SVG VENUE INITIATIVE WHITE PAPER

RECOMMENDATIONS FOR SPORTS VENUES:

Maintaining Broadcast Cabling Infrastructure

SVG VENUE INITIATIVE COMMITTEE MEMBERS

Josh Beaudoin, WJHW, Principal
Chris Brown, Turner Sports, Director, Technical Operations, NBA Digital
Rick Church, Michigan State University, Director of Broadcast Technology (retired)
Steve Hellmuth, NBA, EVP, Operations and Technology
Karen Hogan Ketchum, SVG, Senior Editor and Editor, *Venue Production Journal*
George Hoover, NEP Broadcasting, CTO
Robert D. Jordan, CFE, Van Wagner Sports and Entertainment, SVP
Ken Kerschbaumer, SVG, Executive Director, Editorial
Scott Nardelli, Bexel ESS, VP and GM
Rick Price, MOEBAM! Venue Media Services, President
Don Sperling, New York Giants Entertainment, VP and Executive Producer
Steve Thrap, STAPLES Center, VP, Broadcast Operations
Dwin Towell, Dallas Cowboys, Director of Broadcast Engineering
Jeff Volk, Alpha Video, VP
Chris Williams, WHJW, Principal
Duane Yoslov, Diversified, SVP

SVG VENUE INITIATIVE SPONSORS

For more information about the
SVG VENUE INITIATIVE
please contact
Karen Hogan Ketchum
karen@sportsvideo.org

SECTION D: MAINTAINING BROADCAST CABLING INFRASTRUCTURE

PURPOSE

The increasing demand of covering all the sights and sounds of sports events from all angles and multiple locations inside and outside the venue has necessitated increased levels of cabling infrastructure. To maintain robustness and the required high availability of this infrastructure, there is a need to maintain the cabling runs, connections, and access for the venue. The following pages outline best practices for existing installations on the personnel and procedures to cover basic maintenance, along with recommended maintenance, testing, and replacement intervals. Additionally, this document provides information on establishing standard operating procedures for temporary cabling and for expanding existing cabling infrastructure.

CONTENTS

WRITTEN BY

Rick Price, MOEBAM! Venue Media Services, President; SVG Venue Initiative Committee
Jeff Juniet, Broadcast Engineer

Contributors:

Chris Brown, Turner Sports, Director of Technical Operations, NBA TV and NBA Digital
Rick Church, Michigan State University Athletics, Director, Broadcast Technology,
Karen Hogan, SVG, Senior Editor/Editor, *Venue Production Journal*
Steve Lampen, Belden Wire & Cable, Multimedia Technology Manager
Scott Nardelli, Bexel ESS, SVP and GM
Dave Shoemaker, Pro Sound & Video, VP
Steven Thrap, STAPLES Center/Microsoft Theater | L.A. LIVE, VP, Broadcast Services
Dwin Towell, Dallas Cowboys, Director of Broadcast Engineering
Dave Vickery, Miami Heat, Director of Arena Broadcast Services
Ed Whitehouse, Mobile TV Group, Director of Operations
Chris Williams, WJHW, VP
Dave Zur, Altitude Network Operations Center, GM, and KSE Media Ventures, SVP, Operations and Engineering

D1. Basics of Sports-Venue Broadcast Cabling Infrastructure

For the purposes of this document, *sports-venue broadcast cabling infrastructure* refers to all permanently installed cable running from the truck dock input/output (I/O) connection panels to each of the broadcast panel junction boxes (JBT) throughout a venue for the purpose of facilitating connectivity for broadcasting live events. This infrastructure will be referred to, in general, as *broadcast cabling*.

BRIEF HISTORY OF BROADCAST CABLING FOR NORTH AMERICAN SPORTS VENUES

Pre-1980

Prior to the creation and growth of cable television, live televised sports coverage was generally limited to major sports events on the major TV networks (ABC, CBS, NBC, and CBC). Typical cabling consisted of three to nine cameras being pulled, or "home run," with triax or multicore cable up to 3,000 ft. from the broadcast truck to each camera location in the venue for every event. The play-by-play "booth" locations varied between venues, and all audio/video cabling was typically run directly from the truck.

1980s

Cable television, the launch of ESPN in 1979, the national syndication of Atlanta's Superstation WTBS and Chicago's WGN, and the growth of HBO Sports brought a tremendous increase to the number of live televised sports events. With the increase in number of games televised came an increase in the coverage of the game itself. More cameras were being added as well as more audio coverage from the field. However, standard practice remained that each broadcaster would pull its own cabling throughout the venue for each event.

1990s

The decade saw the rise of regional sports networks and the number of sports venues being built. With more than 40 new professional sports venues opening during the '90s, the necessity for the design and integration of permanently installed broadcast cabling with triax, RG59 coax, and analog audio to all primary camera locations and the booth became standard. Standard-definition video scoreboards and control rooms become standard in most professional sports venues; as a result, use of and reliance on coax, triax, and analog audio for in-house production increased.

Early 2000s

After broadcasters and venues had settled into proven standard-definition workflows and infrastructure, the advent of high definition — and its impact on venue-infrastructure design — began. The primary issue was that existing coax cabling in venues was not capable of carrying digital HD signals more than 300 ft. and thus created many HD/SD compromises and workarounds to get signals in/out of the trucks. The use of fiber-optic cabling was in its infancy in the industry and, because it was so new, was expensive and generally not part of a venue's broadcast cabling infrastructure.

2005-2010

Digital high-definition television became a reality, and its impact on venue broadcast cabling design was reflected in the increased availability of fiber throughout a venue. The use of remote, POV, and robotic cameras to cover a sports event increased, and, given their size and locations, these cameras required single-mode–fiber connectivity. HD video scoreboards and in-venue control rooms factored into the design of new facilities.

2010-current

HD and beyond-HD video scoreboards, as well as the advent of Ultra HD, 4K, and super-slo-mo cameras, is becoming standard in venues. Remote, POV, and robotic cameras have become plentiful and thus impact the venue broadcast cabling. Increased fiber connectivity and clean, dedicated 20-amp power is required at each primary JBT, and additional locations are needed.

WHAT TYPICALLY IS USED IN VENUES TODAY

Triax

The predominant camera cabling for 720p/1080i sports production by regional and local broadcasters

- Most modern camera systems are capable of transmitting up to 1080p60 or 3 Gbps over triax for distances up to 1,500 m (4,920 ft.).
- The majority of today's HD mobile units are outfitted with triax camera systems.
- Most pro and some major collegiate sports venues are currently equipped with permanent triax runs to all common camera locations.

SMPTE Hybrid Fiber (HFO)

The predominant camera cabling for national broadcasters and mobile A units outfitted with SMPTE hybrid cameras. It uses two single-mode fibers for high-bit-rate data transmission and copper elements for auxiliary signals and electrical connections.

- SMPTE fiber availability as a permanent resource in sports venues is increasing.
- SMPTE fiber panel connectors are generally considered field-replaceable but NOT field-repairable.
- High-frame-rate (HFR), super-slo-mo, and 4K cameras require greater than 3 Gbps of bandwidth, which makes SMPTE hybrid fiber ideal because it provides high-bandwidth signal and power over a single cable.
- SMPTE fiber cabling may not be required in the venue as long as there is a minimum of two single-mode fibers with ST connectors and a clean 20-amp electrical circuit for each camera. A SMPTE Hybrid Elimination Device, or SHED, can be used to connect SMPTE cameras to a standard single-mode fiber ST connector.

Single-Mode Fiber (SMF)

Currently the most common and versatile method for carrying full-bandwidth 720p/1080i/1080p/HFR/Ultra HD/4K video signals for distances greater than 100 m.

- Requires signal conversion to transmit and receive
- Standard panel connection via ST connector

Coax/BNC

The most common installed cabling for video signals

- Traditionally used in broadcast cabling to carry analog or serial digital video signals for ancillary purposes, such as return monitors and program feeds
- Commonly used coax, such as Belden 1694A, can safely carry a full 3-Gbps 1080p60 signal approximately 100 m (328 ft.). It is typically used within control-room racks and all distances less than 100 m.
- 4K considerations for coax may include the ability to carry 12-Gbps signals on a single wire.

Audio DT12 and XLR

Still the standard for audio, due to the excellent analog quality

- Robust and easily field-repairable
- Will remain the standard for broadcast audio within venues for many years

DATA/Network Cable

Cat 5e and Cat 6 twisted-pair are current standard network cabling.

- Typically used in venue broadcast cabling to facilitate Internet access and dedicated IP connectivity to the truck primarily from the play-by-play booth location
- Due to traditional distance limitations with Ethernet cabling, many broadcasters facilitate IP connectivity to booth or field-of-play locations using SMF.

D2. Industry Observations: Importance of Proper Maintenance

Several industry professionals from team/venue operations and network broadcast/mobile-unit operations contributed their best practices, insights, and recommendations to this White Paper. They were asked about the importance of proper maintenance of venue broadcast.

> *"We work with the A crews, the biggest and best crews and shows in both sports and entertainment industries. We highly regard the responsibility of being 'the middle wire' for every event and keeping the integrity of that wire at every connection. STAPLES Center is starting its 17th season, and ownership understands the importance of maintenance. STAPLES Center looks like it did the day it opened, and we are a very busy arena. I believe STAPLES Center is relevant for another 15-20 years, and that is due to the commitment by the staff to maintain every aspect of the venue. Inspecting and maintaining the broadcast infrastructure is not overly labor-intensive but very necessary."*
>
> — Steven Thrap, STAPLES Center/Microsoft Theater | L.A. LIVE, VP, Broadcast Services

"One of the most important things you have to do as a venue is maintain the I/O panels. It is not something you can do just once a year. We go through and check things after every major shoot, especially the fiber. The fiber is extremely hard to maintain in a facility because we get such heavy use and a lot of contaminated TAC cables and such. So the networks are very happy when they plug something in and everything works. Aren't we all? Maintaining your infrastructure is extremely important, and it's worth every penny you spend on it."

— Dwin Towell, Dallas Cowboys, Director of Broadcast Engineering

"It's a matter of being able to put the product that you want on the air, and we have to have that reliability in connectivity and flexibility in having some spares for when the three or four broadcasts come in for the same game. The shows don't get any smaller, [and] producers are trying to make the shows better all the time, which means adding more stuff. So knowing that all the available panel connections in a venue are ready and available — and not seeing taped-over panel connectors — is important."

— Ed Whitehouse, Mobile TV Group, Director of Operations

"For many of the older venues, our most common issue is the availability of cabling that is in good condition. Many of the newer venues are fine, but the older ones lack maintenance and often have cables that just do not work. While the venues recognize the importance of keeping the cables in good working order, many do not allocate time or budget headroom to accommodate keeping them in good condition. In a handful of cases, there are venues that lack the infrastructure that keeps current with technology (i.e., fiber). A failure to maintain and support the broadcast cable and power infrastructure impacts the setup schedule. We end up with technicians expending an inordinate amount of time troubleshooting poor venue cabling and then trying to determine workarounds. This impedes setup and, depending on the nature of the issues, causes meal penalties and could impede preproduction."

— Chris Brown, Turner Sports, Director of Technical Operations, NBA TV and NBA Digital

"The number-one reason is to put our teams, venue, and organization forward in the best possible light while providing a world-class entertainment experience to the viewer. The ultimate goal is to provide a transparent mechanism through which the broadcast allows the viewer to feel like they are included in and a part of the in-venue experience. That said, it takes only a few glitches to remind them they are watching TV."

— Dave Zur, Altitude Network Operations Center, GM, and KSE Media Ventures, SVP, Operations and Engineering

"Proactive maintenance on the cable infrastructure lends itself to early warning signs for potential failure. This can also enable an organization to lessen the amount spent on large repairs along with predictive maintenance that identifies issues before they become a problem and minimizes service downtimes."

— Dave Vickery, Miami Heat, Director of Arena Broadcast Services

"The cabling infrastructure in a venue is the least-thought-of but the most critical part of a production. The simplest things can cause the most significant and problematic 'air gap' for an event." — Scott Nardelli, Bexel ESS, SVP and GM

D3. Maintenance Scheduling Best Practices

There may be no moving parts to a venue's broadcast-cabling infrastructure, but there are still many places that wear and fail over time. The connectors used for each game or concert are worn and broken with repeated or improper use; additionally, oxidization and corrosion affect the performance of each connection. To minimize failures, regular inspections and maintenance should be done on the cabling and connectors. Each venue is going to require a different amount of maintenance work for the infrastructure based on the frequency of use, the type of cables, and environment, but the need is universal. There are several recommended practices and tips and tools for performing the required maintenance.

Regular maintenance procedures take several forms based on the time of year and the schedule for the venue. Below is an example of periodic inspections that venue engineers should perform.

DAILY OR PRE/POST-EVENT MAINTENANCE

- Cover any uncovered fiber connections (both SMPTE hybrid and single-mode).
- Check for bulkhead connectors that are hanging loose from their panel.
- Check for liquid, both standing puddles and water marks/residue.
- Look for bent pins or damaged contacts on triax connectors.

WEEKLY MAINTENANCE

- Visually inspect all connectors.
- Clean fiber connections.
- Test audio connection with a tone and a continuity tester.
- Check triax connections for shorts between the connections.
- Check junction boxes for dirt and liquids and clean as needed.
- Check junction boxes and cable interconnect rooms for signs of rodents (i.e. droppings, nests, teeth marks, or damage to the outer jacket of cables).

MONTHLY/QUARTERLY MAINTENANCE

- Visually inspect all connectors.
- Electrically test triax and SMPTE hybrid cabling.
- Test coax connections (at least frequently used connections).
- Apply visible light to fiber connections.
- Clean fiber connections.
- Check bulkhead connectors for tightness.
- Check cable trays for debris, twists, and stresses to the cabling.

ANNUAL MAINTENANCE

- Visually inspect all connectors.
- Test fiber connections for power loss.
- Test fiber, triax, and coax connections for bandwidth.
- Test SMPTE hybrid cabling.
- Test audio connections with tones.
- Clean fiber connections.
- Vacuum cable junction boxes and interconnect rooms.
- Vacuum patch panels, BNC connectors, and triax connectors.

Minimum visual checks of cable boxes and interconnect locations before and after an event is a must. There may not have been any reported problems from an event, but a hurried cable strike at the end of the night could have damaged a connector or left a fiber connection uncovered and exposed to dust.

"One of the most critical preventative measures is to cap the connectors and close the JBT doors after every event. The second is to submit a service record and label ALL modifications to a JBT. Basic care will prevent this example from the 2003 Super Bowl."
— Scott Nardelli, Bexel ESS, SVP and GM

"*At the conclusion of each event, the control-room engineer files an Event Engineering Report, listing any issues that were encountered during the event. Any items that involve broken or dirty connectors are replaced/repaired first thing the next morning by David Carpenter, our senior maintenance engineer. In addition to fixing known problems, all media panels are checked on a daily basis to ensure that things are ready for that night's event and the pending arrival of mobile units. We also conduct monthly and quarterly preventative maintenance on systems in the control room, patch rooms, and other high-use areas. We do not allow any connector anywhere on campus to be out of service for more than 24 hours. To that end, we maintain a very extensive spare-parts inventory, which allows us to replace any broken connector immediately. In very rare instances, we need to do anything other than replace a broken or worn connector."*

— Steven Thrap, STAPLES Center/Microsoft Theater | L.A. LIVE, VP, Broadcast Services

Weekly or monthly tests should include a closer examination and cleaning of the connectors and even a basic signal testing of the connections in key locations. Running a test signal down the line for a few seconds can reveal a number of problems that may have been worked around by a regular broadcast crew or simply not reported to the venue's engineering staff. A heavier-use venue would likely perform a quarterly check of the cabling and connectors and the junction boxes.

Dwin Towell, Dallas Cowboys, Director of Broadcast Engineering, says his engineering

staff takes a "bridge painting" approach with cable infrastructure: you start with a full test and inspection of all connection panels on one end of the stadium, and, when you reach the other end, it is time to start over. This process of full test and inspection takes approximately a week. These maintenance routines include specific testing and thorough cleaning of the junction box and all connectors.

Annual cabling maintenance should include checking cable connections for loss and noise as well as cleaning and replacing all questionable connectors.

> *"Within one to two weeks from the end of the NBA season, we do a box-by-box inspection. Typically, event-level boxes get gunky from liquid debris. We inspect all connections, repair/replace all triax/BNC/audio connections, and check panel security"*
>
> — Dave Vickery, Miami Heat, Director of Arena Broadcast Services

This type of annual maintenance would typically take a team of two technicians three to five days to complete depending on the venue size.

> *"We are in a unique position in that our organization owns the venue, teams, network, and even a portion of the trucks. Having been in the facility-engineer role, my primary concerns were neatness, cleanliness, and security of the main truck dock I/O before, during, and after events. It can't be viewed as anything but a mission-critical technical asset. We always emphasize that it is the main physical portal through which a team/facility/organization is featured. Educating and conditioning the crews to adhere to best practices is pretty easy with the local guys, but it's a lot harder to keep order when the big networks come in, especially when it comes to playoffs or a more than three- to four-truck game."*
>
> — Dave Zur, Altitude Network Operations Center, GM, and KSE Media Ventures, SVP Operations and Engineering

D4. Maintenance Methods and Techniques

Since there are no moving parts to a cabling infrastructure, knowing what is a problem and what is not can be difficult to pinpoint. This is especially true for today's infrastructure that is used primarily for digital signals. The "go/no-go" nature of digital can make finding exactly why a signal is not reaching from point A to point B challenging. Traditional continuity tests are still useful, but a look at the cable's bandwidth will be just as important.

Visual inspections of cabling and connectors can be the best way to be proactive in avoiding problems. Corrosion and discoloration from oxidation are good indicators of eventual failure. Although most cable and connectors inside a venue are fairly well protected and could last the lifetime of the building, other cabling locations are not as favorable. Truck docks and junction boxes located outside can be exposed to some extreme conditions, including rain and high humidity, which can promote the deterioration of connectors. Additionally, a close check for physical damage, such as bent or broken pins, loose bulkhead connections, or dents that distort the shape of a connector should be done on the daily and weekly checks of the venue's infrastructure. Cable trays and ladders should be checked for debris and signs of stress to the cables, such as knots or even a cable tie pulled too tight. Distortions to the shape of the cables greatly increase their impedance and reduce their bandwidth.

COAX

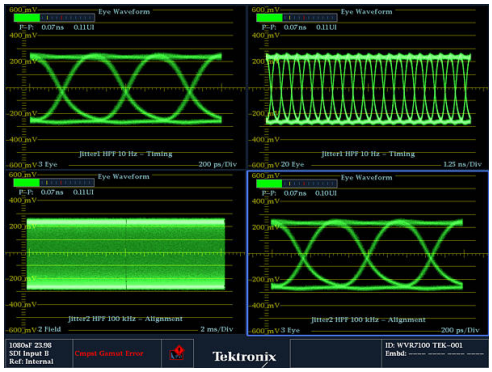
Klein Tools Coax Explorer Plus

Proper maintenance requires going beyond a visual check of the infrastructure and means that specific testing should be performed. Testing coax cables is a two-step process: first, the continuity of the cable must be confirmed, and then the bandwidth over the length of the run should be tested. There are **coax-testing tools** that check for an open or a short on the cable, and these tools are very handy and easy to use.

A more thorough test would be to short one end of the cable (a 75-ohm coax termination would be best) and recheck using the coax-test tool or a multimeter to measure between the center pin and the shield. This method will check both states and provide a higher degree of accuracy since a cable that has been cut or pulled from a connector can still test as good. This type of test should be done during the monthly/quarterly maintenance.

Another test that should be done, at minimum on an annual basis, is a bandwidth test. It requires a signal generator and a test set to view the received signal. Ideally, performing this test in the digital domain using a checksum signal and examining the eye pattern and errors received in the test set would be the best representation of how the cable will handle a high-definition signal. The eye pattern of a digital signal shows the jitter or timing errors in the signal. In a digital circuit, all signals are transmitted in reference to clock signals. The deviation of the digital signals from the clock signal as a result of reflections, interference, crosstalk, and other factors amounts to jitter. As the jitter gets worse over the length of a cable, the signal become more difficult to decode until it is unusable altogether.

Most test sets are available with an **eye-pattern option** and will highlight SDI errors in some fashion. Other signals could be used, but a checksum signal will provide the most stress to the system and give a worst-case test. If digital signals are not available, then a multiburst analog signal would be the next best option. The problem with using an analog signal is that the cable-length limitations for digital signals will not be apparent and could give a false sense of security.



Eye pattern example: Tektronix WVR-7100

TRIAX

Triax tester: Gepco TT-2B

Triax cables should be tested regularly as well. A **triax tester** is a simple and reliable way to test them.

These testers generally check for shorts between the combinations of center pin and inner and outer conductors. As long as the cable tests “good” and the connectors are in good working order, a bandwidth test would need only to be proper reproduction of a camera signal without artifacts, noise, or loss of luminance or chroma levels.

AUDIO CABLING

Audio cabling and connections are the most straightforward cables to be tested. Like triax cables, audio cables need to ensure that there are no shorts between the conductors and can transport signal without adding noise or deteriorating the signal. **XLR testers** are a reliable method for testing for shorts and crossed pins in audio cabling.

XLR tester: Whirlwind XL1600

Signal testing should be done to verify that there is no noise being added to the signal, such as ground hum or EMI. Ideally, a full-bandwidth signal like pink noise should be used, but this is usually impractical so a tone generator that can produce a sine wave at various frequencies will work.

DATA/NETWORK CABLE

Like coax cable, Ethernet or network cabling can be deceptive if not tested thoroughly. Continuity-test tools can check for breaks and proper pinouts but cannot detect bandwidth issues. Certification of the network infrastructure is as important after it is put into service as when it was first installed. Factors that impact the performance of network cabling include ties and straps wrapped too tight, twists or bends in the cable, or heavy weight or objects placed on top of the cable, such as video cabling installed after the network cabling and lying on the top of the cable tray. All these conditions will test "good" for continuity but will require a more in-depth test to determine any real problems. Network cabling should be certified when it is installed and tested on a regular basis afterwards. Annual testing of every drop may not be practical in some venues, but a schedule should be laid out where each drop can be tested every two to three years. Tools for cable certification can vary in price and complexity, but some on the market will test up to 10 Gig over copper and test fiber cabling with the same unit.

Data/network tester: Fluke Networks 10G test kit

In many venues, this type of testing is the responsibility of the IT department, but, as video over IP becomes more prevalent, even in the field, this type of testing will need to be, at the very least, a cooperative task between the video engineers and the IT techs.

FIBER OPTICS

The ability to transport multiple signals with high bandwidth capacity per strand in a lightweight cable makes fiber-optic cabling a robust medium for broadcast. Fiber infrastructure is now the most important and critical part of broadcast cabling for a venue and therefore requires particular attention.

The two primary fiber cable and connector types used in venue broadcast cabling is single-mode cabling with ST connectors and SMPTE hybrid-fiber-optic (HFO) cable/connectors.

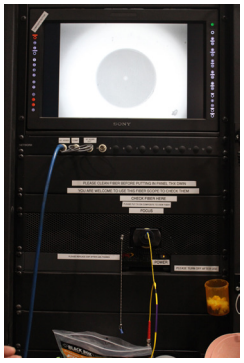
Fiber-optic inspection scope: Fluke Networks FT500

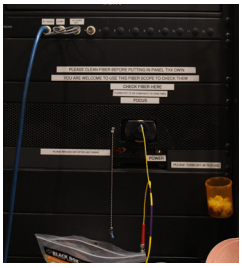
Like all the other cable types that have been discussed, a great deal of the maintenance for fiber begins and ends with the connectors. The signal, or light, runs directly through the center of the fiber-optic cable and requires that any joints, either connectors or fused splices, are clean and free of anything that could refract or attenuate the signal. Given the physical size of the cable, a visual inspection of the connectors is almost always futile. A **fiber-optic scope** is required to view the surface of the fiber connector and allow the engineer to see dirt and scratches.

Hybrid cable checker: Canare FCT-FCKIT

Canare makes a **hybrid cable checker** that allows fast, easy confirmation of HFO cables in the field.

A common problem with fiber connectors is the transfer of dirt from one connector to the other. In an attempt to prevent cross-contamination from dirty connectors, AT&T Stadium has installed a permanent scope and provides fiber-cleaning





Fiber scope and cleaning supplies at AT&T Stadium

Fiber cleaning tool

supplies in its broadcast network dock I/O for use by the crews. Most truck engineers have embraced this unit and use it as an opportunity to inspect and clean their TAC and patch cabling.

Cleaning fiber connections also requires special equipment. Any material or fluid that could etch or cloud the glass must not be used; only **fiber-specific cleaning tools** and materials should be used. A push-type tool that wipes the surface of the connector with an optical cleaning tape is convenient to use for daily or weekly cleanings and moves the process along quickly since there can be hundreds of fiber connections that need to be cleaned in a venue.

The physical condition of the fiber is also important. Similar to copper network and coax, fiber cables that are crushed or bent beyond their allowable bend radius can attenuate the signal or fail altogether. If any work is done in junction boxes, care should be taken to ensure that fiber cables are not intertwined or tangled with other cables.

To manage this in each junction box, STAPLES Center uses a **custom 1RU fiber tray** designed and built by Senior Broadcast Engineer and Fiber Specialist Gregory Glaser. These custom fiber enclosures have replaced all of the facility's older Secor and Ortronics units. They also feature only metal-barrel ST connectors and have completely replaced all plastic ST connectors with metal ones.

Custom 1RU fiber tray at STAPLES Center

Additionally, cables must be properly managed from the junction box to the IDF or I/O to prevent stressing and, possibly damaging the cables. A cursory continuity check with a visible light source would be helpful to verify that there are no breaks in the line. A **visual-fault locator** is a valuable tool for initial inspection.

Visual-fault locator: Fluke VisiFault

Once the physical installation and connectors are confirmed to be clean and functioning, the bandwidth of the cable needs to be checked. Testing both signal loss and faults in the line is necessary to ensure the cable's ability to pass today's high-bandwidth signals. An optical time-domain reflectometer (**OTDR**) can test both of these parameters.

OTDR: AFL M710

The OTDR has become one of the most valuable tools for testing, troubleshooting, and maintaining fiber-optic cabling. These units will measure loss and can present a graphical representation of the line, indicating dropouts and points of high reflection. Additionally, most units can save the measurement data or send it directly to a computer for future reference and tracking. The STAPLES Center credits use of an OTDR with reducing the labor required in troubleshooting a fiber circuit by 50%.

Optical power meter. Fluke Networks OPM4

Another useful test and troubleshooting tool would be an optical power meter. While the OTDR can measure power loss, a power meter can be useful for quick checks during event setup or for weekly checks where a full complement of signal tests is not required. Bexel's Scott Nardelli recommends regularly doing a power-meter test on all single-mode–fiber connections at 1550 nm for best results.

D5. Communication Best Practices

Regular and consistent maintenance is, without question, extremely important, but a solid working relationship with the users of the venue's cabling will go just as far in keeping things functioning. Setting expectations for what the venue will supply or make available regarding cabling and how this equipment should be treated is paramount to preventing problems or identifying them early.

Initial communication with an end user is best done at the time of event booking, wherein a communication packet is sent to the client providing information:

- Venue maps of truck parking, JBT locations, and cabling paths
- Accurate JBT cabling types and quantities available
- Order forms for request of services and special locations
- Venue policies and expected end-user responsibilities

There is an expectation that the broadcast crews will treat the equipment with a level of professionalism. These expectations need to be laid out up-front through open communication between the venue and the crew. Once both parties understand these expectations, the venue can support a show without hindering the production and still be confident that infrastructure will be maintained.

With clear and consistent communication, crews are encouraged to use the fiber-test and -cleaning equipment at AT&T Stadium, and there is signage throughout the venue to encourage proper handling of all connections.

Examples of communication at AT&T Stadium

The STAPLES Center has established solid relationships with many of the crews that use the facility.

The key is establishing a communication relationship with the end user that emphasizes a cooperative partnership between event client and venue operations for a successful event.

As part of event-day communication with end users, Miami Heat Director of Arena Broadcast Services Dave Vickery conducts a meet-and-greet first thing on event day to assess the crew's familiarity with the venue and panels. During the meeting, they provide contact phone numbers and define the venue's conduct expectations.

A consistent set of procedures for pre- and post-event setup and strike is key to building communication between the venue and the broadcast crews.

> *"Our mandate here is to not impede anyone's show but to offer all necessary help in assisting them in producing a great show, with no technical issues caused by building facilities. We are very lucky here in that we deal pretty much with the same crews on a daily basis, and everyone that works here understands how important it is that they assist us in maintaining a good, workable system for each and every show. The only time we get really anal is when a one-off show (wrestling, concert, or special entertainment show) comes in and wants to use our SM-fiber infrastructure. In that case, where we are not familiar with a particular crew or the hardware they are bringing in, we will clean and test all of their fiber prior to letting them connect it to our fiber panels in the arena. Additionally, our patch room is always manned by my team, and we do not allow outside crews access to that room for the purposes of patching up their own interconnects."*
>
> — Steven Thrap, STAPLES Center/Microsoft Theater | L.A. LIVE, VP, Broadcast Services

PRE-EVENT PROCEDURES

Establish point(s) of contact and key personnel for the venue and event crew

- Mobile-unit facilities provider
- Broadcast/event crew
- Tech manager
- Engineer in charge
- Video engineer
- Venue
- Engineer on duty
- I/O engineer
- Staff techs and engineers

How the crews will communicate

- Two-way radio
- Cellphone

Building access

- When the court, field, locker rooms, dressing rooms, etc., are available
- When concourses and fan areas are no longer accessible
- What areas are not to be used or accessed

Cabling and cabling infrastructure

- Who can access truck-dock I/O
- Location of JBTs
- Home- and visiting-team connections
- Paths for temporary cabling
  - Available cable trays or hooks
  - Required securing, covering, and marking methods of temporary cable runs
- Fiber connections
  - Cap and cover replacement
  - Cleaning

Frequency coordination

- Wireless microphones
- Wireless IFB
- Wireless camera
- Wireless intercom
- Two-way radios
- Wireless network router
- Network and Telco

House network access

- Phone lines
- POTS
- Digital/IP/PBX
- Fax

POST-EVENT PROCEDURES

Broadcast crew cabling strike

- Remove all tape and tape residue.
- Return cable ramps to house (if applicable) .
- Cap all connection in the JBTs.
  - SMPTE

- SM/MM fiber
- Triax

Walkthrough

- Identify any broken or damaged connections or connectors
- Complete an Event Engineering Report

D6. Operational Best Practices

Established procedures are certainly essential to maintaining the infrastructure of a venue, but knowledgeable and experienced personnel are needed to consistently and accurately carry out the work. An experienced engineer can use the tools and procedures described here and identify the difference between a marginal cable and good one. Understanding the significance of a clean eye pattern and the errors received during a bandwidth test can show with certainty whether a digital video signal can be sent down a particularly long cable run.

The venue staff should be able to perform most maintenance for the venue's cabling infrastructure. Repairing or replacing XLR or DT12 requires basic tools for stripping and soldering wires. Repairing or replacing triax connectors requires basic hand tools, such as a pair of diagonal cutters, a utility knife, crimp tool and die, and the proper-size wrenches for the make and model of the connector to be installed.

The ability to terminate and repair fiber connections is a growing and beneficial skill for a venue's engineering team.

> *"A big plus for us is the ability to repair broken fiber. We have two Fusion Splicing units, as well as a complete inventory of spare connectors, splice trays, sleeves, etc. This equipment also gives us the freedom to install and terminate our own new fiber runs at a huge cost saving. We have also been known to repair some of our local TV ENG crew's fiber as well."* — Steven Thrap, STAPLES Center/Microsoft Theater | L.A. LIVE, VP, Broadcast Services

Some connections, however, such as SMPTE hybrid fiber-optic (HFO) connectors and cables, require specialized tools and are generally not considered field-repairable. Fiber connections can be difficult and very labor-intensive to replace if someone does not do this on a regular basis. Some venues may consider using an outside fiber technician to perform annual maintenance and repairs to fiber connections, especially SMPTE hybrid cabling connectors.

In recent years, STAPLES Center has added SMPTE connectors to various locations, but, rather than use the all-in-one hybrid cable, they simply run single-mode strands (TAC 6 or 12) and separate Belden copper cable for power and control. The single-mode strands are fusion-spliced onto the SMPTE HFO tails, and the copper is connected with Molex connectors. This method lets them add SMPTE cable fairly easily and, at the same time, allows the additional single-mode strands to be terminated with ST connectors.

> *"Here at STAPLES Center, our Broadcast Services Department consists of six full-time engineers, in addition to myself, and nine part-time engineers, technicians, and utilities. We have a very diverse staff of people with skills in all phases of broadcasting, production, maintenance, and operation. Our responsibilities are to maintain all of our facilities in top-notch working order, as well as to assist with technical issues/needs of the various TV and radio broadcast groups. We maintain our event-production–control room, along*

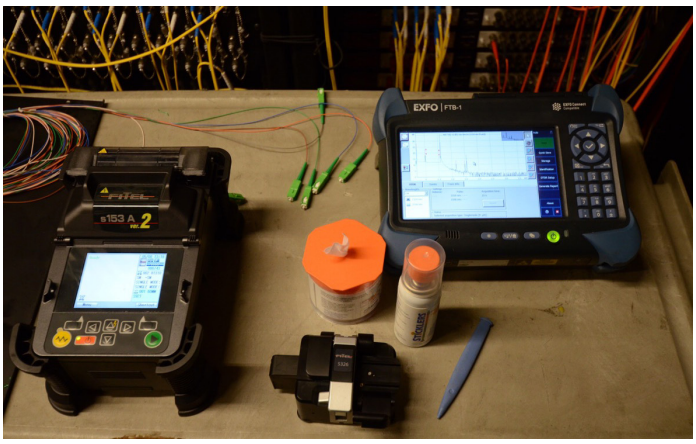
with certain NBA and NHL Network facilities — such as the HSAN and H.I.T.S. systems — as they integrate into our overall system. The patch room is manned from the time of the crew call until the end of the event and the trucks pull out. We are there to provide all the necessary patching and interconnects, as well as to provide technical help and/or troubleshooting. It is very important that we support our system so that any technical problem experienced by the truck is not due to anything that we have not maintained or otherwise neglected. Three of our engineers are certified for fiber. We have two full-time techs checking/servicing all the J-panels and patch room for every event."

— Steven Thrap, STAPLES Center/Microsoft Theater | L.A. LIVE, VP, Broadcast Services

A two-person team of knowledgeable engineers should be able to perform regular pre/post-event maintenance using about 25% of their time per week. This amount of time will vary by venue and also assumes regularly performed maintenance without major replacements. Annual maintenance will take significantly more time, possibly up to three full weeks since there will be more in-depth cleaning and testing of the infrastructure.

TEMPORARY CABLING

As sports production grows and touring shows become bigger, there is sometimes the need for temporary cabling to be run by the production crew. As a result, venues have started to establish standard cable paths and SOPs for running and securing temporary cabling. Some venues will have empty cable trays or hooks available for the additional cable. Others have the crews follow the existing path and secure the cables to the venue's cable trays.



Examples of fiber-splicing equipment at STAPLES Center

Additionally, aesthetics have become very important, and, as a result, venues are providing pass-through ports and specifying where the cable needs to land and how it should be dressed. Temporary cabling must be removed when the show is over.

D7. Planning for Additional Permanent Cabling

With the increasing need for additional connectivity and the changes in the type of cable required, such as the move from coax to fiber, even the best-planned cabling infrastructures cannot keep up. New formats, such as 4K and super-slow-motion, require newer and better cabling to meet the need. At some point, planning for additional cabling or replacing the old cable runs is going to be a part of every venue's future.

Planning for additional cabling needs to start with assessing where the cable starts and ends, how much will be needed, how the cabling will be routed, and whether there is room for the cabling in the existing infrastructure. Determining whether there is enough room is a critical detail in defining the scope of a cabling project. Will the current cable trays have adequate room to handle the amount of new cabling? Will additional conduit be needed? At some point, almost every cable path will move from an outside concourse to an area inside the bowl. This transition will likely be through conduit passing through a hole cut into the wall, usually precast concrete, meaning that there is a limited amount of room for cables to go through. If there are cables to be removed, this becomes less of an issue. However, if the project calls for adding to the existing cabling, then the available space in the conduit and the size of the new cable become more important. If there is not enough room for additional cabling, new holes will need to be cored.

The total cross-section area of the cables and the NEC conduit-fill chart will be needed to determine if everything will fit into a conduit. There are several conduit-fill calculators available on the Web (to speed calculations, links are included in the appendix of this document along with a spreadsheet with the formulas). The NEC standard is 40% of the conduit, so the size of the conduit needs to be considered, especially in plans for any core drilling that may need to be done.

To reduce friction and possible jacket damage to any of the cabling, you will want to avoid "pulling" cable across existing cables. Whether in cable trays or through conduits, consider methods and establish procedures for "placing," not "pulling," new cable where there is existing cable, even if that means additional labor. Since many JBTs are flush-mounted for aesthetic reasons, they are not easily replaced, and, also, running a new conduit to them is not a simple task.

According to Bexel's Scott Nardelli, a common example would be adding one or more cables to a JBT that already has a nearly full conduit: it may be wiser to disconnect and pull back all the cables from the JBT and add the new cables back through the conduit along with the existing cables. By whom and how the cable is installed should also be considered carefully. Companies that specialize in installing structured cabling may seem expensive, but they usually understand that the cable they are installing is considerably more fragile than electrical wire. The tools an installer uses are important as well. Proper cable grips and pull ropes are important to ensure that the cable is placed cleanly and without unnecessary force that could damage the cabling.

The cable path is also important. Bends in the cable path will impede the pull, and too many can make things almost impossible. Applying excessive force can create more problems. Additionally, a bend that is beyond the recommended bend radius of the cable can damage or pinch the cable, creating a point of resistance and loss of signal.

If there is need for additional cable trays and conduit, the space required to add these will need to be looked into as well. Cable trays may be stacked to save on overhead space, but conduits and pass-throughs need a closer look. Will there be space on the other side of the wall? Are there any other conduits running through the wall, such as plumbing or electrical conduit, that could be in the way? Building codes are also something to be aware of in planning new cable runs: is a plenum-rated cable required, and are the pass-through and conduits properly sealed?

Fire safety is incredibly important and cannot be ignored. Licensed structured cabling contractors are familiar with the laws and ordinances of the municipality. If the work is being

kept in-house, requesting a visit from the local Fire Marshal could go a long way to avoid having to do things twice.

Complete removal of unneeded cable will need to be considered on practical, financial, and planning levels.

The practical examination of the removal of cable can be as simple as asking whether removing the cable will cause damage to other cable runs in the same conduit or tray. The reduced weight on the cable trays and increased room in conduits are some clear benefits of getting the old cable out but may not outweigh the possible damage caused by pulling on cable bundles that have become twisted and intertwined. Depending on how the cables were originally installed and whether other cable bundles have been pulled through the same paths over the years, cables could be twisted very tightly together. Conversely, if the cable pulls were done with planning and care, old cable runs could slide right out.

The condition of the cables in the cable trays and conduits should be assessed because additional money will need to be budgeted for removal. How much can or should be budgeted for removal? A good labor estimate, according to Pro Sound & Video VP Dave Shoemaker, is 18-24 worker-hours per JBT. Cable removal can be quite expensive but might be necessary depending on the condition of the old cable and the space needed for additional replacement. Miami Heat Director of Arena Broadcast Services Dave Vickery has found that coax cabling is not being used very much in JBT/Es, if at all, and is being removed and replaced one for one with single-mode fiber. Pro Sound & Video has said that 60%-70% of its cabling projects are to add single-mode fiber. Consulting other venues, broadcast crews, and systems integrators will give a venue's Engineering Management a good representation of where the technology is going and how that needs to be supported.

D8. Industry Observations: Planning for the Future

"The shows don't get any smaller." This statement can be a glimpse into the future of broadcast technology. Some venues have already installed 4K systems, and many are preparing for these high-bandwidth signals by upgrading and installing a fiber infrastructure. IP video could be the next big technology change. The interfaces can work with fiber or Cat 5e/6 cabling, and the major manufacturers are working toward providing IP infrastructure solutions. Some manufacturers, such as Sony and Evertz, have product lines on the market that are installed in some broadcast facilities. As these tools become more rugged and reliable, there is no reason to think that they will not start showing up in broadcast trucks. This could mean that venues will begin to build IP video networks or will certainly need to have the cabling infrastructure to support a network. This could mean that, as the industry moves forward, a JBT may be equipped only with fiber and data-network cabling. Fiber and IP networking are most certainly the foundation of all future broadcast infrastructures.

> *"We clearly need to work both internally and with visiting networks to look forward and anticipate new technologies, processes, and needs. At this time, it seems to be all about adding more fiber for imaging, [adding] wireless capability, and increasing the bandwidth available for everything from a basic ticker data feed to complex multiplexed intercom/video/data links. Networked EVS, ChyronHego (graphics), and miscellaneous telemetry seem to be at the forefront driving the new requirements."*
>
> — Dave Zur, Altitude Network Operations Center, GM, and KSE Media Ventures, SVP, Operations and Engineering

"Fiber is the future! If you have a chance to build a new facility from scratch or remodel an older facility, just load it up with single-mode and SMPTE fiber. The next necessity is Cat 5e or Cat 6. Between the two, you can keep 97% of all broadcast groups satisfied!"

— Steven Thrap, STAPLES Center/Microsoft Theater | L.A. LIVE, VP, Broadcast Services

"We are currently planning and budgeting to add SMPTE hybrid fiber to all the primary camera locations, as SMPTE was not part of the original design. As for IP infrastructure for broadcast cabling in venues, I am concerned that there is not a standard or common grounding and shielding practice for category cable installed between JBT locations, IDF closets, and the truck I/O panel."

— Dwin Towell, Dallas Cowboys, Director of Broadcast Engineering

"The continuing evolution of digital-broadcast technology requires the constant monitoring of bandwidth capacity within the facility infrastructure. With the newest emerging technologies, signal-transmission and -delivery systems will drive the necessity to continuously improve with expanded functionally. Stay current with growth through technology conferences, reading of industry journals, and attending manufacturers' trade shows."

— Dave Vickery, Miami Heat, Director of Arena Broadcast Services

"The ideal broadcast cabling would be copious amounts of single-strand ST single-mode fiber. There should be a minimum of six to 12 strands available at every JBT and, for the primary positions, up to 24 (main camera well, announce booths, etc.). Each venue that supports three-way telecasts should have enough power for a minimum of four mobile units with at least three of the services capable of supporting 3-phase 400-amp services and the fourth no less than 3-phase 200 amps. Uplink support has been generally good but needs a minimum of 3-phase, 200-amp services, all with ST single-mode fiber that drops down to the main TV I/O. They should also support a receive site for aerial coverage that includes multiple 30-amp services for equipment and ST single-mode fiber that terminates in the primary broadcast-dock I/O."

— Chris Brown, Turner Sports, Director of Technical Operations, NBA TV and NBA Digital

D9. Conclusion

Having read what some of the most respected sports-broadcast and venue professionals have shared, it is clear that the importance of properly providing for and maintaining a modern broadcast-cabling infrastructure in a sports venue goes beyond just keeping the truck guys happy. Providing and maintaining the integrity of the "middle wire" in your venue is a reflection of your brand. Whether you're a sports team, municipality, or venue-management company, effectively investing time and resources into your broadcast cabling will keep your venue technically relevant and your broadcast partners engaged with your brand for years to come.

D10. Resources

Belden On-Line Resource Center has helpful info and such tools as Conduit Capacity Calculator.
http://www.belden.com/resourcecenter

Gepco has a helpful hybrid-fiber-connector–cleaning instructional video.
http://www.gepco.com/technical/technical_hybridfiber.htm

Anixter has a comprehensive resources page as well.
https://www.anixter.com/en_us/resources/literature/technical-references.html