Broadcast Technology at Trent Radio

prepared June 25, 2018 by Rob Hailman

As part of the “Trent Radio Foundations” project funded by the Community Radio Fund of Canada, I was engaged through the past year by Trent Radio in the role of Broadcast Technology Advisor, in order to review and document Trent Radio’s existing broadcast technology infrastructure and prepare recommendations for maintenance and upgrades.

Overall, Trent Radio’s broadcast infrastructure is in good working order, although some components are beginning to show their age. The main risks & challenges in the near future relate to the reliability of aging systems & availability of replacements, as well as some ongoing challenges with the reliability of our recently-installed digital studio-transmitter link.

Following an overview of the current broadcast infrastructure in place at Trent Radio, this report will provide a summary of these risks and challenges, and a series of recommendations to address them.

Finally, the attached appendices contain block diagrams of the signal paths in use by Trent Radio’s broadcast facility and the layout of the racks in Studio A and Studio B, as well as an inventory of the equipment in use by Trent Radio’s broadcast operations.

Current Infrastructure

Studio facilities

Trent Radio’s broadcast facility centers around two main studios: Studio A, for live broadcasts, and Studio B for pre-production. While the design and contents of each studio are oriented towards a specific purpose, the technical infrastructure in place allows each studio to be used for both pre-production and live broadcasts.

Studio A

Studio A’s facilities are built around an EELA Audio SBM console, with the following inputs:

- Microphones:
    - Electro-Voice RE20
    - Sennheiser 421
    - Shure SM57
- Telephone: hybrid coupler integrated into console, connected to line 2
- Turntables: two Technics SL-1200mk2

- CD: Gemini CDX-2250 dual CD player
- Cassette: Marantz PMD510 dual cassette recorder
- CPU: Core i3-7100 3.9GHz, Windows 10 Professional, via Behringer 4-ch audio interface
- Miniplug
- Remote: 4 sources, selectable via remote line selector in Studio A rack:
    - BBC: currently unused
    - Logger: playback from LGR01
    - Comrex: remote broadcast feed via Comrex ACCESS
    - BT: Amped BTSA1 Bluetooth audio receiver

The EELA Audio SBM is a purpose-built broadcasting console, and as such has features specifically for that purpose:

- “Cue” channel & speaker, for monitoring inputs without sending signal to main output
- Relays on the microphone channels, for engaging “on air” light and muting monitor speakers when a microphone is engaged
- Built-in VCA limiter
- Monitor selector switch, to choose between console output and off-air signal

Additionally, Studio V is connected to the external input of the console. This input is passed through when the console is disengaged or powered off, sending the Studio V feed to the transmitter.

The main output of the Studio A console is sent to the Studio B rack, and from there to the studio-transmitter link. Three tape outputs are sent to each channel of the cassette deck and the CPU, for the recording of live broadcasts as well as pre-production.

The off-air monitor signal is fed from an Inovonics 531 modulation monitor, in the Studio A rack.

Studio B

Studio B facilities are built around a Mackie 1604VL24 console, with the following inputs:

- Microphones: two Sennheiser 521
- Telephone: Gentner Hybrid Coupler, connected to line 2
- Turntables: Technics SL-1200mk2
- CD: Pioneer PD-103 CD player
- Cassette: Marantz PMD510 dual cassette recorder
- Selector switch, with two inputs connected:
    - Sony MDS-JE630 Minidisc player
    - Miniplug

- CPU: Core i3-7100 3.9GHz, Windows 10 Professional, via Behringer 4-ch audio interface

As the primary purpose of Studio B is as a pre-production studio, most channels are routed via the CPU rather than directly to the console output. This is done by assigning these channels to the aux 5 / 6 output, which is in turn connected to the record input of the Behringer audio interface. This is in turn directly sent to the output of the interface, allowing the board mix (apart from the CPU channel) to be recorded while the main and monitor outputs receive all channels.

As the Mackie console is not a dedicated broadcast console, it lacks the features outlined in the description of Studio A. Many of these are accomplished by a purpose-built turret, which directs both the microphone inputs and the monitor outputs:

- Switches for each of the microphone channels
    - When disengaged, the microphone is muted
    - When engaged, the monitor speakers are muted, and the on-air light is illuminated
- Monitor selector
    - Selects between console output, and off-air signal
- Monitor volume

The console has both “control room” and “main” outputs. The control room output is sent to both the turret, for the monitor speakers, as well as to a headphone amplifier. The main output is sent to the Studio B rack, and from there to the studio-transmitter link.

The off-air monitor signal is fed from the same Inovonics 531 modulation monitor as Studio A.

Remote broadcast equipment

As mentioned above, Trent Radio’s facilities include remote broadcast capabilities, via the Comrex ACCESS unit in Studio A. This is matched with a Comrex ACCESS Portable handheld unit, which connects to the studio unit over the internet. This equipment transmits the audio input to the portable unit, as a digital audio stream, into Studio A.

The Comrex ACCESS Portable has both a stereo miniplug input, and an XLR microphone input. This allows for many remote broadcast configurations, from a single microphone through to the stereo output of a full-fledged remote studio.

Additionally, the Comrex ACCESS unit supports a “back channel” of audio sent from the studio to the remote site, allowing for communication & coordination outside of the broadcast audio. This is not currently used.

Other studio facilities

Studio C is Trent Radio's third studio space. Studio C is used primarily for special projects, and as such is not permanently wired in to Trent Radio's broadcast infrastructure. A few options exist for broadcasting from Studio C, including using the Comrex remote broadcast equipment, or running cables as needed into Studio A.

Studio V is Trent Radio's "virtual" studio, a PC in the basement of Trent Radio House. Studio V's primary purpose is to broadcast Radio Free Peterborough outside of scheduled live programming, but it is can also be used to automate scheduled unattended programming, such as Red Morning Radio from 0800 to 0900 daily.

Studio-transmitter link and transmission facilities

Studio-side processing

The Studio B rack contains the equipment for processing of Trent Radio's broadcast signal prior to the studio-transmitter link. The signal chain is as follows:

- Studio selector switch: selects between the Studio A and Studio B outputs.
- Symetrix 422 AGC/Leveler: automatic gain control, for consistency in broadcast volume. Currently bypassed.
- Symetrix 425 Compressor/Limiter: additional dynamic range control, for control of peak levels.
- Behringer Ultralink Pro distribution amplifier: splits signals, output 1 / 2 on to STL and output 3 / 4 to basement for stream and logger
- Sage Digital ENDEC: emergency alert system encoder/decoder, overrides broadcast in event of emergency alerts.
- Comrex BRIC Link II: encoder for studio-transmitter link

Studio-transmitter link

The studio-transmitter link (STL) consists of a pair of Comrex BRIC Link II units, one at Trent Radio House and one at the transmission facility. These devices connect the studios and transmitter over an internet stream: the studio-side unit receives analog audio and outputs the audio digitally over the internet, while the transmitter-side unit receives this digital stream and outputs analog audio to the transmitters.

While the connection is made over the public internet, some security measures are in place: the two devices are paired to each other, so each will only send/receive data from the other. Additionally, the connection is made over a virtual private network (VPN), so that the configuration interface and audio stream are encrypted and not accessible to third parties.

On the studio side, two redundant internet connections are in place: a cable internet connection provided by Cogeco (shared with the rest of the Trent Radio House network) and a Bell Fibe fibre-optic connection. At the transmission facility, only one internet connection is in place: a fibre-optic connection via Cable Cable.

Transmission facilities

Trent Radio's transmission facilities are located at 1925 Television Road, at the site of the CHEX TV tower. Both antenna space on the broadcast tower, and space inside the transmitter shed, are donated to Trent Radio by Corus Entertainment which owns and operates the facility.

Transmission itself is done by a pair of Nautel VS1 1000W transmitters, operating at 700W per Trent Radio's broadcasting license. These are connected to the antenna via a remotely-controllable RF switch, enabling one or the other two be connected to the antenna. This switch is controllable over the internet over the same VPN as provides the STL, allowing Trent Radio staff to switch between transmitters without needing to physically be present on site.

Additionally, a network-enabled Inovonics 531N modulation monitor is connected to the transmitter output. This is a similar device to the meter in Studio A, with a web interface allowing both the meter display and audio output to be monitored over the internet.

Streaming, logging & off-air monitoring

In addition to our FM broadcast, Trent Radio transmits a live internet stream of our broadcast. This is served from a Linux server in the Trent Radio House basement (STRM) which receives audio from the Studio B rack and transcodes it to MP3 and OGG streams, both in high- and low-bandwidth versions. STRM also serves the Radio Free Peterborough stream, which is used by Studio V and also available over the internet.

This same feed is also directed to LGR01, a Windows XP machine serving as Trent Radio's primary logger. LGR01 is a As such, this is not a proper off-air logger, but rather a recording of the audio from the studio prior to the STL. This is a higher-fidelity recording that would otherwise be captured, but does not capture broadcast interruptions due to failures in the STL or at the transmission facility.

The feed to the stream and LGR01 is upstream of the Sage ENDEC, so emergency alerts are not sent via stream or captured in the LGR01 recording.

Off-air logging is provided by LGR02, a Windows 7 machine, also located in Trent Radio's basement. This is fed by a Panasonic RX-FS410 radio, i.e. a boombox. This meets our obligation for maintaining audio logs, albeit with poor fidelity.

Further off-air monitoring is provided by the Inovonics 531 modulation monitor in Studio A, connected to a rooftop antenna. This provides the off-air audio in both Studio A and Studio B, and is also connected to the Tascam MD-350 minidisc recorder in Studio A as an emergency logger.

Risks and Challenges

While Trent Radio's broadcast facility is, generally speaking, in good working order, some aspects of our infrastructure present certain risks and challenges to our ongoing capacity as a broadcast facility.

None of these points present any sort of immediate crisis; rather, they are indications of the places where effort and investment is likely best spent to improve Trent Radio's broadcast quality and future technical sustainability.

In studio

Studio A console

The EELA Audio SBM console in Studio A is almost 30 years old, and beginning to show its age. While regular maintenance has helped its longevity, some components are degrading due to wear and tear:

- Dirty gain pots on some channels, resulting in crackling when gain is adjusted
- TT2 remote start button is intermittent, interrupting right channel audio
- Cue buttons on some channels are intermittent / unreliable

Due to the age of the console, replacement parts are not readily available.

Turntable cartridges and styluses

All three turntables in Trent Radio's studios use Shure cartridges and styluses. In May 2018, Shure announced that they had discontinued manufacture of their phono product line; while there is still some availability for Shure phono products, it is only a matter of time until they are no longer available.

Trent Radio has a reasonable inventory of replacement styluses for the near future. However, once these are depleted, alternative cartridges and styluses will need to be found.

Cabling in Studio B

While not directly a risk to Trent Radio's broadcasting ability, the cabling in Studio B (both to the console, and the rack) is somewhat chaotic. This may present an obstacle to future maintenance or improvements.

STL & transmission facilities

Volume & modulation control

The Nautel VS1 transmitters, installed in 2017, are remarkable for their clarity and low noise floor, but do not provide the same dynamic range control as the previous SBS transmitter.

Carrier modulation, the manner in which our audio signal is carried over the air, is regulated by Innovation Science and Economic Development Canada, who specify the peak permissible modulation level, analogous to peak audio volume, and prohibit the broadcasting of unmodulated carrier, i.e. complete silence.

The Symetrix 425 compressor / limiter provides some dynamic range control, and the transmitters have some further dynamics processing, but control over Trent Radio's overall broadcast volume and carrier modulation is somewhat lacking.

Network connectivity to transmitter site

At Trent Radio House, there are redundant internet connections serving the STL. However, at the transmitter site, only one connection is in place. While this connection is generally reliable, it does represent a single point of failure in our signal chain, which is outside of Trent Radio's control.

Electrical reliability at transmitter site

The transmitter site is outside of city limits, and so utility service is not as reliable as may be desired. While there is a generator serving the facility, recent experience has demonstrated that brief power interruptions do still occur.

In the event of a power outage, it takes a few minutes for all of the internet-enabled devices to reconnect. As such, what may be a momentary interruption in electrical service can become a three-minute broadcast interruption.

Stream and IT infrastructure

Aging computers

While not directly relevant to our broadcast operations, many of the computers in the Trent Radio network are 10 or 15 years old, including LGR01, LGR02, and STRM. These computers continue to function, but are running unsupported operating systems and can not be relied upon to remain in service indefinitely.

STRM / LGR01 audio feed

Both STRM and LGR01 are fed from the same channels on the distribution amplifier in Studio B, run through splitters to connect to both computers. This causes reduced audio fidelity, and inconsistent volume across channels.

LGR02 audio feed

The audio feed to LGR02, while intelligible, is very low fidelity as it originates from a consumer-grade radio located in the basement.

Recommendations

Given the risks and challenges outlined above, the following recommendations will serve to improve both Trent Radio's current operations, as well as the long-term reliability of our broadcast facility:

1. Pursue the replacement of Studio A console & related systems
    - In consultation with a committee of staff & community members, identify and implement a replacement to the EELA Audio console in Studio A.
    - In preliminary discussions with HP Services (Gary Hooper & Michael Lewis) they have recommended a Wheatstone digital audio system.
    - Recommended timeline: 3 - 5 years.
2. Identify alternative phono cartridges and styluses
    - Determine a suitable replacement from another manufacturer, and purchase an inventory of cartridges & styluses before the current inventory is depleted.
    - Recommended timeline: 1 year
3. Improve Studio B cable management
    - To improve maintainability, reroute cabling in Studio B in a more orderly fashion.
    - Recommended timeline: within 1 year
4. Review signal processing for volume & modulation control

    - Improving our broadcast quality, especially improved control of modulation peaks, may be possible tweaks of the current signal chain and settings, or may require the purchase of additional software and equipment.
    - In the immediate short term, a review of the capabilities of our existing equipment should be a priority.
    - Recommended timeline: 3 months or less
5. Power down transmitters during shutdown periods
    - Given the remote administration capabilities of our transmitters, shutting down the RF output and going completely off air is trivial.
    - Develop a plan for doing so during the regular inter-season shutdowns.
    - This would ensure the prevention of extended periods of unmodulated carrier.
    - Additionally, this may be a worthwhile time to schedule alternating between the two transmitters.
    - Recommended timeline: before end of summer season.
6. Redundant internet connection at transmission facility
    - Address single point of failure in our STL with a redundant internet connection at the transmitter site.
    - One possibility per HP Services is a mobile data (LTE) hotspot, to only be used in the case of a failure of the main connection.
    - Recommended timeline: 3 - 6 months
7. Uninterruptible power supply at transmission facility
    - Address short power outages at the transmission facility through the installation of one or more uninterruptible power supplies (UPS) at the transmission facility.
    - Depending on budget, these could either power all equipment in the rack, or just the network equipment. In the latter case, the broadcast would be momentarily interrupted but the STL would remain active.
    - HP Services is preparing specific recommendation of UPS units for both budgets.
    - Recommended timeline: 3 months or less
8. Identify & implement replacement computers
    - Studio PCs were upgraded to Windows 10 last year, with only minor issues
    - This IT modernization project should continue through to the systems in the Trent Radio House basement that are core to our broadcast operations; in particular, LGR01, LGR02, and STRM.
    - Recommended timeline: 1 - 2 years
9. Separate feeds for STRM and LGR01
    - To improve audio quality of our livestream and LGR01 recordings, a proper distribution amplifier should be used to split the feed rather than a passive splitter.
    - This may be possible with the channels on the existing distribution amplifier, or another one may be required in the Trent Radio House basement specifically for this purpose.
    - Recommended timeline: within 1 year
10. Improved feed for LGR02

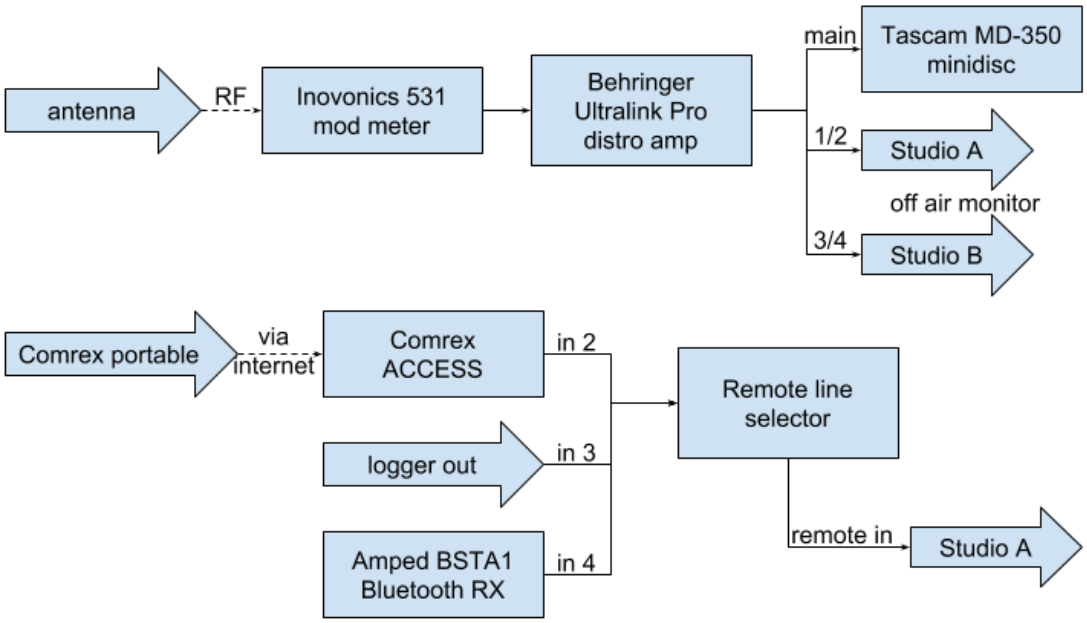
- Rather than receiving audio from a radio in basement, LGR02 should be fed from the modulation monitor in Studio A for a higher fidelity recording.
- This should require little more than running cabling from Studio A, via the basement, to LGR02.
- Recommended timeline: within 3 months

Given the realities of Trent Radio's constraints both with respect to budget and staff capacity, it may very well not be possible to implement all of these recommendations - at least not in the specified timelines. Rather than being set in stone, these recommendations are intended to serve as the starting point for planning the next steps in Trent Radio's technical operations.

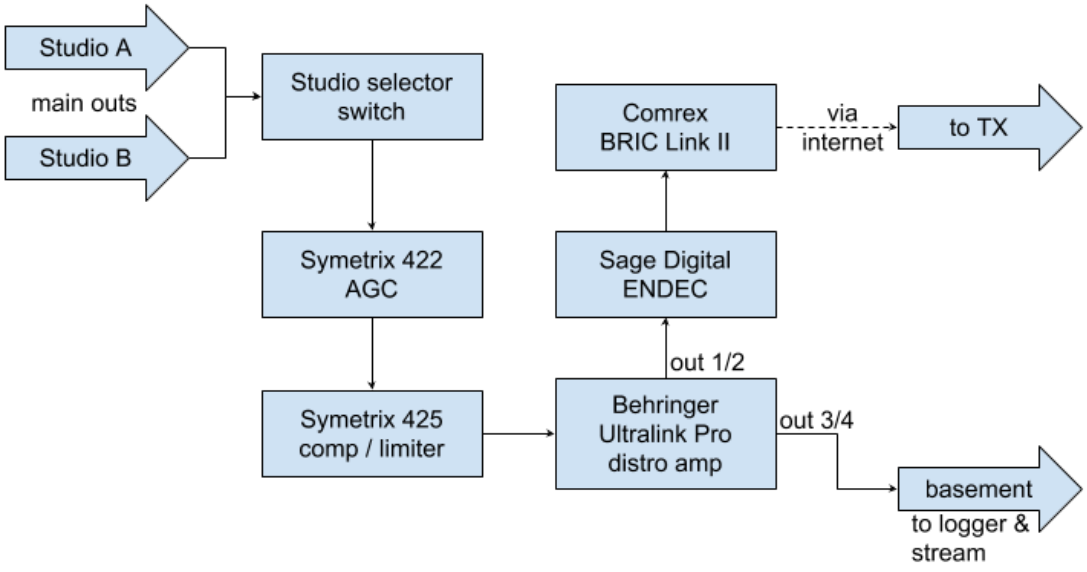
Appendices - Diagrams & inventory

Appendix A - Signal flow block diagrams

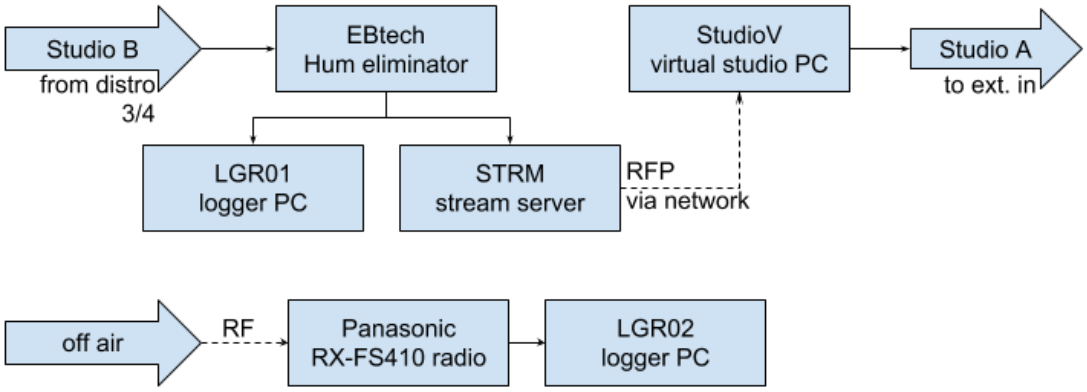
A1 - Studio A rack



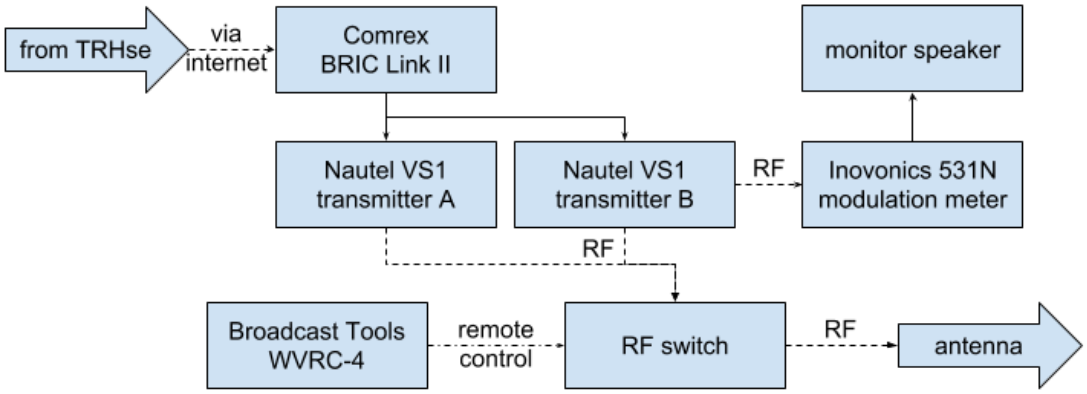
A2 - Studio B rack



A3 - Trent Radio House basement

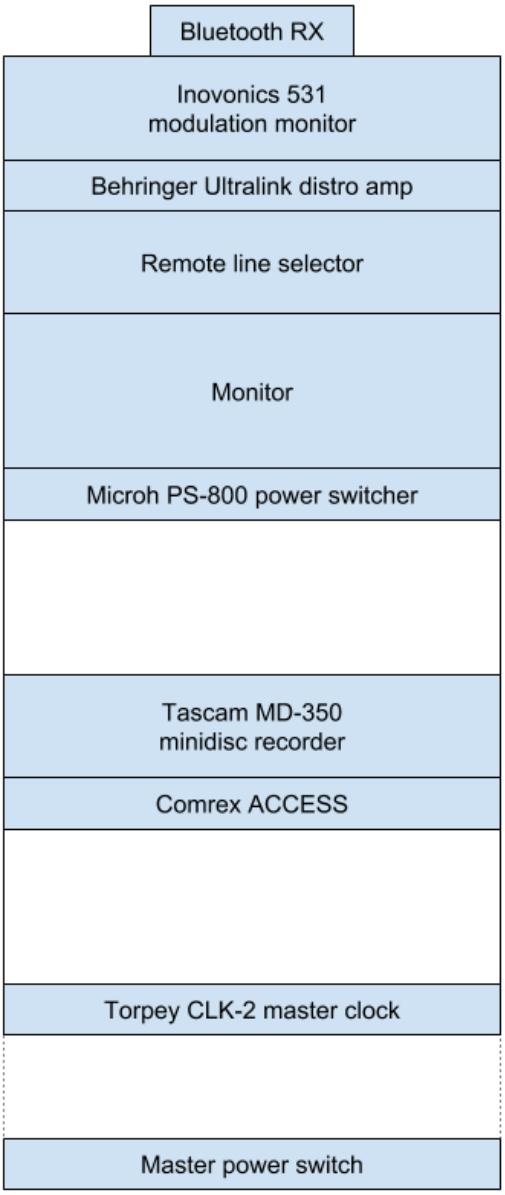


A4 - Transmitter site

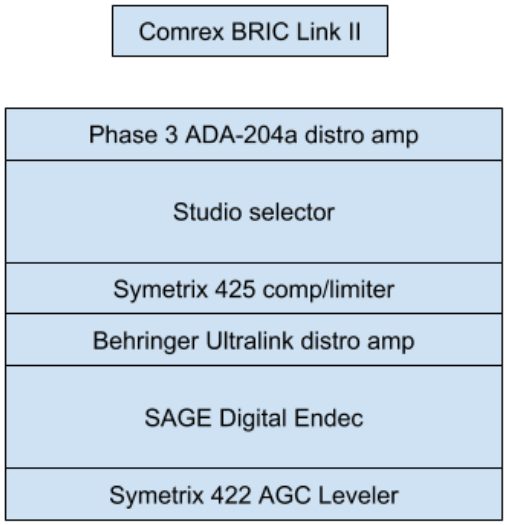


Appendix B - Rack layout diagrams

B1 - Studio A rack



B2 - Studio B rack



Appendix C - Equipment Inventory

Type	Manufacturer	Model	Location	Notes
Microphone	Electo-Voice	RE-20	Studio A	Mic 1
Microphone	Sennheiser	421	Studio A	Mic 2
Microphone	Shure	SM57	Studio A	Mic 3
Turntable	Technics	SL-1200mk2	Studio A	TT1
Turntable	Technics	SL-1200mk2	Studio A	TT2
CD deck	Gemini	CDX-2250	Studio A	CD 1/2
Cassette deck	Marantz	PMD510	Studio A	Cassette 1/2
Console	EELA Audio	SBM	Studio A	
USB audio interface	Behringer		Studio A	
Microphone	Sennheiser	521	Studio B	Mic 1
Microphone	Sennheiser	521	Studio B	Mic 2
Telco coupler	Gentner	Hybrid Coupler	Studio B	
CD deck	Pioneer	PD-103	Studio B	
Minidisc player	Sony	MDS-JE630	Studio B	
Cassette deck	Marantz	PMD510	Studio B	Cassette 1/2
Console	Mackie	1604VL24	Studio B	
Turntable	Technics		Studio B	

Turret			Studio B	
USB audio interface	Behringer		Studio B	
Bluetooth receiver	Amped	BTSA1	Studio A rack	
Modulation monitor	Inovonics	531	Studio A rack	
Distribution amplifier	Behringer	Ultralink Pro	Studio A rack	from modulation monitor output
Remote line selector			Studio A rack	
Monitor			Studio A rack	for remote line selector
Minidisc recorder	Tascam	MD-350	Studio A rack	
IP codec	Comrex	ACCESS	Studio A rack	for remote broadcasts
Master clock	Torpey	CLK-2	Studio A rack	studio clock controller
IP codec	Comrex	BRIC Link II	Studio B rack	for STL
Distribution amplifier	Phase 3	ADA-204A	Studio B rack	not in use
Studio selector			Studio B rack	
Compressor / limiter	Symetrix	425	Studio B rack	
Distribution amplifier	Behringer	Ultralink Pro	Studio B rack	from studio selector
Emergency alert	Sage	Digital ENDEC	Studio B rack	
Automatic gain control	Symetrix	422	Studio B rack	currently bypassed
IP codec	Comrex	BRIC Link II	TX rack	for STL
Transmitter	Nautel	VS1	TX rack	Nautel-A
Transmitter	Nautel	VS1	TX rack	Nautel-B
Modulation monitor	Inovonics	531N	TX rack	
Remote control	Broadcast Tools	WVRC-4	TX rack	controls RF switch
RF switch			TX rack	
Monitor			TX rack	
Hum eliminator	EBTech	Hum Eliminator	TR House basement	
Radio	Panasonic	RX-FS410	TR House basement	For LGR02 off-air recording