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Cost Saving and Production Enhancement Techniques for the 2006 Winter Olympics

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ABSTRACT

The 2006 Winter Olympics presented an opportunity for CBC-SRC to re-write the book on how to produce large international sports events. The 'Remote Production' system, capitalizing on cost-effective, high bandwidth fibre circuits, allowed the English and French Sports departments to produce the event in Toronto and Montreal respectively, thereby reducing the on-site personnel in Italy by two-thirds. The operating cost savings resulting from this was significant, as hotel, travel and per-diem costs were slashed, and on-site construction costs were significantly reduced.

This system model was first pioneered in 2003 on an International Athletics (IAAF) event in Paris and was first used for Olympic production by the CBC/Radio-Canada French sports department in 2004 for the Athens Olympics. But the 2006 Winter Olympics in Torino offered the first opportunity to implement the system model across both the English and French networks simultaneously, using a triangulation of fibre circuits between Torino, Toronto and Montreal. For the first time, existing control rooms and temporary production edit facilities were employed in the network centers using AVID non-linear editors exclusively. Multiple contribution program feeds transmitted from Italy were recorded into central servers in Toronto and Montreal, providing instant access to feeds for editing and delayed playback.

This paper provides a description of the system, discussing the technology used and the rationale for its use, as well as describing the operational impact and changes to workflow.

INTRODUCTION

Every two years, thousands of the world's best athletes come together and compete at the pinnacle of human athletic endeavour: the Olympic Games. In a two-week period, hundreds of heats and medal events take place in up to 30 venues and arenas spread across the host country. The challenge of producing and distributing live television images to over a billion viewers is a huge undertaking—so much so, that for one month every two years, the Olympic International Broadcast Centre (IBC) becomes the largest production facility in the world.

To maintain a common production standard and 'look', the International Olympics Committee (IOC) mandates a single broadcast company to be the host broadcaster and produce and distribute all of the main event footage of each Olympic event. In Turin, this company, TOBO[1], provided the equipment and production personnel to generate the core television images for distribution to the world. Of course, many countries also supply their own cameramen, reporters and production crews to generate additional programming, as viewers in other countries expect to see additional coverage of their own athletes, win or lose. For this reason, international broadcasters are awarded rights[2] by the IOC to shoot and produce additional footage, as well as broadcast the images generated by the host broadcaster.

Since the 1996 Summer Olympics in Atlanta, CBC/Radio-Canada has had the Canadian radio and television broadcast rights for the summer and winter Olympics, a contract slated to end after the 2008 Beijing Summer Games. To fulfill this broadcast mandate, every two years the CBC has to mobilize a massive production system—up to 60 tons of equipment and 500 people requiring 24,000 square feet of production space—in a temporary location somewhere in the world. Because of the magnitude of the system requirements, the CBC/Radio-Canada system is created from different sources within the English and French television networks. In fact, much of the equipment is borrowed from capital replacement work orders; the purchase of new production equipment is timed to allow first use on the Olympics, before deployment to its assigned place elsewhere in CBC.

For 16 days, 20 hours a day, the equipment runs flat-out producing over 500 hours of programming across multiple TV networks (English and French Television, Newsworld, RDI, Country Canada, TSN and RDS), synthesizing streams from as many as 15 different venues in a single day. Although the Winter Olympics require coverage of fewer venues, the number of programming hours is about the same as for the Summer Olympics. When it's all over, a two-day tear-down sees the system dismantled and boxed, and all the equipment shipped back to Canada.

In 2002, with only Athens (Summer 2004), Torino (Winter 2006) and Beijing (Summer 2008) remaining on the current contract, CBC management requested that CBC Technology investigate whether it would be possible, through the use of new technology or workflow, to reduce operating costs for the remaining Olympic events. A study released in 2002 concluded that:

a) Production efficiency was already very high; for the Sydney Olympics, English and French television networks combined used significantly less production and technical personnel than other major broadcasters from the US, Japan and Europe. Thus, no operating cost savings were available through personnel reduction.

b) The use of fibre optic transmission instead of satellite would halve transmission costs while increasing available bandwidth, in both directions. The built-in redundancy of the fibre optic paths also held the promise of increased reliability, with no susceptibility to weather fade or sunspot activity.

c) Capitalizing on the increased bandwidth available from fibre, the CBC would be in a position to displace the main Olympic production facilities (normally on site at the venue IBC) back into existing CBC/Radio-Canada facilities in Toronto and Montreal. This would entail compressing and streaming multiple program feeds over the international fibre circuits instead of a single, integrated feed.

[1] TOBO – Torino Olympic Broadcasting Organization

[2] For the Winter games in 2006, eighty countries were represented by Rights Holding Broadcasters

However, by doing this, the following cost savings could be realized:

- Reduction of personnel at the Olympic venue would be significant, rendering reduced accommodation and travel costs.
- Equipment requirements at the venue would be reduced, resulting in reduced shipping, installation and temporary construction costs.

This new concept of remote production was first tested in August 2003 on an international track and field event held in Paris. Both CBC and SRC Sports produced the event in temporary facilities in Montreal, using multiple video feeds transmitted on fibre to Montreal. This test fully validated the viability of the concept, as well as confirmed the reliability of transmitting via fibre. As a result, planning moved forward for use at the Athens Olympics in August 2004.

During this time, CBC was initiating first deployment of server technology throughout the Corporation, as a replacement for end-of-life tape-based production systems. As the Olympics system relies on upcoming capital acquisitions, this became a significant driver for adopting server-based, non-linear technology for CBC/Radio-Canada's Olympics production. This move had a significant impact on the Olympic system design plans, as Olympic production relies on the supply of 'pre-purchased' equipment from pending work orders to meet the temporary production requirements, and all the upcoming work orders were specifying server-based production systems. It was concluded that the significant work-flow change brought about by remote production, coupled with the major work-flow change required to move from tape-based to server-based post production, would be too great a load to place on the Olympics production staff. Accordingly, it was decided that the French networks would pilot the remote production concept on the Olympics, producing in Montreal using existing tape-based production, while the English networks would produce the event in Athens while piloting non-linear server-based Olympic production. In this way, the pain of progress would be distributed between the two networks.

The Athens event proved to be a success from the viewpoint of the new technologies deployed. SRC Sports produced the event in Montreal, using existing studio and control room facilities located there, while in Athens, CBC Sports used AVID non-linear editing and server record technology for the first time. Out of this came the decision to implement full remote production for both networks for the Turin Winter Games. The mandate issued by CBC management was for both networks to locate the majority of their production equipment and personnel in Toronto and Montreal, while producing with non-linear editing and server technology exclusively.

Late in 2005, the CBC made the decision to implement a limited high definition Olympics program distribution for the Turin Olympics, on both the English and French HD networks. CBC Technology was directed to integrate a preliminary system for delivering high definition signals to the English and French network HD channels. Due to bandwidth constraints, English and French HD network transmissions were programmed from two HD host feeds (compressed and routed from Turin to Toronto and Montreal) and upconverted standard definition signals from the network centre control rooms. In Toronto, the AVID server was large enough to support an HD post production suite. This was used to produce two hours of HD prime time material daily (usually the ice hockey 'Game of the Day').

This paper describes the system and workflow implemented to meet these requirements.

THE BACKBONE

The fibre backbone implemented by CBC for the Turin winter Olympics was based on existing common carrier ATM[3] networks. CBC contracted a one-month lease of three OC-3 fibre circuits between Canada and Italy with Deutsche-Telekom (T-Systems in North America), who managed the portion from Turin to Toronto and Montreal, and sub-contracted local loops with Telecom Italia and Videotron. Each OC-3 comprises a raw payload bandwidth of 149.5 Megabits per second (Mbps).

Two additional leased OC-3 circuits were also established between Toronto and Montreal to allow signals to be passed between the two cities. These circuits allowed program signals required by both networks to be carried only once between Italy and Canada, thereby avoiding signal duplication on the more expensive transatlantic paths. At each site, the CBC crew provided backbone and interface to the ATM public carrier capable of managing throughput of multiple signals, including OC-3, Ethernet (100 Base-T) and T1[4].

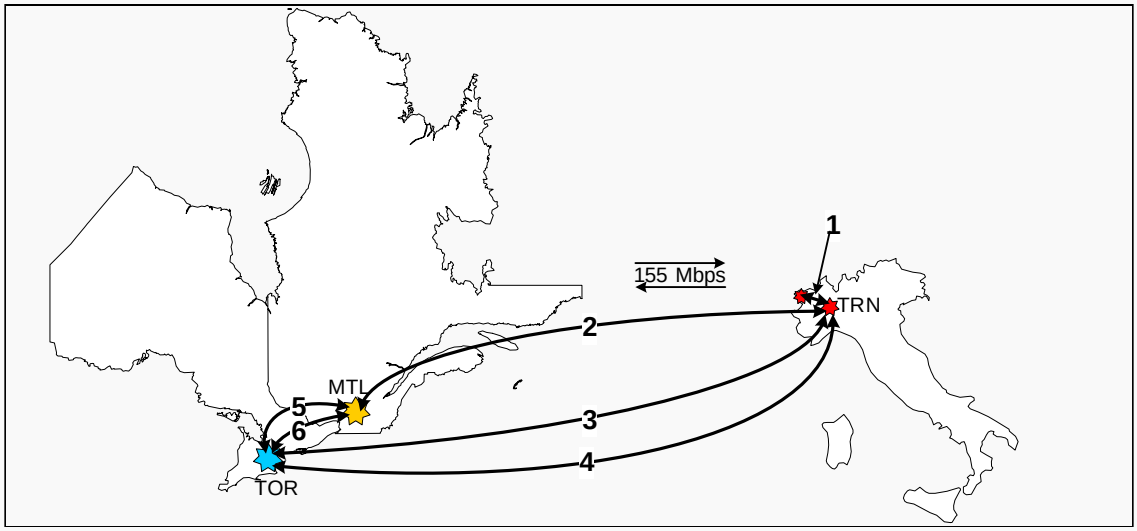


Figure 1. 2006 Olympics Fibre Paths

In Turin, because the mountain venues (downhill and cross-country skiing, snowboarding, bobsled) were so far removed from the city venues (skating, hockey), TOBO implemented a Mountain Broadcast Centre (BMC) for rights holding broadcasters to create satellite technical facilities. The Corporation took the decision to connect this site with the main IBC located in Turin's city centre using an additional OC-3, to ensure a full extension of services—video, audio, intercom and data—between the two sites. While this increased the technical complexity of the system, it ensured that CBC/Radio-Canada operations personnel could rapidly transmit program segments from the mountain back to Canada, essentially expanding the networked system interconnectivity beyond the main IBC and into the mountains.

[3] ATM: Asynchronous Transfer Mode

[4] T1, the North American telephony standard operating at 1.544 Mbps, comprises 24 DS-0 channels of 64 kbps each

In total, six OC-3 circuits serviced the CBC Olympic production for the Turin Winter Olympics in 2006, providing the system with a total of 900 Mbps (bi-directional) interconnected bandwidth. In comparison, the 2000 Summer Olympics transmission system provided 60 Mbps of satellite bandwidth to transport all network signals from Sydney to Toronto and Montreal. Despite this fifteen-fold increase in bandwidth availability, the leased transmission costs for Turin were less than half that of Sydney (though it should be noted that the transmission distance was significantly less). Let's take a look at what all this bandwidth was used for.

Program Feeds: Video and Audio

For remote production on the 2006 Winter Olympics, it was determined that the English and French Sports networks would each require 16 standard definition program feeds, comprising a mix of common feeds (feeds sent to both network centres) and unique feeds. The total number of program feeds sent from Torino was 23, each one of which passed through a processing chain as shown in Figure 2:

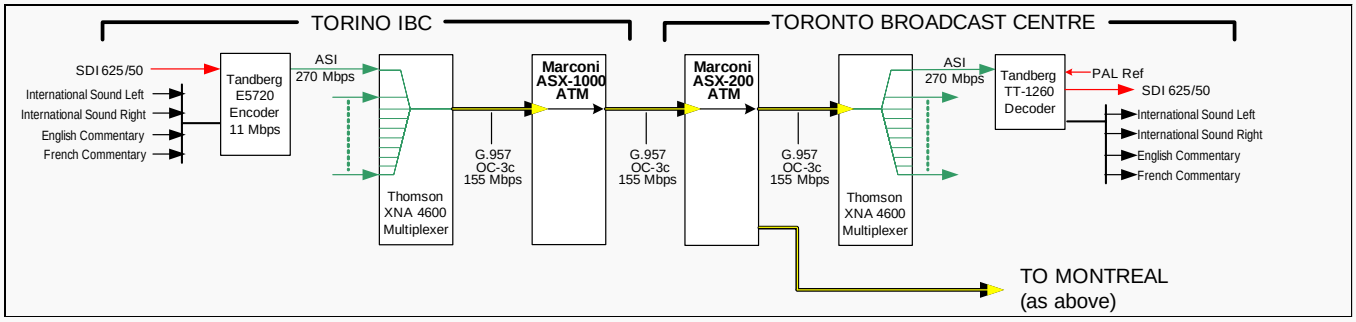


Figure 2. A Single Program Path Across the Backbone

For each feed, program video and audio signals were compressed using Tandberg MPEG-2 encoders, programmed to compress the SDI digital video signal (and four associated audio signals) from approximately 220 Mbps down to 11 Mbps. As many as 13 of these compressed program streams were subsequently multiplexed onto a single OC-3 fibre circuit, which in turn was passed to the Marconi ATM backbone equipment and the interface to the international carrier's ATM network. In Toronto and Montreal, the procedure is reversed to obtain the signals back to baseband SDI. While a very efficient bandwidth-to-picture quality ratio is achieved, the process does introduce a path delay[5]. Figure 3 shows a block diagram of the program feeds transmitted from Italy to Toronto and Montreal and the return feeds used for monitoring and voice-over requirements.

[5] Compression video algorithms apply predictive encoding that evaluate the picture change from frame to frame across a 'Group of Pictures', or GOP. Unchanging picture elements in the GOP are allocated much less bandwidth, leaving more bandwidth to capture the changing elements. This results in a huge efficiency in coding, but because the encoder must analyze the entire GOP before deciding how to apply the coding, the process introduces a delay of at least ½ second.

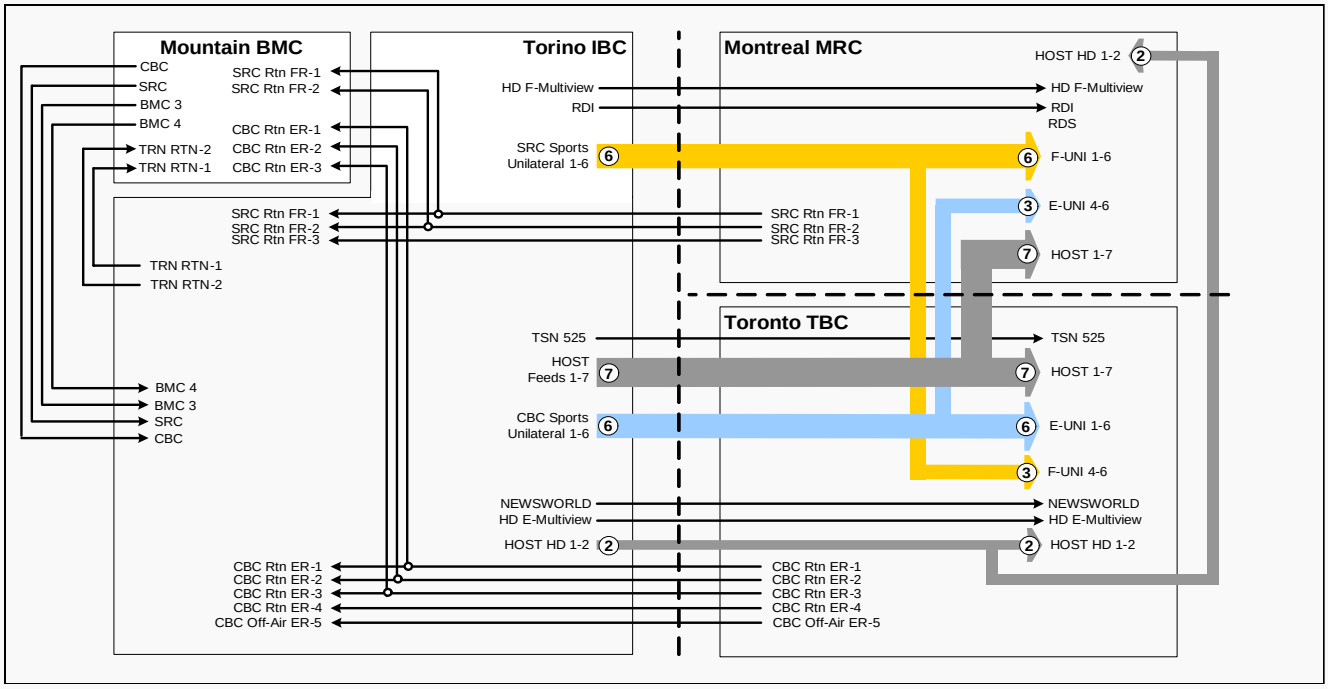


Figure 3: International Program Paths

Communications: Intercom, Phone, Internet

Intercom and phone interconnects were provided for in the backbone using multiple T1 circuits. Each T1 is capable of carrying 24 bi-directional intercom or telephone circuits. Operating at 64 kbps, each circuit provides a frequency bandwidth optimized for voice transmission (< 3 kHz) which, while unsuitable for transmission, is enough for efficient voice communication. There was an extensive requirement for communications of this type, such that each network centre was provided with 48 channels of intercom interconnected to a 200 x 200 central matrix in the Turin IBC.

The backbone also provides Ethernet interconnectivity across the ATM backbone, appearing as a transparent data bridge to TCP/IP networks. Through this, the CBC's 'Groupwise' e-mail system was extended into the Turin IBC, allowing operations and technical personnel cost-effective access to the internet and CBC intranet.

Within each of the three transatlantic OC-3 'pipes', multiple video, audio, intercom, phone and ethernet VPN paths were created. In total, over 50 video paths, 160 audio paths, 140 duplex intercom/phone paths and 24 Ethernet VPN paths were created across the four sites, interconnected by the CBC backbone.

THE PRODUCTION SYSTEM

The production systems located in Toronto and Montreal used existing studios, cameras and control rooms, augmented with additional monitoring, intercom and audio processing. In both network centres, temporary production facilities were constructed according to the requirements of the Olympic workflow.

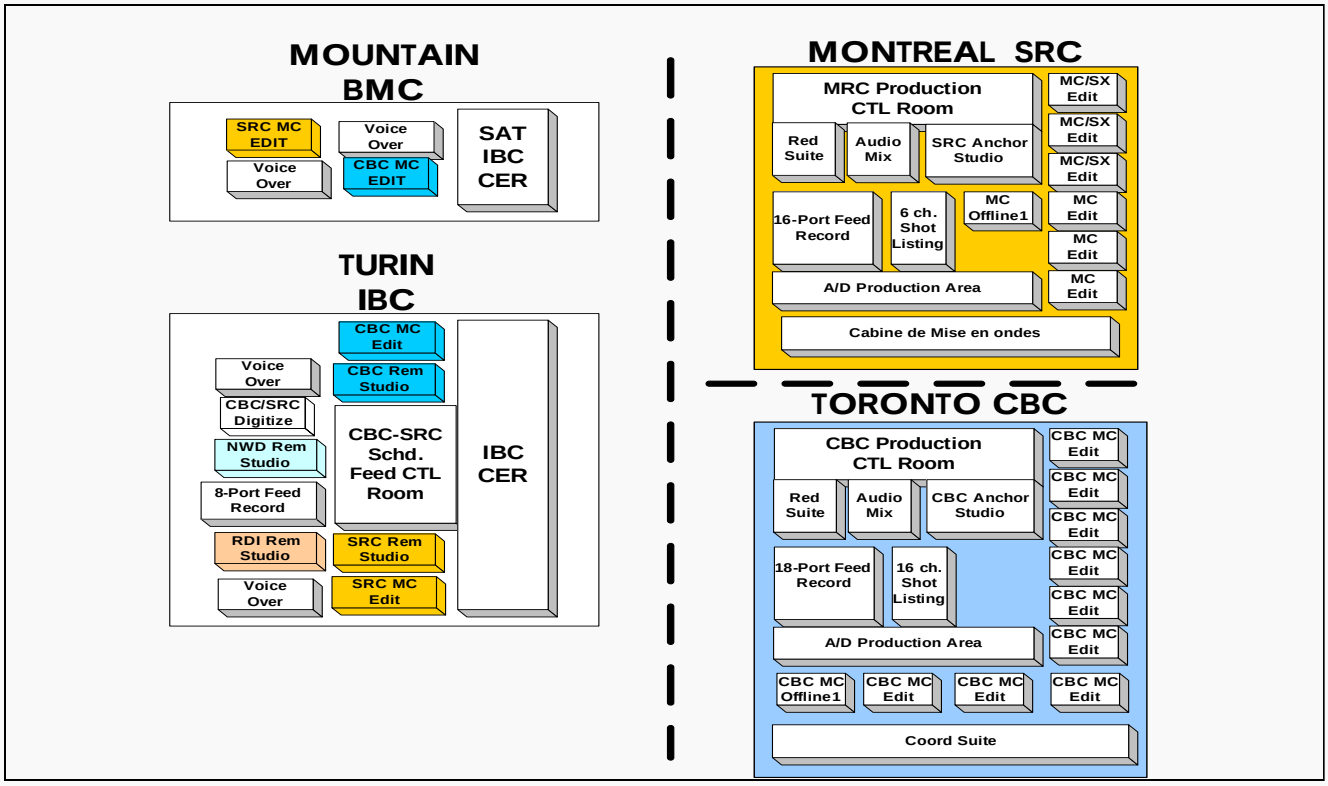


Figure 4: Production Facilities Provided in the Four Locations

Toronto and Montreal used variations on the same production system, so only the system in Toronto will be described: Twelve edit booths produced highlight packages in temporary facilities constructed above Control Room 40 on the 10th floor of the Toronto Broadcasting Centre. As the live sports were integrated in Control Room 40, with the anchor set constructed in the adjacent Studio 41, the proximity of the edit facilities meant that the entire Olympic production team in Toronto could operate as an integrated unit.

An AVID Isis storage server located in the 6th floor central equipment room was connected by multiple 10-Gigabit fibre to 'uplink switches' located on the 10th floor. These switches serviced all of the edit stations on the 10th floor, a mix of Media Composer and Newscutter platforms. From the 10th floor, a record room controlled 18 Airspeed record servers (also located in the 6th floor central equipment room), as well as back-up SX tape recorders for archiving the incoming feeds.
Once the production segments were complete, the producer of the segment would sign-off on the edit and instruct it to be sent to playback. This entails a file transfer "push" from the central Isis storage to an Airspeed play-out server. From this two-channel server, control room personnel could preview, edit in and out points, and play out the segment into the control room switcher.

The AVID system, operating at a (standard definition) compression rate of 25 Mbps, offered the system over 1000 hours of storage. As material was accumulated at between 150 -200 hours per day, this was sufficient for five days contiguous recording. Once over 75% full, it was necessary to purge early material. As all material ingested was catalogued according to date, this was as simple as purging a single folder (Day 1 folder material was purged on Day 5, Day 2 purged on Day 6, etc.). Occasionally, a clip of this material was required later in the event; when that happened, it was a relatively simple matter to return to the archive tape and re-digitize the required material back into the AVID.

Small satellite AVID production systems were also provided in Turin and the mountain venue to support the main systems in Toronto and Montreal. This enabled a production team to start pre-assembling program segments from the early morning material, compensating for the six-hour time zone shift, which in turn allowed the Canadian production crews to start their shifts later in the morning. Files produced on the AVID servers in Italy were subsequently transferred as AVID MXF files directly to the servers in Toronto or Montreal. This path was slightly slower than real-time (due to low available bandwidth on the fibre for this application), but proved very useful as it maintained quality and required only the sender to take action.

HD Production (Live)

The drawing below shows a high-level block diagram of the processing required to generate a live HD stream in each network centre. As a common stereo audio derived from the SD production was required, compromises were necessary in order to integrate upconverted studio and unilateral images into the HD stream. Although a significant portion of the HD channels featured upconverted audio, the key program material (hockey and skating events) was delivered in full-resolution high definition.

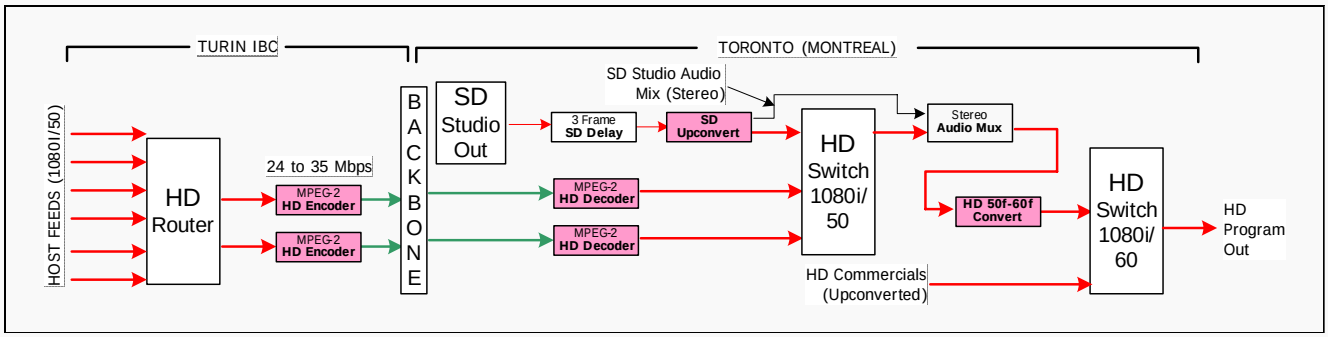


Figure 6: High Level HD Live Production

AVID HD Media Composers and HD Airspeeds were used in Toronto to produce a 'Game of the Day' post-produced segment, broadcast in prime time. This allowed commercial-free hockey to broadcast daily on the HD channel. In order to conform with CRTC programming requirements, only two hours per day of independent HD programming was allowed.

THE CHALLENGES

Critical to the success of remote production is ensuring that the production quality and operational workflow is not affected by the distance between the venues and the production centres. So, what are the immediate differences between on-site production—in some cases a few miles from the venues—compared to remote production, thousands of miles from the venues? Some of the key questions raised by production staff concerning the viability of remote production were:

1. Connecting with the Action: There may be as many as 30 to 40 host and CBC/Radio-Canada feeds entering the IBC at any one time. Of course, not all are active all the time, but producers in the network centre can only schedule contribution on (16) feeds routed back to each network centre. How do they know that there is not some activity they may want to receive on the feeds that are not being routed back to Canada?

To ensure that producers in Canada could monitor all the activity taking place in Turin and be able to make informed decisions about which feeds to route through to the network centres, a dedicated HD signal of all incoming feeds was created in Turin and transmitted to each network centre. Referred to as the 'Multiview', this HD image carried a mosaic of all the incoming feeds into the IBC in Turin, as well as the signals actually being transmitted on the backbone. In this way, a producer in Toronto was able to see active pictures of all CBC and host broadcaster feeds available in Turin, as well as the feeds actually selected for transport to Canada. This is shown below:

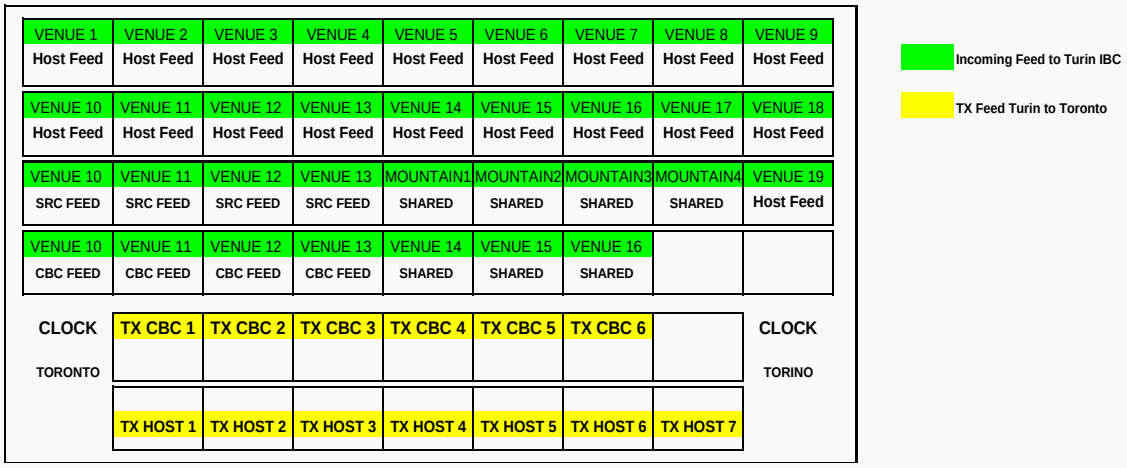


Figure 7. Example of 16 x 9 HD Multi-view Display Layout (Toronto Network)

2. Time Zone Differences: For the Turin Winter Games, there was a six-hour time zone difference between where the event was taking place and where the majority of the production was located. What impact would this have on the ability to produce the event thoroughly?

Through use of small satellite production systems in the Turin IBC and the mountain BMC, early morning events could be pre-assembled on-site and then fed as file transfers on to the network centres in Canada. Feed recording in the network centre would commence at 3:00 a.m., but the main production crew usually started their shift at 6:00 a.m. A second shift would work the afternoon and evening, so the production day comprised two ten-hour shifts, as would be the case if the production crews had all been located in Italy.

3. Communications: The production model needed to migrate from a single, large production facility at the venue to three smaller production facilities located in three different cities. What impact would this have on communications and production coordination?

There is no doubt that production coordination is more complex when production is spread over multiple sites. Provision of multiple intercom trunks and internal phone lines between the venues proved sufficient to overcome these inherent problems, but production personnel were placed under additional strain learning the new workflows and communications. There was no instance when the production quality suffered as a result of remote production, although the requirement placed on the technical support personnel was significant and called for additional resources in Toronto and Montreal.

4. Distance between Talent and Production: Once a production segment has been produced in the network centre, how does a presenter located in Italy provide a 'voice-over' commentary?
This proved to be one of the biggest challenges in the remote production workflow. Once a program package had been produced in Toronto or Montreal, the reporter (who was located at the venue, the IBC or the BMC, depending on the sport and the time of day) would be made ready to 'voice-over' the package.

For this to happen, the reporter would receive a feed of the video package, played out directly from the AVID Media Composer, over a return line from the network centre. The reporter's voice would be routed back to the network centre and be recorded back into the Media Composer, where the editor would insert the voice on the edit timeline and consolidate the finished package for play-out[6]. This technique allowed quick addition of commentary into any production package from any location covered by the system.

5. HD Audio Source: As the HD channels were not full-time, but relied on a mix of original HD material mixed with upconverted SD studio output material, the audio used for the HD program channels had to be taken from the SD studio output and mixed (in stereo) into the HD path. Consequently, the HD system was complex and required extensive audio timing and monitoring to maintain audio-video synchronization[7].

CONCLUSION

The system implementation of remote production for the 2006 Winter Olympics in Turin was a success. The system met all the operational requirements placed on it and met the fiscal requirement of reducing on-site personnel by two-thirds. Of a total production and technical crew of 450 required for the four television networks[8], only 150 were located in Italy. On-site shipping and construction costs were halved, resulting in further cost efficiencies.

Technically, the system performed very well, was stable and robust throughout and had minimal impact on operating efficiency. Intercom paths through the fibre backbone exhibited less than 80 milliseconds of delay[9]—less than many cell phone connections—and the large distances spanned by the system had no impact on operations staff in Toronto and Montreal.

Operation of the system was complicated compared to a single-site operation, with a greater reliance on intercom, telephone and technical expertise. The intercom requirements were significant: a 216 x 216 matrix in Turin; 64 x 64 matrix in the mountain venue; 136 x 136 in Toronto; and 128 x 128 in Montreal, all interconnected by 120 intercom trunks between the four sites.

[6] The Return Path Encoders were programmed for 'Mega-Low Delay and dedicated low-delay audio return paths were provided to reduce the round-trip path delay to about 300 milliseconds. The AVID editor was able to offset forward the recorded commentary track by this amount in the AVID system to re-synchronize the voice-over audio to the picture.

[7] The HD paths from Turin featured a longer path delay than the SD paths that carried the source audio material

[8] CBC Sports, SRC Sports, Newsworld and RDI

[9] The International Telecommunication Union's Standardization Sector, or ITU T, recommends in standard G.114 that the one-way delay should be kept below 150 ms for acceptable conversation quality.

File transfers were used extensively between Italy and Canada, although the throughput was slow, mainly due to the limited bandwidth available for this purpose. Certainly, the overall server throughput was significantly improved when compared to linear tape-based production.

The high definition channels produced exceptional program footage and met all requirements to deliver original HD material to the channels, rather than simply upconverting SD material. Even the upconverted material was of superior quality, due to its origination from 625/50 material, rather than 525/60 SD program output.

The remote production system has been developed and adapted for use on large international sports events, where hotel, travel and temporary construction costs are very high. As the requirement for sports event production in high definition develop, the model must be revisited to ensure that the increased bandwidth requirement of HD does not wipe out savings in other areas. Short-term sports events local to North America are likely better served by mobile broadcast trucks, at least until movement of high-bandwidth fibre in North America is optimized for short-duration leases.

ACKNOWLEDGEMENTS

The CBC/Radio-Canada remote production system was developed and implemented with the concerted efforts of many individuals from the following departments; their enthusiasm and expertise made the Turin remote production possible:

CBC Technology – Systems Development Group, Broadcast Engineering Groups (Toronto and Montreal)
Special Events Group
CBC Sports Operations and Technical Producers
SRC Sports Operations and Technical Producers
Toronto Maintenance Department
Montreal Maintenance Department
Montreal Test and Training Department

The Team

Producing an event of this size and technical complexity required the concerted effort of a team of CBC/Radio-Canada technicians and engineers. Grouped by department and with apologies to anyone omitted through oversight, the core design and implementation team was:

Technical Producers:
Benoit Trottier, Claude Dion, Dietmar Niemietz, Joe Cerilli

Special Events Group:
Martin Dupras, Nicholas Teasdale, Eric Bradette.

The Team (continuing)

CTO Engineering:
Anthony DuBoyce, Michael Matheson , Michel Beland, Ian Munro, Pierre Leduc, Lucien Leduc, David Marangoni, Graham Campbell, Ivan Vulic, Adam Vulic, Chris Sweeting

Toronto TV Network Sports:
Joe Sidoli, Peter Li

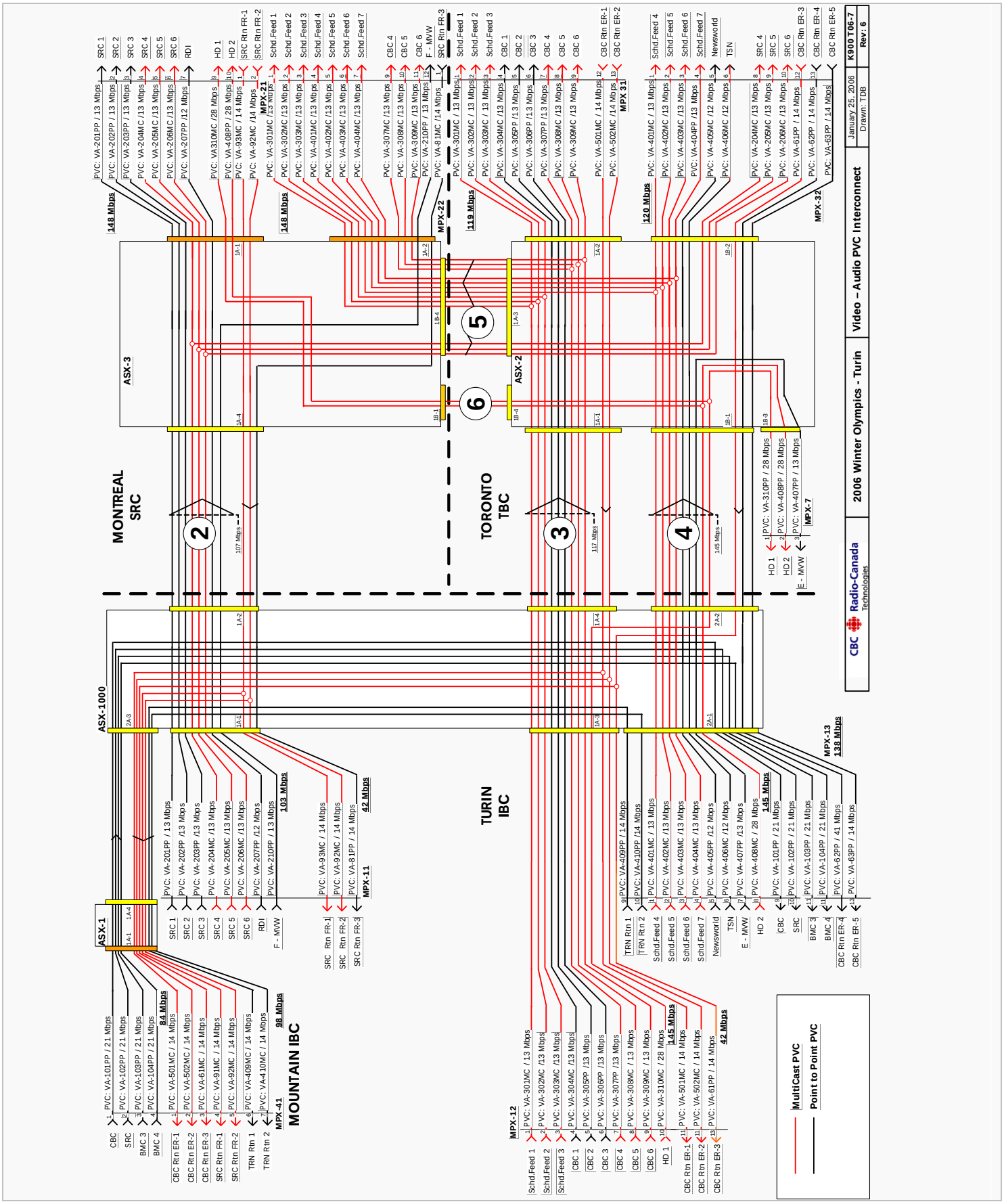
Toronto Maintenance:
Demetrios Georgoulios, Tony Ning, Nick Petrolekas, Patrick McCready, Jo-Anne Park, Greg Cain

Toronto Technical Training:
Greg Svaluto, Robert Johnson, Paul Sampson

Montreal Production Technique et Design TV:
Bruno Vigneault, Andre Bernard, Raymond Gagnon, Carl Boislard-Lanois

Montreal Maintenance:
Frederic Dorion, Matthieu Rochon, Jean-Pierre Leveille

Anthony Duboyce graduated with his B.Eng from Concordia University, Montreal in 1985. He first joined CBC in 1988, working for Strategic Engineering and Production Capital Projects on implementation of new digital audio systems. In 1997, Anthony left the Corporation to pursue other engineering ventures, mainly in the U.S., where he worked as a design consultant with a systems integrator for clients such as ABC, Turner and Echostar. He returned to CBC in August 2002, where he now leads an engineering group mandated to support new production systems and workflow deployment in the field. This work has included support for implementation of non-linear editing systems for the Olympics and track and field events in Torino, Athens, Helsinki and Paris.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