Summary of Technology and Innovation in the Tokyo 2020 Games

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Abstract

This article provides a quantitative overview of the technologies introduced in the Olympic and Paralympic Games Tokyo 2020 from the perspective of the evolution of technologies in past Games, and describes the success factors of the projects, the legacy of the Games, and the innovation initiatives.

Keywords : Communication networks, Information systems, Cyber security measures, Innovation

1. Foreword

The Olympic and Paralympic Games Tokyo 2020 (hereinafter referred to as "Tokyo 2020 Games"), which were postponed for one year due to the pandemic of the new coronavirus infection (hereinafter referred to as "coronavirus pandemic"), were an event that relied more heavily on digital tools than previous Games. Specifically, digital tools were used, first of all, to provide a remote work environment for staff engaged in the vast amount of plan revisions and contract changes, as well as to proceed with immigration application procedures, health management, and social distancing measures for the Games stakeholders. In addition, as Games without a centralized Olympic Park where the competition venues are located, it was necessary to construct the most extensive communication and broadcast contribution network in the history of the Games. Furthermore, cyber security measures were another issue that attracted worldwide attention, following the cyber incident that had occurred at the opening ceremony of the PyeongChang 2018 Games. While general spectators were banned from competition venues, the digital media that distributed the results of the games gained the most access in the history of the Games. The Games were also supported by the largest number of partner companies, and many innovation projects were planned and implemented by them.

The author believes that accurate and quantitative records of numerous and various technologies as well as innovation projects that supported the Games will not only serve as a reference for large-scale events in the future, but will also contribute to the development of the industry as footprints of historical projects. As a summary of such special issue of articles, this article reviews the Tokyo 2020 Games, including the evolution of technology introduced in the past Games, analyses the factors that enabled the Games to be a great success in terms of technology operation, and also discusses the technology legacy of the Games.

2. Evolution of Games Technology

The information systems and broadcast technologies introduced in the Olympic and Paralympic Games have evolved in response to the technological trends of the eras and the contributions of partner companies (Table 1) [(1)].

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Table 1 Olympic Host Year, Host City, and Technologies Introduced [1]

Year/Host city	■ Games management perspective (results measurement, information systems, etc.) □ Games watching perspective (broadcast, digital media, etc.)
London, 1948	□ TV broadcast covering a 50-mile radius
Rome, 1960	□ First live TV broadcast of the Olympic Games in 18 European countries
Squaw Valley, 1960	■ Data processing of competition results by computer (punch card input)
Tokyo, 1964	■ Aggregation and distribution of competition results by on-line system ■ Adoption of quartz timers □ First live broadcast by relay vehicles and helicopters □ First live satellite broadcasting relay
Grenoble, 1968	■ Timing and scoring by using quartz timers with 1/1000th second accuracy and computers
Mexico City, 1968	■ Large-scale broadcast centre and press centre □ First color broadcast, live slow-motion video
Sapporo, 1972	■ Direct guidance on an electronic bulletin board
Munich, 1972	■ Information retrieval by computer system, private television system □ Video recording, instant replay
Montreal, 1976	■ Integrated results system
Sarajevo, 1984	■ Systematization of the Games management business (accreditation, hotel reservations, uniform distribution, ticket sales, etc.)
Los Angeles, 1984	■ Dedicated technology teams for each competition venue ■ Messaging system (e-mail, voicemail, bulletin board, application entry form)
Seoul, 1988	■ Integrated information system (competition results/games management) ■ Olympic Computer Centre □ First live high-definition broadcast
Lillehammer, 1994	■ INFO (games information retrieval system) and CIS (Commentator Information System)
Atlanta, 1996	■ From mainframe to client-server system □ First official Olympic website on the Internet
Nagano, 1998	□ Full-scale use of the Internet
Sydney, 2000	□ BS digital high-definition test broadcast (Japan)
Salt Lake, 2002	■ Competition data feed in XML format
Turin, 2006	■ Wi-Fi service for media
Beijing, 2008	□ High-definition broadcast of all competitions □ Liberalization of media content posting on their websites
Vancouver, 2010	□ Streaming video distribution using video signals provided by OBS □ Authorized social media (Facebook, Twitter, etc.) □ Mobile application for the general public
London, 2012	■ Media use of INFO on mobile devices (myInfo+) ■ Data service of streaming video distribution for right-holding broadcasters □ Official YouTube channel by IOC □ 8K Ultra-High Definition (Super Hi-Vision) exhibition broadcast
Rio de Janeiro, 2016*	■ Partial cloud-based games information system □ Introduction of 360-degree camera images
Pyeongchang, 2018*	■ Complete cloud-based games information system ■ 5G trial introduction □ Introduction of free viewpoint images and afterimage video
Tokyo, 2021*	■ Introduction of face recognition ■ Full-scale introduction of Public Safety-LTE radio system ■ Full-scale introduction of 5G ■ CRM platform in corporation with the IOC □ Ultra-High Definition (4K) standard signal □ Content distribution for right-holding broadcasters via the OBS cloud □ Official website operation platform by the IOC

* Items after Rio de Janeiro 2016 were added by the author.

2.1 Evolution of Game Management Technologies

The Tokyo Games in 1964 adopted the first online system for aggregating and delivering competition results, and the system evolved into an integrated information system through the Games in the 1980s and 1990s. Since the PyeongChang 2018 winter Games (and

the Tokyo 2020 as the first summer Games), this system has been implemented in a fully cloud environment operated by worldwide partners (partners that continuously participate in multiple Games), contributing to a significant reduction in operations and costs that previously required at a data centre in each host city.

The information system that supports various administrative tasks accompanying the personal information management, such as the accreditation of the participation of Games officials, has been further developed for the Tokyo 2020 Games. This system was combined with a face recognition system for the secure entry of the stakeholders and staff. It also worked with immigration management, health management, and screening test management of the stakeholders for the special operation of the Games under the coronavirus pandemic.

2.2 Evolution of Game Watching Technologies

After the partial introduction of the high-definition live broadcast in the Seoul 1988 Games and the full introduction for all events in the Beijing 2008 Games, the Olympic Broadcasting Services (OBS) adopted Ultra-High Definition (UHD) video signals as the standard for the Tokyo 2020 Games. It means all competition footages were basically recorded in the UHD format [2]. The shift to remote production by broadcasters, which has been a trend in recent years, has made further progress due in part to the coronavirus pandemic. As an environment to support this trend, the collaboration between OBS and the worldwide partners was realized for the cloud-based contents distribution.

Meanwhile, the official Olympic website, which was first introduced in Atlanta 1996 Games, was provided in seven languages in Tokyo 2020 Games, and accessed by the largest number in the history.

3. Technology Overview of the Tokyo 2020 Games

This section provides a field-by-field summary of all the technologies that supported the Tokyo 2020 Games.

3.1 Infrastructure and technology equipment that supported game operations

Having no Olympic Park built as a centralized location of venues, the Broadcast Contribution Network connecting the 43 competition venues and the International Broadcast Centre (Figure 1) spanned 1,900 km of optical fiber and 10,000 km of leased lines, making it one

Figure 1 International Broadcast Centre This is the base where competition images from all venues are aggregated and distributed to each country. (©2021-International Olympic Committee-All Rights Reserved)

of the largest in the history of the Games due to the large number and distributed locations of competition venues. Furthermore, the data network for the Games, which spanned approximately 100 locations, including the athletes' village, Main Press Centre, and other non-competition venues, consisted of 1,200 km of optical fiber, 3,900 km of metal cable, 5,000 km of WAN lines, and 16,000 network devices, and was connected to two data centres in Japan (which accommodated 35 physical servers, 220 virtual servers, and 490 TByte of storage capacity) and overseas data centres operated by worldwide partners. In addition, 85,000 applications, the largest number in the history of the Games, were submitted for use of spectrum by the Games' stakeholders, of which 64,000 were approved and monitored in cooperation with the Ministry of Internal Affairs and Communications (MIC). (For details, see Chapter 2 "Telecommunication, Radio, Broadcast" of this special issue.)

The technology equipment installed included 17,000 PCs, 20,000 smartphones, 15,000 Personal Mobile Radios (6,300 of which were Public-Safety LTE systems, the first full-scale introduction in the history of the Games), and 2,900 printers and MFPs. Kitting out such a large amount of infrastructure and equipment without fail, which involved installing, operating, and removing them at all venues, was a major challenge for each Game. It required careful planning in advance and a complete team structure (Figure 2) including the Equipment Deployment Centre and venue technology teams. (For details, see Chapter 6 "Games Management, Operation Centres" of this special issue.)

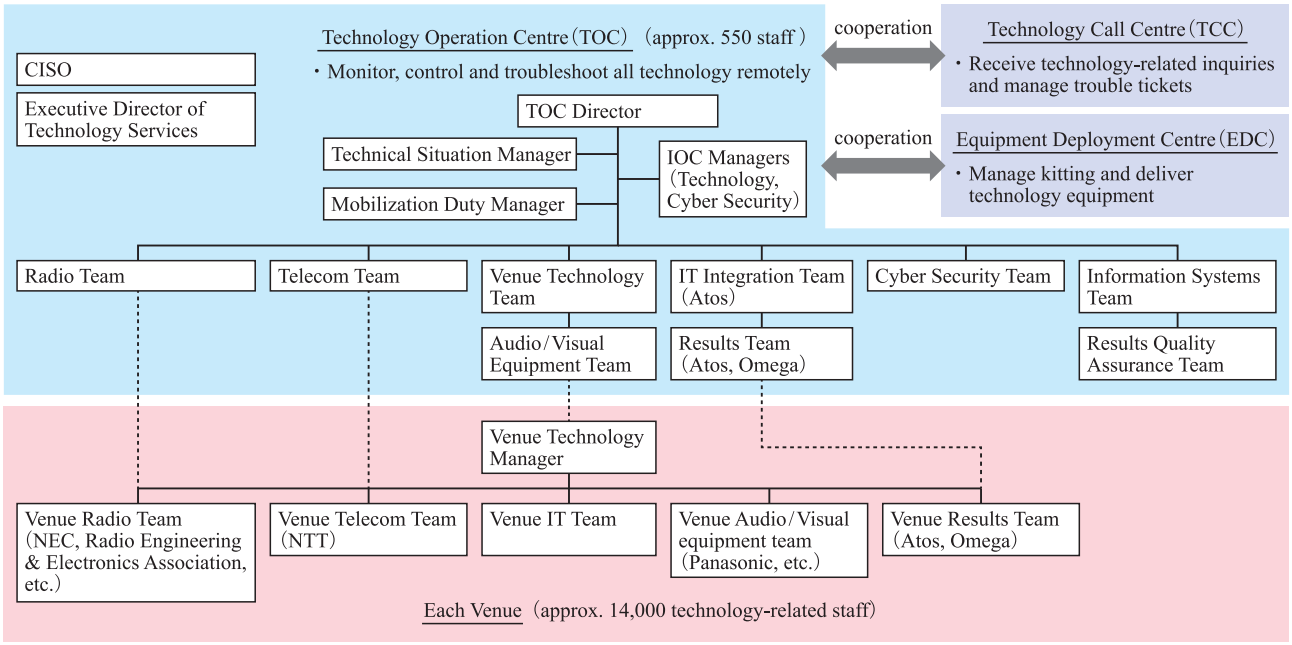

Figure 2 Organization Structure Supported Technology Services The structure was divided into three main sections : the Technology Operation Centre (TOC), the venues, and other centres (Technology Call Centres, Equipment Deployment Centres). Each staff were assigned under the respective duty managers of the teams.

3.2 Results Systems and Information Systems That supported Games

Since the ODS (Olympic Diffusion System) was originally strengthened to increase the number of users beyond the capacity of past Games, it was able to cope stably with the increased number of users via the Internet due to the coronavirus pandemic. Specifically, myInfo, the Games information system for the media, was provided to 16,000 users at the Olympics (previously capped at 10,000 users), and CIS, the information system for commentators, was provided to 450 users at the Olympics (previously capped at 300 users).

The video adjudication system has been adopted for 30 Olympic and 13 Paralympic sports, numbers that far exceeded those used in the past Games.

As for the game management system, the number of registered Games stakeholders increased significantly from the past Games to 420,000 for the Olympic Games and 310,000 for the Paralympic Games. This is mainly due to the large number of contractors who were registered to provide transportation and security services in accordance with the decentralized layout of the venues. The 66 business applications and the 120 business websites were built and operated to support businesses of these large numbers of Games stakeholders. In particular, Tokyo 2020 ICON, an infection control support system that was implemented in a short period of time to ensure the safe operation under the coronavirus pandemic, was used to register a total of 490,000 participants during the Games time, to manage 1.79 million health information and 920,000 screening test results, and to issue 53,000 negative certificates. (For details, see Chapter 3 "Information System, Digital Media" of this special issue.)

3.3 Successful Cyber Security Measures

While the stable operation of technology has always been a universal issue throughout the history of the Olympics, cyber security and congestion control of the mobile communication environment have emerged as focal points since the London 2012 Games [3]. Especially for cyber security concern, cyberattacks and cyberterrorism in recent ICT-driven event operation can be relatively inexpensive and effective means to carry out the undesirable actions such as radical political propaganda through the media, obstruction of the Games by terrorism, and fraud in the sales of Games tickets, which are regarded as typical interferences in the Games.

In 2014, a group of experts from the ICT industry, including the author, joined the Tokyo 2020 Organising Committee (hereinafter referred to as the "Organising Committee") and began analyzing cyber security risks that could affect the operation of the Games and examining countermeasures. During the nearly seven

years of study and preparation, new malware and security risks emerged, and critical incidents occurred at the PyeongChang 2018 Games. Also, related solutions became more sophisticated and cloud-based, and the power structure of the solutions industry changed. Therefore, it was essential to constantly review and reexamine countermeasures.

Despite the cyber security risks of the Tokyo 2020 Games being pointed out in the media prior to the Games, no cyberattacks affecting the Games were observed, and the Games were successfully completed[4]. The followings can be cited as success factors: ① the early establishment of an information security management system by the Organising Committee, ② implementation of secure architecture design and proactive countermeasures in collaboration with partner companies, IOC, and OBS, ③ repeated security audits and practical exercises of incident handling, and ④ prompt incident response through global collaboration and cooperation during the Games. (For details, see Chapter 5 "Cyber Security" of this special issue.)

Figure 3 Technology Operation Centre (TOC) This centre remotely monitors and controls all technologies and directs trouble-shooting. (©2021-International Olympic Committee-All Rights Reserved)

3.4 Stable Operation of Technology during the Games Time

Each of the Games uses a trouble-ticket management system of the technology field to register all incidents that occurred from the test event period to the Games time period according to their severity level, and the Technology Operations Centre (TOC) manages them (Figure 3). In particular, a comparison with the past Games shows that the number of high severity incidents that occurred during the Tokyo 2020 Games was significantly lower than those in other recent Games (Table 2).

This is partly due to the fact that the postponement of the Games by one year allowed sufficient time for testing information systems. But it is also due to the extremely small number of troubles that have frequently occurred in past Games, such as communication infrastructure problems, delays in the delivery of venue technology, and disruptions in the operational support of venue technology. Needless to say, this is due to the high-quality services and careful operations provided by many technology-related partner companies, including telecommunication partners, as well as the staff of the Organising Committee.

4. Conclusion

4.1 System Centred on Expert Human Resources

Since the large scale and wide range of technologies

Table 2 Number of Incidents That occurred in the four weeks which started before the Games, ended at the closing ceremony of each Olympic Games.

Counting period (Set to 4 weeks for comparison)	Incidents				Service request
	Severity level 1	Severity level 2	Severity level 3	Severity level 4	
Tokyo 2020 Games counting period 7/12～8/8	12	35	1,091	6,755	9,808
	Total 47		Total 17,654		
The Rio de Janeiro 2016 Games counting period 7/25～8/21	30	203	Total 32,673		
	Total 233				
London 2012 Games counting period 7/16～8/12	21	111	Total 25,473		
	Total 132				

【Definition of Severity】
Severity level 1: Critical system/service is not working.
Severity level 2: Critical system/service is at risk of failure.
Severity level 3: A component of the system/service is not working and multiple users are affected.
Severity level 4: A component of the system/service is not working and a specific user is affected.

are required for the Games, it is clear from the past Games that one of the conditions for success is to have a system consisting of expert staff in each field within the Organising Committee, and to proactively face partners and suppliers and lead the project[1]. In the Tokyo 2020 Games, several gold partners in technology-related fields sent their experts as seconded staff at an early stage, and these staff took the lead in establishing ICT governance to implement and operate the back-office environment in the preparation phase for the Games. This ICT governance, which was a major feature and advantage compared to the past Games, continued to be brushed up and functioned throughout the Games time.

4.2 Innovation Initiatives

Many innovation projects were planned by technology partners to introduce their latest technologies as showcasing in the Games. On the other hand, projects planned by partners tend to experience insufficient communication and sometimes conflicts of interest with the teams that build and operate the infrastructure that is central to Games operations, such as communication networks and common system platform. Thus, there were concerns that this situation would cause problems and reworks that could have been avoided otherwise.

Therefore, the Organising Committee launched the Innovation Promotion Office in 2017 to separate the projects aiming at showcasing innovation from the projects introducing core technologies essential to the Games operations, to balance the two different types of projects. As a result, many of the innovation projects were successfully completed in terms of the introduction and operation of solutions, although the objectives of the projects were not always fully achieved because many of the competitions were held without spectators due to the coronavirus pandemic. (For details, see Chapter 4 "Innovation Projects, Innovation Initiatives (Covering High-presence Communication, 5G, Robots, Drone Show, Projection Mapping)" of this special issue.)

On the other hand, because of the technology team starting its activities early on, we were able to initiate several activities to promote "open innovation" throughout the preparation period of the Games. Referring to advice from the Technology Advisory Committee, which was established in 2016 to reflect the opinions of external professionals, activities including the followings were carried out : ① Tokyo 2020 Ideathon, held three times in total, aimed at solving issues related to the operation of the Games, ② Tokyo 2020 Open Innovation Challenge, a contest to develop an application for spectators to watch the Games, for which the final judging was held in 2020, and ③ the significant improvement of the web accessibility of the competition results pages in the official website and mobile app, which was achieved with the cooperation of visually impaired students from Tsukuba University of Technology. All of these were the results of the participation and contribution of the younger generation in the preparation process of the Games.

4.3 Legacy of the Games

While the Tokyo 1964 Games left behind a lot of hardware legacies in the host city, such as bullet trains and highways, a theme often discussed by the Technology Advisory Committee mentioned above was "what kind of software legacy the Tokyo 2020 Games can leave behind."

The fact that many competitions were held without spectators due to the coronavirus pandemic was very unfortunate in terms of the spectator experience which could have been one of the valuable legacies. On the other hand, the CRM (Customer Relationship Management) platform was built and operated in collaboration with the IOC for the first time in the history of the Games. This platform preserves the precious records of multi-millions of people who have participated in the Games in various ways, such as the Games ticket holders or volunteer staff. And this, for example, will be a beneficial legacy to be utilized in future Games and sporting events, as clearly seen in the case of the London 2012 Games[5]. (For details, see Chapter 3, "Digital Media" of this special issue.)

Furthermore, all of the accomplishments reported here were achieved through collaboration, discussions, rehearsals and careful handling of problems, by a great team consisting of those seconded to the Organising Committee, those of partner companies, and of related organizations including the national government and the Tokyo Metropolitan Government. Above all things, the greatest legacy of the Games is that these engineers and project managers will contribute to the future digitization projects and use of technologies in Japanese society based on their experience working on the historic project.

I would like to take this opportunity to thank all the partners, suppliers, related organizations, and volunteers for their participation and significant contributions to the Games.

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