes: ☐ …………………... No: ☐

7. Rate your familiarity with general computer use? (Check one)................. Unfamiliar: ☐ Novice: ☐ Intermediate: ☐ Expert: ☐

8. What is your favorite sport? ……………………………..…………………….. ____________________________

9. What is your favorite winter sport (if different)? ……………….…………… ____________________________

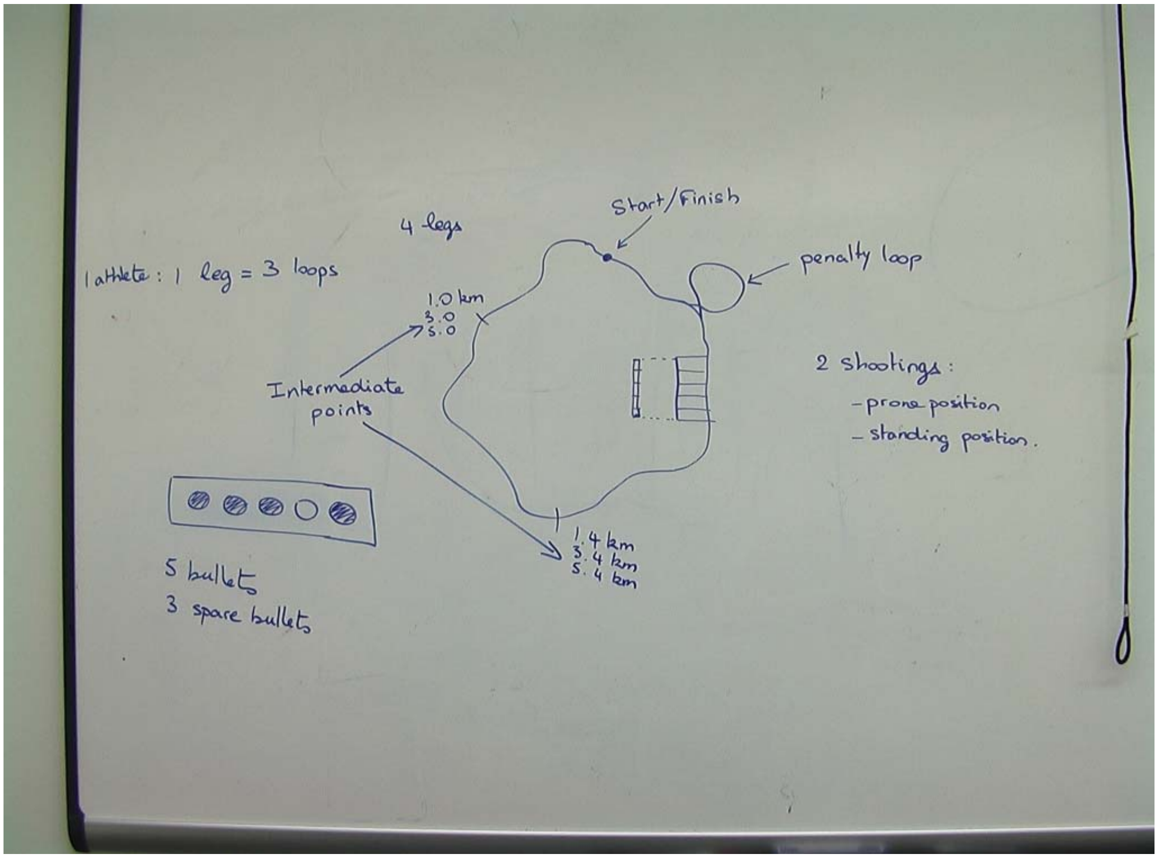
10. Do you have any broadcasting experience? .... Yes: ☐ …………………... No: ☐
(e.g. work for the campus TV channel, radio station, etc.)

If yes, give some details: ………………………………………………… ____________________________

____

____

Appendix 32: Biathlon rules during on a white board during the experiment



Appendix 33: Mid-questionnaire for the experiment

Please answer the following questions using a check mark in the appropriate box.

How easy was it to find:	Very easy (1)	(2)	(3)	(4)	Very difficult (5)	Don't know / Rather not say
The intermediate time of 3.4 km of, for instance, Tracy Barnes?						
The prone shooting result of, for instance, Tracy Barnes?						
The rank of, for instance, Tracy Barnes?						
The final rank of the USA team?						
The final time of the USA team?						
The origin country of, for instance, Anzela Brice?						
The age of, for instance, Tracy Barnes?						
The names of all the team members of the USA?						
The number of spare bullets used by, for instance, Tracy Barnes?						
What was the team who won the women relay of the 2002 Winter Olympic Games?						
Is the CIS easy to learn?						

Appendix 33: Mid-questionnaire for the experiment (Continued)

As a viewer, how much did having access to the following screens/information affect your viewing experience/enjoyment of the event?

	Greatly Distracted (1)	(2)	Neutral / No effect (3)	(4)	Strongly added (5)	Don't know / Rather not say
Team Start List						
Team Member Start List						
Start Order						
Progress Screen						
Shooting Screen						
Past biathlon results						
Biathlon rules						
Venue information						
Biathlon schedule						

Appendix 33: Mid-questionnaire for the experiment (Continued)

If, as a viewer, you could have access to any of these types of information in addition to TV, which would you pick? (Rank 1 to 5, 1 being your first choice)

	Rank
Team Start List	
Team Member Start List	
Start Order	
Progress Screen	
Shooting Screen	
Past biathlon results	
Biathlon rules	
Venue information	
Biathlon schedule	

About your overall experience:	Strongly disagree (1)	(2)	(3)	(4)	Strongly agree (5)	Don't know / Rather not say
I enjoyed using the CIS						
I am more interested in biathlon than I was before						
I am more interested in Winter Olympics than I was before						

Appendix 33: Mid-questionnaire for the experiment (Continued)

What do you think of the CIS overall interface?.......................	______________________
What would you change in the CIS? (if anything)………………	______________________
What do you wish you knew about the CIS before……………. hand? (if anything)	______________________
What additional information would you like to have …………… available while using the CIS?	______________________
Did you get lost while using the CIS?	Yes: ☐ No: ☐
Give an example and any explanation………………..	______________________
What was your strategy for using the CIS?.............................. How did you decide what pages to go to/when?	______________________

Appendix 33: Mid-questionnaire for the experiment (Continued)

Overall, what would you change about the CIS?...................... ____________________

(e.g. interface, number of screens, data,…) ____________________

____

____

Which screens seem the most useful; to you?......................... ____________________

____

____

____

Which screen(s) did you enjoy using the most?....................... ____________________

____

____

____

What is your favorite source of detail / information?………….. TV: ☐ CIS: ☐ The Internet: ☐
(for this experiment) Papers: ☐ Audio Commentaries: ☐

Appendix 34: Example of a Note Card for the experiment

Athlete's name: Kong Yingchao			
Leg#: ______			
Intermediate points	**Time**		
Int1 - 1.0 km			
Int2 - 1.4 km			
Int3 - 3.0 km			
Int4 - 3.4 km			
Int5 - 5.0 km			
Exch./Finish - 6.0 km			
Shootings	**Results**	**Number of Penalties**	**Number of Spares**
Prone	○ ○ ○ ○ ○		
Standing	○ ○ ○ ○ ○		

Appendix 35: Example of a Bonus Question for the experiment

Leg 1 – 12:02:00

Bonus Question 1: Who are the four team members of team USA?

Answer: ______________________________

____

____

____

Appendix 36: Post-questionnaire for the experiment

Please answer the following questions using a check mark in the appropriate box.

Rate the complexity of each task:	Very easy (1)	(2)	(3)	(4)	Very difficult (5)	Don't know / Rather not say
Repeating the audio commentary						
Repeating the audio commentary and answering the bonus questions						
Repeating the audio commentary and keeping track of the results						
Repeating the audio commentary, keeping track of the results and answering the bonus questions						

How easy was it to find:	Very easy (1)	(2)	(3)	(4)	Very difficult (5)	Don't know / Rather not say
The intermediate time of 3.4 km of, for instance, Tracy Barnes?						
The prone shooting result of, for instance, Tracy Barnes?						
The rank of, for instance, Tracy Barnes?						
The final rank of the USA team?						
The final time of the USA team?						
The origin country of, for instance, Anzela Brice?						
The age of, for instance, Tracy Barnes?						
The names of all the team members of the USA?						
The number of spare bullets used by, for instance, Tracy Barnes?						
What was the team who won the women relay of the 2002 Winter Olympic Games?						
Was the CIS easy to learn?						

Appendix 36: Post-questionnaire for the experiment (Continued)

If, as a viewer, you could have access to any of these types of information in addition to TV, which would you pick?
(Rank 1 to 5, 1 being your first choice)

	Rank
Team Start List	
Team Member Start List	
Start Order	
Progress Screen	
Shooting Screen	
Past biathlon results	
Biathlon rules	
Venue information	
Biathlon schedule	

About your overall experience:	Strongly disagree (1)	(2)	(3)	(4)	Strongly agree (5)	Don't know / Rather not say
I enjoyed using the CIS						
I am more interested in biathlon than I was before						
I am more interested in Winter Olympics than I was before						

Appendix 36: Post-questionnaire for the experiment (Continued)

What did you think of the CIS overall interface?....................... ____________________

What would you change in the CIS? (if anything)……………… ____________________

What do you wish you knew about the CIS before……………..
hand? (if anything) ____________________

What additional information would you like to have ……………
available while using the CIS? ____________________

Did you get lost while using the CIS? .... Yes: ☐ No: ☐

Give an example and any explanation……………….. ____________________

What was your strategy for using the CIS?..............................
How did you decide what pages to go to/when? ____________________

Appendix 36: Post-questionnaire for the experiment (Continued)

How did your strategy evolve over the course of this…………
experiment? ______________________

Overall, what would you change about the CIS?......................
(e.g. interface, number of screens, data,…) ______________________

Are you often in similar situations, multitasking ....
under pressure ? Yes: ☐ No: ☐

If yes, give some examples……………………………. ______________________

Which screens seemed the most useful to you?..................... ______________________

Which source of information was the most informative/useful?	CIS: ☐ Papers: ☐	The Internet: ☐ Audio Commentaries: ☐
Which was the easiest to use?	CIS: ☐ Papers: ☐	The Internet: ☐ Audio Commentaries: ☐
Which added the most to your enjoyment?	CIS: ☐ Papers: ☐	The Internet: ☐ Audio Commentaries: ☐