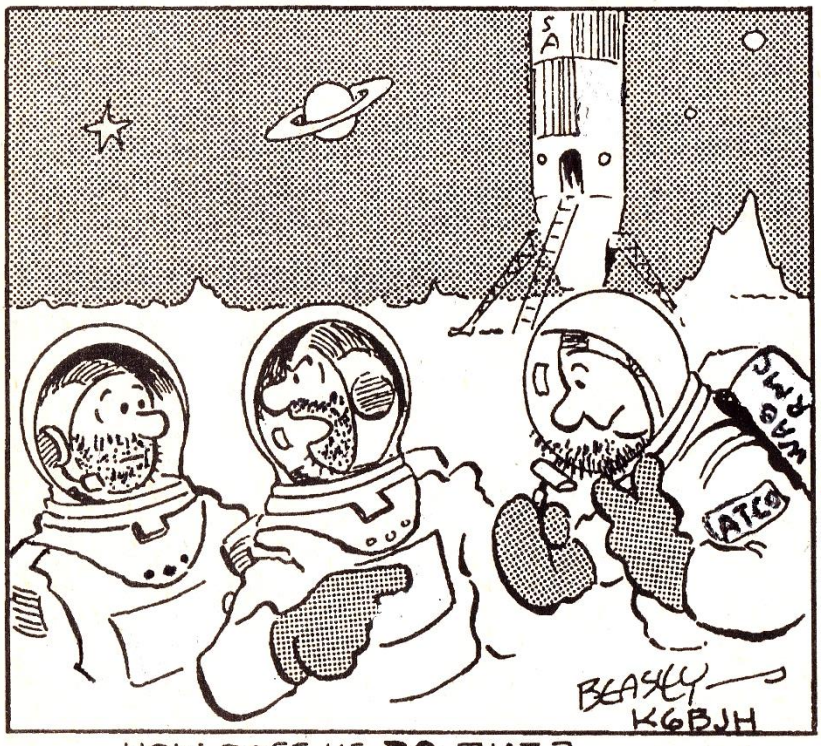
ATCO NEWSLETTER

VOLUME 43 NUMBER 1 **January 2026**

The ATCO newsletter is the official publication of a group of amateur television operators known as "AMATEUR TELEVISION IN CENTRAL OHIO Group Inc" published quarterly (January, April, July, October)

ATCO SPOTLIGHT TOPIC



ACTIVITIES ... from my Workbench

It's Newsletter time again! As I write this, we are bracing for a significant snowstorm this weekend. I've gassed up the snowblower just in case, though in my experience, being well-prepared usually ensures the snow won't happen at all. If my preparation keeps the roads clear for the rest of you, I'll be expecting a "Thank You" in the next issue!

Repeater Technical Update

The **ATCO ATV repeater** is functioning, but I've noticed the **439 MHz input** seems to be losing sensitivity.

- **The Plan:** As soon as the weather clears, I'll be checking the equipment. If the issue isn't internal, I'll need to inspect the antenna and feedline which will require warmer weather.
- **Sensitivity Testing:** I plan to run a threshold test by reducing an external signal until it disappears. I recall hitting the repeater from my QTH with just 500mW in the past, but I need to re-verify those numbers.
- **Help Needed:** If anyone is available to assist with signal testing, please reach out.

A Call for Activity

I'll be honest: ATV activity in our area is getting thin. It's a bit of a "chicken and egg" problem—when activity is low, enthusiasm wanes for everyone, myself included.

I know there are at least 10 of us locally who just need a little "push" to get back on the air. **Consider this that push!** I am willing to step up, lead projects, and even donate parts (I have several "spare" antennas in my crawl space that need a good home). If you need help getting back on the air, let me know. Whether it's via phone, email, or **147.48 simplex**, please speak up and let me know you're still out there.

The Future of the repeater Bulletin Board: A New Project

The ATCO repeater bulletin board has been silent since Dale's passing two+ years ago. While I have his original equipment, I'm proposing a more modern approach: **a Raspberry Pi and Mesh-based system.** Instead of sending files via 23 cm DVB-S from home, we could use our existing (and currently underutilized) Mesh facilities to upload data directly to a new controller at the repeater. This would allow *any* of us to send messages or graphics to the repeater.

Let's Talk Over Breakfast (My Treat!)

I'd like to organize a special breakfast to discuss this. We need help with:

- Hardware construction & packaging
- Raspberry Pi software
- Documentation & Installation
- Slide show graphics and content
- Topics to display on the bulletin board

If we work together, we can build an **interactive system** that rivals social media for information sharing and gives our Mesh system a real multiple purpose.

Breakfast is on me—I just need your interest, ideas and your hands. Let me know if you're interested and I'll organize the meeting.

Cell phone, call or text - 614-580-4793

Email - art.towslee@gmail.com

That's about it for this time guys. 73 for now,

…WA8RMC

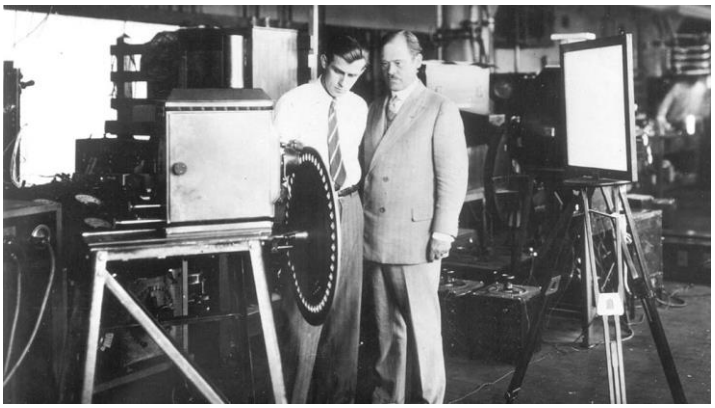
THE ORIGINS OF ELECTRONIC NEWSGATHERING

Guys, the following is a summary of a series of articles by James O'Neal in TV Technology Magazine August-December 2025 about the History of ENG (Electronic News Gathering). The summaries are included here in part. For the complete articles, CTRL CLICK on the article headers below. WA8RMC

- The Origins of Electronic News Gathering
- The History of ENG, Part 2: Turning 'You Are There' Into Reality
- The History of ENG, Part 3: Camera Advances Push ENG Into the Modern Era

The Origins of Electronic Newsgathering

By James E. O'Neal published August 4, 2025
Tracing the beginnings of television news' most essential ingredient



"Ground zero" for ENG appears to be "on-the-scene" coverage in August 1928 of New York Gov. Al Smith announcing his candidacy for U.S. president. The event was televised over General Electric's Schenectady station, WGY. Ernst Alexanderson (right), who headed up GE's early television research and was responsible for the live event coverage, is seen here with assistant Ray Kell, examining a 48-line mechanical scanner used in his TV broadcasting initiative.

The public's interest in viewing distant "breaking news" events was stoked more than 100 years ago by the French Pathé motion picture company, with that organization producing and distributing the first "newsreels" to European movie houses in 1909 and in the United States two years later.

These short presentations of major news developments allowed audiences to experience such events in greater detail than the still images that appeared in newspapers and magazines. By the 1930s, a few specialty movie houses catered to serious "news junkies" by offering only newsreels running on a continuous basis, a precursor to the 24/7 schedule initiated by CNN in 1980.

Even in television's infancy, broadcasters realized that merely reporting news events from a studio setting provided little in the way of engagement with their viewing audiences. Almost from the time that radio moved out of the starting gates, "man-on-the-scene" reporting—enabled by access to a well-established network of telephone circuits—became a standard ingredient of newscasts.

Some radio reporters developed a knack for creating very good "word pictures" of what they were witnessing in connection with breaking news events, with this practice developing into something of an art form by the 1940s. (Recall Edward R. Murrow's reporting of live events as war broke out in Great Britain, which began with "This Is London" and included the warbling of air-raid sirens and other wartime sounds.) The best the few television stations in operation during World War II could do was to augment the reading of news service copy with a map indicating combat locations.

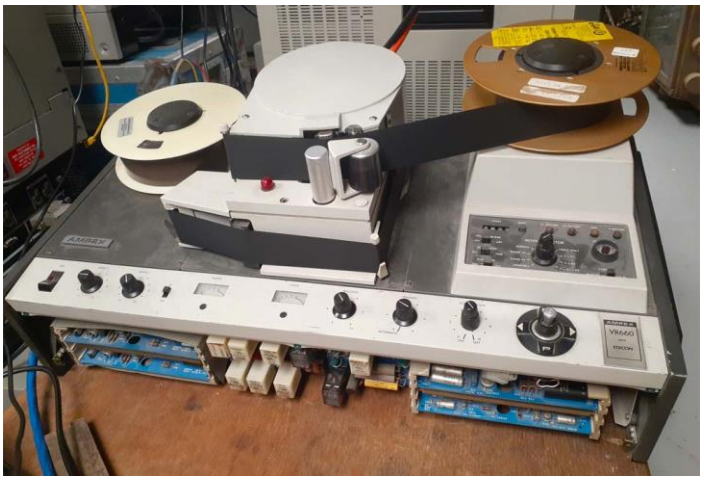
While pioneer television broadcasters longed to emulate the immediacy and spontaneity in on-the-scene reporting provided by their radio counterparts, the physical size, weight and electrical power consumption of TV gear precluded such operations. The equipment in use in the medium's formative years was also finicky. An image orthicon camera required several minutes for warm-up and alignment. (Even the initial network reporting of the 1963 assassination of President John F. Kennedy was via a "bulletin" slide and a newscaster voiceover as studio cameras had been switched off and couldn't be forced into immediate operation.)

Another factor limiting coverage immediacy was connectivity. Unless a common carrier (regional or national telecom) had already established coaxial cable or microwave linkage close to the area of interest, or a clear microwave path existed between the news scene and television station or mountaintop transmitter site, “live shots” were not possible.

On-the-scene video recordings were not really an option, either, as first-generation VTRs were large and heavy on power consumption (think multiple racks of vacuum tubes), making even the recording and delivery of tapes back to the station or network by a courier equally prohibitive in terms of spontaneity in news coverage. Even with the time required for chemical processing and editing, it was faster and less complicated for television broadcasters to send a crew with a 16-millimeter sound-on-film camera to a news scene.

However, by the mid-1960s, aided by the advent of better and more reliable solid-state devices (especially transistors), broadcast equipment manufacturers were beginning to show (and deliver) a number of smaller and less power-consumptive counterparts to the vacuum-tube-based designs that had launched the postwar television industry. This technological shift was especially noticeable as the second generation of videotape recorders started to appear, with VTR pioneer Ampex beginning to shrink the size and weight of its machines by replacing vacuum tubes with transistorized circuitry.

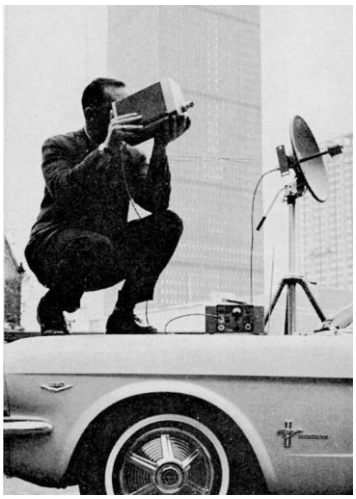
One of Ampex’s videotape recorder developments apparently caught the eye of someone at Triangle Publications, a major Philadelphia-based broadcast group that operated stations in multiple markets. The new Ampex machine—the VR-660—was released in late 1962. Despite its small physical size (about 30 by 18 by 15 inches) and a price tag about one-quarter that of the “quad” machines then in use by broadcasters, it delivered video also as good as the quads.



The VR-660, along with a “miniaturized” television camera from consumer/industrial electronics company Sylvania, provided the basis for experimentation by Triangle with videotape as an alternative to film for capturing news events. The release of the VR-660 by Ampex in late 1962 spurred some early ENG experimentation by at least one broadcast group. The 2-inch helical scan machine was much smaller and less costly than its “quad” counterparts, but provided almost identical video quality. The unit served as the centerpiece of Triangle Publications’ early experimentation with electronic newsgathering. (The VR-660 shown here is a later model equipped with rudimentary editing capability.)

During the mid-1960s, the group trialed an early iteration of single-camera no-frills completely electronic newsgathering. The experiment was conducted at Triangle’s New Haven, Conn., station, WNHC-TV (now WTNH), and at its Altoona, Pa., property, WFBG-TV (now WTAJ). Other Triangle stations may have also participated in the trialing, but after 60 years and multiple station ownership changes documentation is scant.

The compact size and reduced power requirements of the VR-660, along with the availability of a self-contained vidicon camera—a Sylvania vidicon model designed for industrial applications and providing “FCC-legal” EIA RS-170 sync—allowed Triangle engineers to create a small, easily maneuverable mobile unit that would be the forerunner of ENG units emerging a decade or so later



The vehicle selected for the experiment—a Chevrolet ½-ton "panel truck"—was not much larger than automobiles of the era, allowing it to be easily driven and parked very close to events being covered. The greatly reduced power requirements of the solid-state gear selected for the project also negated the need for prearranging AC power drops necessary to meet the demands of that era's conventional television mobile units, with their large, vacuum-tube-driven image orthicon cameras and racks of support electronics.

Triangle Publications used this modified Chevrolet panel truck in their ENG trialing some 60 years ago at its Altoona, Pa., property, WFBG-TV. In addition to a rooftop hatch, the van was also equipped with a "24-volt battery box," a 1-kilowatt DC-to-AC inverter and a second generator coupled to the vehicle's engine. The vidicon camera used in the project was a Sylvania industrial model with a small TV set mounted on top, as the camera had no electronic viewfinder.

Even in television's infancy, broadcasters realized that merely reporting news events from a studio setting provided little in the way of engagement with their viewing audiences. Almost from the time that radio moved out of the starting gates, "man-on-the-scene" reporting—enabled by access to a well-established network of telephone circuits—became a standard ingredient of newscasts.

All gear in the Triangle vehicles—camera, recorder, video monitor and a small audio mixer—was easily powered via a 1-kW DC-to-AC inverter driven by a 24-volt battery charged from a second generator driven by the vehicle's engine.) Triangle's modifications also included the cutting of a 3-foot hatch into the top of the vehicle and adding a support platform below for the camera operator, so that if time was of the essence, coverage of a news event could begin immediately without unreeling cables or setting up the camera "on sticks." Due to the portability of the gear and the vehicle modifications, the operator could also record events while the van was in motion. Rather curiously, there was apparently no attempt to incorporate microwave gear to the van's equipment package to enable live transmissions, though at least one manufacturer was offering small, solid-state microwave links designed specifically for such applications. (By the mid-1960s, Microwave Associates (later M/A-COM and now MACOM) touted "lunch-box-sized" transmitters consuming a mere 50W that were intended "to bring live TV field coverage within range of every broadcaster." The company even offered a small camera as an "accessory.") Although the Triangle newsgathering vehicle design was revolutionary, its use was rather short-lived. (When the author joined the WNHC-TV staff in 1970, the early ENG experiment was just a distant memory among some of the older staffers.) This was likely due to a number of factors, the greatest of which was the inability to easily edit the videotapes produced.

By the mid-1960s, at least one manufacturer was offering compact solid-state microwave gear for live transmission of news events. Although interest in the technology was initially limited, it would play a major role in the ENG "boom" that would occur in the next decade. In this December 1964 Microwave Associates ad, the hood of a 1964 Ford Mustang serves as a platform for both the operator of a small camera and the "lunch-box-sized" microwave transmitter.

While the VR-660 utilized 2-inch videotape, its recordings could not be played back by conventional "quad" broadcast VTRs due to differences in head scanning. (In the interest of simplifying design and operation, the VR-660 incorporated a helical tape scan as opposed to the transverse scanning used in larger machines.) To edit recordings, stations either had to purchase a second VR-660 (around $14,000 in 1965; more than $140,000 in

2025 dollars) or transport the 100-pound machine from the van to the TV studio for dubbing the video to conventional "quad" VTRs that did provide editing capability.

Another major factor that possibly sidelined this early ENG attempt was the widespread conversion to color television broadcasting taking place in the 1960s. The initial Ampex VR-660s lacked color capability, and there were no small or easily portable color counterparts to the Sylvania camera at the time of the Triangle experiment. (Ampex did eventually add both color and editing features to the VR-660, but by that time, Triangle stations had moved away from ENG and into 16-mm color film for capturing news events.)

Although this very early foray into electronic newsgathering ultimately went nowhere, it doubtless captured the attention of others in the industry (the June 1965 issue of Broadcast Engineering magazine featured a cover story account of the WFBG-TV implementation). It was only a matter of time, along with the creation of equipment better suited to task, before the Triangle experiment would be repeated by others.

(The next chapter of this series tracing ENG's history examines the beginnings of electronic newsgathering in its modern form, along with its early rollout at both station and network level.)

Television news coverage, and the immediacy that comes with it, ultimately spelled the death knell of the theatrical newsreel, with the final installment coming from British Movietone News in May 1979 (U.S. newsreel production had ceased some 12 years earlier). With this background, and the rise of numerous successful television entities that do nothing but broadcast news, it's interesting to trace the evolution of "on the scene" television newsgathering and the technological developments that have now made it possible to capture and transmit live video from anywhere in the world.

Early Attempts

After a century, it's sometimes a bit difficult to establish the true origin of many technologies and events—witness the competing claims for the invention of the telephone, radio, aviation and others. However, a very strong claim for priority in ENG exists for Schenectady, N.Y., TV station WRGB, which at the time of the history-making event operated under radio station WGY's call sign.

WGY was owned by General Electric, and its wizard of combined electrical and mechanical engineering, Ernst Alexanderson, had begun experimentation with television around 1926. He succeeded in developing a 48-line mechanical system, and with it, broadcast the first televised drama, "The Queen's Messenger," September 1928.

Alexanderson had also devised a portable version of his equipment, and in the previous month transported it to the New York statehouse in Albany to televise Gov. Al Smith as he accepted his nomination as the Democratic presidential candidate on Aug. 22. This first-ever bit of televised "breaking news" was reported to have been clearly received on the handful of television receivers that existed then. (Alexanderson later continued his television research independently of WGY, with the experimental call sign W2XCW. This pioneering station later became WRGB.)

Electronic television's first generation of vehicles for "outside broadcasts" reflected the bulk and weight of the vacuum tube-driven cameras, monitors and support gear they had to carry. While this late-1940s-vintage 17,500-pound Dumont "Telecruiser" was capable of capturing and relaying video back to the studio, its requirements for external power and special parking arrangements were not conducive to coverage of "breaking news." Claims might be made by fledgling U.K. and German television operations in connection with the televised coverage of horse racing and the 1936 Berlin Summer Olympic Games, but these are better characterized as live coverage of sporting events, not breaking news.

A priority claim for the first electronically televised breaking event has to go to NBC and its 1939 experimental television station, W2XBS (later WNBT and now WNBC), which in November 1938 broadcast live the burning of an abandoned New York City building, and a few months later, covered the opening of the New York World's Fair, with President Franklin Roosevelt, New York Mayor Fiorello La Guardia and RCA President and CEO David Sarnoff all appearing before the camera.

ENG in the Postwar Television Boom

However, it was not until the end of World War II in 1945 that television began to be taken seriously by the general public and receivers started appearing in homes in substantial numbers. During this period, early TV broadcasters began to emulate their radio counterparts by increasingly taking programming out of the studio and into real-world environments, including live coverage of breaking news.

Credit for the first live coverage of a breaking "hard" story by television likely goes to Los Angeles station KTLA, which, not long after exchanging its experimental call sign W6XYZ for the commercial call, took its mobile setup to the scene of a massive explosion at a city electroplating plant. The Feb. 20, 1947, incident killed 17 people and damaged 11 nearby buildings beyond repair. KTLA microwaved video from the scene to its transmitter location atop Mount Wilson for retransmission to the few hundred TV sets then in use in Los Angeles.

This two-camera television origination vehicle was constructed for use by pioneer Los Angeles station W6XYZ. Although the date of this photograph has not been established, it would have been prior to the station's transition from experimental to commercial status in January 1947. Although its physical size might lend itself to on-scene news coverage, a connection to an external electrical power source was necessary. KTLA also gets the honors for the first continuous television coverage of an evolving event—the attempted rescue of a 3-year-old girl who had fallen into an abandoned well. The station's coverage of this 1949 event spanned nearly two days in April.

KTLA also wins—hands down—the honors for development and deployment in 1958 of the first helicopter television broadcasting platform, the "Telecopter," which was the brainchild of the station's chief engineer, John Silva. Silva first experimented with a "tethered" configuration for video delivery, and with the success of this arrangement shifted to a "wireless" version, employing a special mobile microwave transmitter and non-directional antenna package built by General Electric.

The antenna was hinged so as not to impede helicopter landing operations, stowed horizontally until the aircraft was in flight. It was then dropped to a vertical position beneath the craft, radiating equally well in all directions. Signals could be easily tracked from an elevated receiving dish.

(As an historical note, Silva was not the first to transmit video from an aerial platform. Near the end of World War II, the military experimented with drone operation using early RCA camera gear, and in 1955, NBC used a Goodyear blimp to transmit portions of the Jan. 1 Tournament of Roses parade; however, Silva was the first to deploy a helicopter in an ENG application.)

Homegrown Equipment

KTLA was certainly not alone in devising methodology for airing news events as they happened. By the late 1940s, RCA was offering a two-camera "remote" unit in its catalog of TV-specific equipment, and a number of stations either purchased such ready-made products or "rolled their own" in an attempt to supplement studio programming.

On Feb. 20, 1947, a massive explosion leveled a Los Angeles electroplating plant. The blast, which killed 17 people and destroyed a number of nearby buildings, occurred less than a month after W6XYZ had been commercially relicensed as KTLA. The station provided on-the-scene coverage of the aftermath.

And while these smaller mobile video origination platforms could be used in coverage of a scheduled news event, spontaneity was not their strong suit, as external electrical power was required, necessitating the pre-ordering of a power company "drop," or running heavy cables to a suitable AC source.

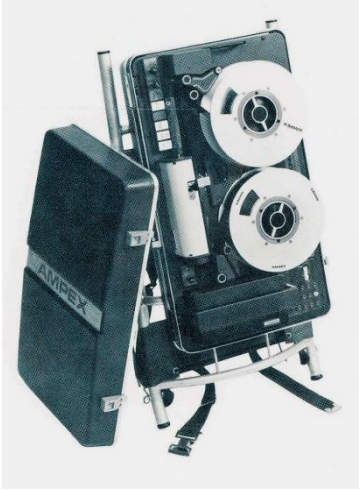
However, by 1952, engineers at Washington, D.C.'s CBS affiliate, WTOP-TV (now WUSA), overcame this limitation with the creation of a one-camera vehicle (a modified passenger car) for event coverage. (As little documentation survives, it's possible that the network may have been involved in the project, as CBS was then part-owner of WTOP-TV.)

In addition to providing some of the very first televised on-the-scene coverage of unfolding news events, Los Angeles station KTLA also was the first to provide a bird's eye view of such events via its "Telecopter," which launched in 1958. In this photo, a special-made nondirectional microwave transmitting antenna is about to be installed on the Bell 47G-2 helicopter leased by the station prior to its deployment. (Image credit: From the Don Kent collection, courtesy of the Early Television Foundation)

A surviving photo (on the cover) shows the unit in operation, with CBS newsman Walter Cronkite describing a news event as technicians operate an RCA camera and microwave transmitter. Power demands for this gear would have been minimal compared to those required by vans with multiple cameras, monitors and other origination equipment, and could have been met by an auxiliary AC generator driven by the car's engine.

Despite the efforts of station and network engineering teams in devising smaller and less power-consuming mobile video origination platforms, throughout most of the postwar first three decades, the favored methodology for capturing most news events for television broadcast remained the 16-millimeter motion picture camera, due to its small form factor, ease of handling and portability.

*(*The next part of this series will examine the initial attempts at breaking away from news film as solid-state equipment began to replace vacuum tube-driven broadcast gear.)



The TKP-45—RCA's early entry into the three-tube ENG camera field—was introduced at the 1974 NAB Show. With the introduction of increasingly better and more reliable transistor types during the 1960s, broadcast television equipment steadily moved away from large and power-hungry vacuum tube designs to transistorized versions. The introduction of the integrated circuit also played a role in miniaturizing gear and making it more reliable.

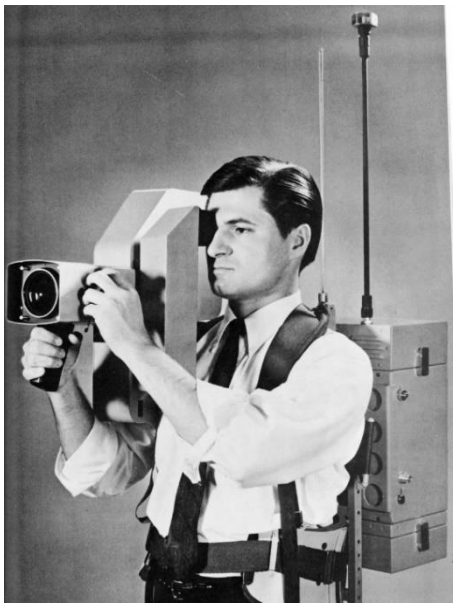
CBS Laboratories created such a device as early as 1968, the Minicam VI. RCA ushered in the era of self-contained portable cameras with the release of the TKP-45 in 1974. Video recorders also became more compact, with Ampex introducing

a portable version of its "quad" machines, the VR-3000, in 1967. This rather revolutionary recorder was deemed "portable" in that its 55-pound load could be managed by one person and powered by batteries
Ampex's first-ever "portable" 2-inch quadruplex videotape recorder was the "go to" capture device in several early ENG rollouts. Weighting 55 pounds, it provided 20 minutes of recording time on tapes that could be played directly on conventional quad VTRs. (Image credit: Ampex)

With this miniaturization of cameras and recorders, it was just a matter of time until someone decided to pair them and go out and cover a news event. Just who, when, and where this initial "modern" ENG initiative took place will likely remain a mystery; however, by 1974, at least several broadcasters and a couple of major networks were quietly trialing ENG.

Project X: 'Anyone Talking About It Will Be Dismissed'
Nashville's WLAC-TV (now WTVF) was one of these early electronic newsgathering adopters, and in mid-1974 launched a secret project to construct the first ENG vehicle in that market. According to one member of the engineering team who took part in the initiative, none of the personnel involved were allowed to reveal to other station members or others what they were working on, under the threat of instant termination if there was a leak of information.
"Station management really wanted to beat the competition," said Butch Smith, one of the six or seven WLAC-TV engineers assigned to the project. "We were told by the station's director of engineering, Ralph Hucaby, not to reveal anything about what we were working on, under penalty of dismissal from employment."

Smith said that work on the ENG unit took place in a locked area of the station's basement and due to its secretive nature, one of the construction team dubbed it "Project X."
"I'm not 100% certain when we went on the air with our first live transmission from the van, but construction started sometime in July and it took us three or four months to complete," said Smith. "We beat the other Nashville stations considerably."
According to Smith, the station selected Ikegami HL-33 cameras for the project, but after more than half a century, he is uncertain about the video recorder used. He recalled that, as the van was equipped with a 2-GHz microwave transmitter, a majority of the stories covered went live.
"We had a receive site on top of the high-rise Life and Casualty Insurance Company tower building, as they owned the station then. This was a 33- or 34-story building, and we could go live from just about anywhere around Nashville."
The NAB Show That Heralded in the ENG Era. A year later, interest in ENG had increased to the point that the April 1975 NAB Show offered its first "workshop" on the subject, with show organizers not really prepared for the number of individuals who decided to learn about the new methodology. As the post-show issue of *Broadcasting* magazine headlined it, "ENG is SRO at NAB."



"If you're not already into electronic newsgathering, get your toe in the water," declared Julius Barnathan, ABC's then-vice president of engineering operations, and one of the workshop's presenters. (Another was WLAC-TV's Ralph Hucaby.)

Broadcasters, eager to learn as much as they could about ENG, stood three-deep at the rear of the room, and according to *Broadcasting*, "completely lined the side walls and were crouched or seated on the floor in front of the stage."

Another presenter, Thomas M. Battista, vice president and general manager of then CBS St. Louis O&O, KMOX-TV (now KMOV), described that station's ENG experimentation, observing that in addition to benefiting local news coverage, it also served as a pilot program for CBS's eventual foray into ENG.

He noted that with ENG, KMOX-TV had covered 20% more stories in March 1975 than in the same period a year earlier. Battista stated that the number of technical personnel involved in news coverage at his station shrank from 56 to 50. (WLAC-TV's Hucaby reported that he expected his station's expenditure of $300,000 (almost $2 million in today's money) would be fully amortized in six years.) "If you put together a good system and come up with better news programs, you'll make loads more money and won't have to worry about the cost," said Battista. If that weren't enough inducement for attendees to start budgeting for ENG equipment—of which there was plenty at the show—ABC's Barnathan offered two other incentives. "The first key to ENG is the ability to 'go live,'" he said. "The second is 'to save your ass late in the afternoon.

Considered by some to be the 'great grandaddy' of color ENG cameras, CBS Laboratories' 'Minicam VI debuted in 1968 just in time for CBS's coverage of the Republican National Convention that year. Support electronics were contained in a backpack, with the camera wirelessly transmitting signals to a remotely-located camera control unit. CBS Labs collaborated with Philips to produce and market the camera as the Philips PCP-90.

(As an historical note, a few years prior to the KMOX-TV O&O implementation, the CBS network had trialed electronic technology as an alternative to news film, equipping a few two-person crews with either CBS Laboratories Minicam VI's (introduced in 1968), or the slightly later Norelco PCP-90 three-tube cameras and Ampex VR-3000 backpack two-inch quadruplex videotape recorders, introduced in 1967).

This approach, the use of traverse-scan videotape recording, allowed the field-generated tapes to be played directly on conventional studio VTRs. The camera/VTR package could scarcely be considered portable, however, with the recorder weighed more than 50 lbs. and the camera, along with its backpack support package, tipping the scales in excess of 40 pounds. The technology did offer one real advantage for the network, though, as it allowed reporting and transmission of news in locations where no film processing was available. NBC also experimented with a similar equipment package, but declared that while it gave "excellent results," the camera/VTR combo was "too bulky and heavy to replace 16mm film cameras.")

How Best to Go ENG—'Flash Cut' or Phase In?
Likely as a result of the workshop, and perhaps out of a desire to provide better news coverage and save some money in the process, more and more stations followed Barnathan's admonishment and dipped their toes in the (ENG) water.

One of those stations taking Barnathan's advice was KGLO-TV (now KIMT) in Mason City, Iowa. David Ostmo, the Sinclair Broadcast Group's regional engineering director, and based in San Antonio, Texas, got his start at the small market Iowa station and recalled his experiences with the Akai handheld cameras and reel-to-reel recorders being used by KGLO-TV.

"They were looking for a less-expensive way to do news coverage," said Ostmo. "Film and processing cost a lot and around 1974, they had acquired an Akai VT-150 camera and a half-inch VTR. We would bump the half-inch tape across three-quarter (U-Matic) for editing, but sometimes we would play the half-inch directly to air." Ostmo recalled that even with the acquisition of the ENG gear, KGLO-TV continued to capture news events on film. "The image was so much better with film at that point in time, and they shot the important stuff on film even though there was latency in getting it processed and edited," he said. "The film processor wasn't that old when I was there, so I imagine they were still amortizing it. I'm not sure when they went completely to ENG. I left in 1978 and they were still shooting some film."

Jay Ballard, who began his broadcast engineering career at Boston stations WHDH-TV and WBZ-TV, also recalled the substandard video quality experienced in many early ENG implementations. “Early ENG quality suffered, as the equipment was not designed for broadcast use, noting in particular the single- or two-tube cameras placed into service at some stations. “Some chief engineers complained that they did not produce ‘broadcast quality’ news footage; however, their objections were overruled by the immediacy permitted by electronic newsgathering means.”

Ballard, who eventually moved to Washington’s NBC O&O, WRC-TV, and then to NBC network operations in New York, recalled that while NBC did experiment with ENG, the network initially shied away from taking it mainstream. “The big swing to ENG at NBC occurred when the Vietnam War ended in 1975,” he said. (Secretary of State Henry) Kissinger called a press conference and the networks elected not to carry it live. CBS scooped everyone by shuttling the (ENG) tapes they made over to their M Street operation and playing them to that network ahead of everyone else.

Ballard recalled that in the wake of the CBS scoop, other networks quickly began to take ENG’s immediacy much more seriously. “Shortly thereafter, PCP90 portable cameras and VR-3000 backpack VTRs showed up in Washington. Later, two-piece cameras from Bosch Fernseh and Ikegami were shipped down from New York. NBC spent a ton of money on ENG.”

Ballard noted that even with this initial 1975 push to join the ENG club, the big transition began the following year at the political conventions and the arrival of a three-tube camera with image quality matching that of much larger studio models. “For NBC, ENG really began with the 1976 Democratic Convention in NYC,” he recalled. “RCA had just announced the TK-76 one-piece camera, and with a portable Sony U-matic recorder, the transition was underway.”

Breaking Away From Film

Despite the immediacy that ENG brought to reporting, as pointed out by Ostmo, image quality wasn’t always that great, and many stations (and networks) still clung to news film. There were also other reasons for retaining film-based operations.

For the networks and some of the larger television stations, craft union jurisdiction quickly became an issue in attempts to transition away from news film.

“Back then, a network film crew consisted of five people — a photographer, a sound person, an electrician to handle the lighting, a producer, and of course, the on-camera talent,” observed Ballard. “It was a mix of IBEW or NABET and IATSE people.”

George Lemaster, who worked at NBC’s WRC-TV in Washington in the mid-to-late 1970s, recalled union jurisdictional issues there.

“At NBC in 1975, news from the field was still mostly done on film,” said Lemaster. “You had union (IATSE) cameramen who were experienced and good at what they did. The ENG crews were made up of NABET people who eventually took control of the event capturing. There were, of course jurisdictional issues. Eventually, some of the IATSE camera operators converted to ENG positions, new to electronics, but they sure knew how to shoot news footage.”

Lemaster explained that this transition was a learning experience for both film camera operators and station engineering personnel-turned-camera-operators, but once the dust settled, the initiative paid off in much faster turnaround of news stories.

Another reason for easing into ENG, rather than flash cutting, was the not inconsequential expense involved in the purchase of color film processing equipment as local stations — following the lead of networks — began to convert from monochrome to full-color operations in the late 1960s and early 70s. A color processor could cost in the tens of thousands (more than $100k today), and these large investments needed to be amortized.

Some stations, however, opted to move completely from film to tape almost overnight. Tulsa’s KOTV was one of these. Lemaster, who worked in the station’s engineering department prior to his move to Washington’s WRC-TV, recalled the Oklahoma station’s transition.

“George Jacobs, the director of engineering at Corinthian Broadcasting, which owned KOTV then, decided to just ‘zero out’ the station’s photochemical budget for one year and use that amount to purchase ENG equipment,” recalled Lemaster. “That was in 1975, just before I went to NBC in Washington.

Jacobs purchased several Sony VO-2850 U-Matic machines, a Sony editor, two Sony DXC-1600 single-tube color cameras and recorders, and a CVS 504 timebase corrector needed to air the video from the (helical scan) VTRs.

“KOTV was a non-union house and this was a ‘cold turkey’ conversion," Lemaster said. "One day we were doing film and the next day, tape. The film editors transitioned over to editing tape.” Lemaster recalled that in spite of the differences in technology, the changeover went fairly smoothly. However, after some two decades of post-war II television, use of news film was so entrenched, some felt it would never be completely displaced by ENG.

“Will ENG ever replace news film?” Hugo Bondy, chief engineer at Atlanta’s WAGA-TV asked rhetorically in a 1976 SMPTE presentation on ENG. “Ever is a long time and I’m not that much of a ‘seer,’ but I am not holding my breath yet. Film footage will, undoubtedly, shrink. A year ago, I would have said 40%. Now? Who knows, perhaps it will drop to 20%.”

Bondy opined that until a self-contained “camcorder” the size and weight of then-current 16-mm film cameras was developed, “the total reliance on 100% ENG is risky,” explaining that some breaking news events such as a large fire ruled out the laying cables from camera to truck, or getting camera and VTR operators with their heavy equipment close to the scene of action.

Wane Caluger, who spent a large part of his engineering career at Nashville’s WSM-TV (now WSMV), recalled that his station had a slightly different reason for continuing with legacy film operations.

Butch Smith recalls a serious safety issue associated when the first generation of compact ENG vans took to the road and full-service gasoline filling stations were still the norm. A request by the van’s operator to ‘fill it up,’ while he or she stepped away for a few minutes sometimes resulted in the station attendant mistakenly inserting the pump nozzle into a cable or camera port and flooding the interior with gasoline. WAGA-TV’s Hugo Bondy included this photo in a 1976 SMPTE presentation. (Image credit: SMPTE)

“The guy running the station’s film processor had worked side deals with several area high schools to process their sports footage, so the processor kept going,” said Caluger. “The dual tape/film operation probably went on for four or five years.”

THE ENG Floodgate Opens

Despite poor image quality, jurisdictional issues, prior investments in film technology and general skepticism surrounding wholesale technological switches, there was no turning back, once cameras and recorders were placed in the hands of news crews.

The real genesis of what was to be called “ENG,” may be traced to St. Louis’s KMOX-TV (now KMOV).

The station is regarded as being first in the nation to completely move into the modern era of ENG, doing so at the behest of its then-owner, CBS. The network used the O&O in a pilot project to evaluate technology for expediting the airing of news events. KMOX-TV began its initial experimentation with ENG gear in February 1973, using Akai portable gear, and the results were so gratifying that use of film ended completely in mid-September of the following year.

By that time, KMOX-TV had purchased three Ikegami HL-33 cameras, modified three Chevrolet vans to accommodate microwave gear and provide additional power for lighting gear and an IVC video recorder and support electronics. Crews were also provided with Sony VO-3800 portable U-Matic VTRs. An ENG operation center and editing bays were added at the station. (After editing on the helical scan VTRs, recordings were transferred to 2-inch quad tapes for playback in newscasts.)

In a special report on the KMOX-TV ENG project published in the July 1975 issue of *Broadcast Engineering* magazine, the station’s news coverage was reported to have increased by 20% since going ENG, and that interest in the initiative had brought inquiries from broadcasters as far away as Japan, Canada and Great Britain. (At the time of the article’s publication, 21% of CBS affiliates had begun to move into ENG, and the number was expected to grow to 37% by the end of 1975.)

With KMOX-TV credited as the first all-ENG operation in the country, it’s then vice president and general manager, Thomas Batista, prophetically stated in the report: “I have a feeling we won’t be the last.”

VIEWERS CAN'T DISCERN 4K,8K RESOLUTION

By Tom Butts From TV Tech magazine. 10/27/25

To calculate the resolution limit, researchers conducted a study that measured participants' ability to detect specific features in color and greyscale images on a screen

(Image credit: DirecTV for Business)

Researchers in the U.K. have confirmed what many in the broadcast industry have known for years: most viewers have trouble detecting 8K—or even 4K—video resolution. According to the researchers at the University of Cambridge and Meta Reality Labs, the human eye has a resolution limit: in other words, there are only so many pixels the eye can see. Above this limit, a screen is giving our eyes more information than they can detect. To calculate the resolution limit, the researchers conducted a study that measured participants' ability to detect specific features in color and greyscale images on a screen, whether looking at the images straight on or through their peripheral vision, and when the screen was close to them or further away.

The precise resolution limit depends on a number of variables, including the size of the screen, the darkness of the room, and the distance between the viewer and the screen. However, for an average-size U.K. living room, with 2.5 meters (~8 feet) between the TV and the sofa, a 44-inch 4K or 8K TV would not provide any additional benefit over a lower resolution Quad HD (QHD) TV of the same size.

The researchers have also developed a free online calculator where users can enter the size of their room and the dimensions and resolution of their TV to determine the most suitable screen for their home. Their results are reported in the journal *Nature Communications*. Display resolution is considered equally important for the many other screens consumers use, on phones or computers, whether they're used to take pictures, watch films or play video games, including games in virtual or augmented reality. Even car manufacturers are offering higher and higher resolutions for in-car information displays and satnav screens.

"As large engineering efforts go towards improving the resolution of mobile, AR and VR displays, it's important to know the maximum resolution at which further improvements bring no noticeable benefit," said first author Dr Maliha Ashraf from Cambridge's Department of Computer Science and Technology. "But there have been no studies that actually measure what it is that the human eye can see, and what the limitations of its perception are."

"If you have more pixels in your display, it's less efficient, costs more & requires more processing power to drive it," said co-author Professor Mantiuk, also from Cambridge's Department of Computer Science and Technology. "So, we wanted to know the point at which it makes no sense to further improve the display resolution."

The researchers created an experimental set-up with a sliding display that allowed them to measure exactly what the human eye can see when looking at patterns on a screen. Instead of measuring the specifications of a particular screen, they measured pixels per degree (PPD): a measurement of how many individual pixels can fit into a one-degree slice of your field of vision. Measuring PPD helps answer a more useful question than 'how high is the resolution of this screen?' Instead, it answers the question 'how does this screen look from where I'm sitting?' The widely accepted 20/20 vision standard, based on the Snellen chart that will be familiar to anyone who has ever had their vision checked, suggests that the human eye can resolve detail at 60 pixels per degree.
"This measurement has been widely accepted, but no one had actually sat down and measured it for modern displays, rather than a wall chart of letters that was first developed in the 19th century," said Ashraf.

Participants in the study looked at patterns with very fine gradations, in shades of grey and in colour, and were asked whether they were able to see the lines in the image. The screen was moved towards and away from the viewer to measure PPD at different distances. PPD was also measured for central and peripheral vision.

The researchers discovered that the eye's resolution limit is higher than previously believed, but that there are important differences in resolution limits between color and black-and-white. For greyscale images viewed straight on, the average was 94 PPD. For red and green patterns, the number was 89 PPD, and for yellow and violet, it was 53 PPD.

"Our brain doesn't actually have the capacity to sense details in color very well, which is why we saw a big drop-off for color images, especially when viewed in peripheral vision," said Mantiuk. "Our eyes are essentially sensors that aren't all that great, but our brain processes that data into what it thinks we should be seeing."

The researchers modelled their results to calculate how the resolution limit varies across the population, which will help manufacturers make decisions that are relevant for the majority of the population: for example, designing a display which has retinal resolution for 95% of people rather than an average observer.

Based on this modelling, the researchers developed their online calculator, which enables people to test their own screens or help inform future buying decisions.
"Our results set the north star for display development, with implications for future imaging, rendering and video coding technologies," said co-author Dr Alex Chapiro from Meta Reality Labs.
Over the past several decades as many television markets worldwide transitioned to higher definition video, BBC, NHK, EBU and ITU all conducted research that agreed with these findings.

Just a warning for those who are inclined to work on projects and drink coffee at the same time…

ARRL WANTS EVERY HAM TO HELP PASS THIS BILL

Does your neighborhood prohibit outdoor TV antennas? If it does, you REALLY need to help pass this Bill! I sent in my response. You should too! *It's not too late to enter your call into the list supporting the passage of this bill.WA8RMC*

ARRL needs every radio amateur in the United States to send letters to Washington as we continue our nationwide grassroots campaign to pass the Amateur Radio Emergency Preparedness Act (H.R. 1094 / S. 459) to secure antenna rights. The process is simple: click the button at **www.arrl.org/HOA**, put in your call sign, and press the red **SEND MY LETTERS** button. **That's all you need to do!**

The letters will automatically be sent to your elected officials encouraging them to support the bipartisan bills. This legislation is intended to prevent restrictive homeowners' association (HOA) rules that currently prohibit or severely limit the installation of amateur radio antennas. Passage would give amateur radio operators the same rights to install antennas on their property as those enjoyed by users of TV antennas, wireless internet, and flagpoles.

Spreading the Word

ARRL CEO David Minster, NA2AA, was the guest on the Ham Radio Crash Course YouTube channel. Host Josh Nass, KI6NAZ, talked with Minster for 45 minutes about this important letter writing campaign.

ARRL West Gulf Division Director John Robert Stratton, N5AUS, shared insight into the importance of getting every ham to send a letter on the W5KUB Amateur Radio Roundtable podcast with Brett Glass, WY7BG, and Glen Popiel, KW5GP. See that discussion on YouTube, listen to it on Podbean, or view it on Facebook.

"You don't have a be a member," said Stratton. "Any amateur radio operator in or out of an HOA should go to the website." Go to **www.arrl.org/HOA**.

ARRL is also encouraging radio clubs to provide letters of support, and is urging each club officer to sign the letters. There are instructions for clubs on how to complete the letter [PDF] and a sample letter that each club can customize with their information [DOCX].

Send your letters now.

50 STATE BROADCASTING ASSOCIATIONS PASS RESOLUTION BACKING ATSC 1.0 SUNSET

By George Winslow published July 31, 2025
Resolution supports FCC 'establishing a clear, industry-wide date-certain transition plan for the full deployment of Next Gen TV (ATSC 3.0) as well as a sunset date for ATSC 1.0'

WASHINGTON—Fifty state broadcasters associations, as well as groups representing stations in Washington, D.C., and Puerto Rico, have passed a resolution urging the Federal Communications Commission to set a clear industry-wide transition plan to the full deployment of NextGen TV, aka ATSC 3.0.

The NAB has been pushing a plan for the FCC to approve a February 2028 sunset for the top 55 markets and the remaining stations to make the transition by February 2030. Most major broadcasters, such as Sinclair, support the cutoff dates while some LPTV groups and other broadcasters, like Weigel Broadcasting, have opposed it. TV set manufacturers and the CTA have also opposed proposals that would mandate 3.0 tuners in all TV sets.

The resolution supported a firm cutoff but did not make any mention of a specific date. The resolution stressed that broadcasters have worked hard to deploy NextGen TV broadcasts in markets reaching 75% of the population and that new standard offers a number of benefits for consumers, local news and national security. The resolution also argued that those benefits can't be fully realized under the current deployment requirement to air 1.0 broadcasts alongside the 3.0 broadcasts.

"Continued reliance on spectrum-sharing agreements and regulatory and market uncertainties limit the full deployment of Next Gen TV on a voluntary basis alone," the resolution said. "Whereas without a date-certain for a Next Gen TV transition, the transition itself and the significant improvements ATSC 3.0 makes for broadcasters and viewers alike—could be at risk," the resolution stated, "be it resolved this 31st day of July, 2025, by the broadcaster associations named below, representing all 50 States, the District of Columbia & the Commonwealth of Puerto Rico, that we support the Federal Communications Commission establishing a clear, industry-wide date-certain transition plan for the full deployment of Next Gen TV (ATSC 3.0) as well as a sunset date for ATSC 1.0."

VERSATUNE UPDATE

As many of you know, we were working on the design of a completely self-contained DVB-T / DVB-S receiver for DATV use. However, the progress has come to an abrupt halt. We finally developed software free enough from bugs to release the design for production but after I went through a parts availability and cost edit, I found that the tuner we need is obsolete and all parts have been liquidated. There are no parts available from them and no alternate sources found. With that information we declared the project dead.

It's too bad the tuner vendor did not tell us that they were obsoleting their tuner without any chance of a last time buy opportunity. We found they stopped production and liquidated all parts almost 2 years ago without any notification to anybody. (It's sure good I found out about this before I purchased production parts!!!!). I tried to contact the tuner vendor to see if they had any paper documentation left hoping that if they did, they would at least send me a copy of the printed circuit board in it. If I had a Gerber file of the board, I could replicate the complete tuner because all parts are still available from their manufacturer. There is no proprietary information here as the tuner is obsolete. They didn't even reply to multiple Emails sent to them.

Well, what to do now? I have a couple if irons in the fire which look promising. More info later. Check with me at Hamvention coming up in May. We may have information at the ATN booth 1003-1004 and also at the ATV Forum on Hamvention Saturday. I'll keep you posted.…WA8RMC

NEXTGEN TV AT CES 2026: PEARL TV FOCUSES ON LOW-COST 'VANILLA' CONVERTER BOXES

Broadcasters seek to mimic the success of the previous DTV converter box program to bring more affordable access to ATSC 3.0

LAS VEGAS—The challenge of attending CES is its size. The convention utilizes all of the enormous Las Vegas Convention Center as well as several other facilities, so often getting from one vendor appointment to another is an exercise in logistics and physical endurance. This was not as much of a problem for me this year as I was focused on what was happening in ATSC 3.0

Not that CES wasn't enormous—it certainly was—but the ATSC booth was located in the new Grand Lobby of the LVCC and that seemed to be where all of the NextGen TV information was. While I didn't see every vendor at the show, I cannot recall seeing an ATSC 3.0 or NextGen TV reference anywhere on the various floors.

I spent time listening to presentations about the latest and greatest television displays. My consistent question after the presentation was the same: "Does this set include a NextGen TV receiver?" To their credit, I didn't have anyone say "no," but I also didn't hear anyone say "yes"—mostly because I think they didn't know what I was asking for. The one exception was Sony, which doesn't even exhibit televisions as a product at CES anymore; they knew the vast majority of their sets are NextGen TV-ready. So after a long day on the floor I went back to the ATSC booth and found out the latest.

The Quest for Cheap Converter Boxes

The biggest news is the work that Pearl TV is doing with its partners iWedia and Skyworth on the creation of a low-cost, plain "vanilla" converter box—think of the coupon-eligible converter boxes of the original DTV conversion two decades ago. Anne Schelle, Managing Director of Pearl TV, says that by creating a model with tailored specifications, it qualifies the units for discount pricing from the IP owners and the chip set manufacturers.

I say "plain vanilla," but in truth, the final specifications are still being worked out and it is a bit of a balancing act. The idea is to bring the box to market at $60 or less, which presents some interesting challenges. According to Miguel Rivera, Skyworth's Director of Business Development for North America, the explosion of AI infrastructure has created a supply chain issue on components such as DDR memory chips.

Understanding what consumers want is critical for the success of the project. Pearl is working with Magid Associates to analyze consumer data to help ensure that this device ticks the right boxes. Ultimately what will be delivered is a converter box with an antenna input and an HDMI output that will allow any display to present NextGen TV to the viewer.

Target: 50K Boxes for Retails By the End of 2026

One area where this converter box will outperform the original DTV converter boxes is that there are already many successful implementations of ATSC 3.0 tuners in the market so much of the refinement has already been accomplished.

Additionally, Skyworth and their software partner iWedia already have considerable experience since Skyworth is providing the tuners for TV 3.0 in Brazil and Mexico as well as being licensed to provide the receivers for televisions marketed under the Panasonic and Phillips brands. This level of experience should ensure that these new converters function properly.

According to Rivera and Zillow Radonjic, business development manager for iWedia, this CES was technically the first demonstration of a prototype for the project. The target is to have a working demo by the end of the summer when the complete list of specifications is better defined and an initial run of approximately 50,000 units by year end. Schelle expects that promotion of NextGen TV and the units will begin around that same time frame. Of course all of this is dependent on supply chain stability.

I asked Schelle what metric Pearl would use to measure the success of the venture. She offered that success would be "incremental." Pearl's belief is that by delivering a working model of an affordable converter, other manufacturers would step up to the plate and deliver similar units under their own branding. Several times during the conversation, the need to sunset ATSC 1.0 was mentioned so I asked what Pearl would see as the best 1.0 sunset rulemaking. Robert Folliard, Gray Television's senior vice president of government relations and distribution, offered that broadcasters need a hard date from the FCC as soon as they are comfortable. Neither Schelle nor Folliard believe that maintaining the current status was tenable for much longer. Given that Pearl was using the DTV CECB (coupon-eligible converter box) model to develop this new device, I asked if they were considering presenting this program to Congress to generate support similar to the coupon program. While the answer wasn't immediate, it was "yes," but only as an idea and it wouldn't be the deciding factor on whether or not to proceed.

A 'Soft' Market for NextGen TV

When asked about how satisfied she is with how the consumer electronics manufacturers are approaching NextGen TV, Schelle admitted that the market is certainly soft and that the business model has changed. Folliard also spoke about how set manufacturers have created their own walled gardens and are hoping to get broadcasters to pay to be discoverable within their Home Screen environment.

I postulated that I wouldn't be surprised if the large manufacturers didn't adopt the cellular model and give away televisions if the consumer signs up for a multi-year subscription plan. Schelle said he was happy to hear that, since they had been having similar discussions.

While the affordable converter box was the most interesting ATSC 3.0 development I looked at, I have to give an honorable mention to Zapper Mini. One of the challenges that I see to any renaissance of OTA television is the idea that every set in the house has to have an antenna cable drop.

The Mini uses a regular Zapperbox as a gateway and then uses WiFi or Ethernet to connect Mini's to the gateway. You can put these on every television in the house with the gateway connected to a single antenna. It is an interesting technology that I am looking forward to trying in my home.

…**Bill Hayes**

Bill Hayes is the former director of engineering and technology for Iowa PBS and has been at the forefront of broadcast TV technology for more than 40 years. He's a former president of IEEE's Broadcast Technology Society, is a Partnership Board Member of the International Broadcasting Convention (IBC) and has contributed extensively to SMPTE and ATSC. He is a recipient of Future's 2021 Tech Leadership Award and SMPTE Fellow.

UNDERSTANDING RF/MICROWAVE PUSH-PULL AMPLIFIER DESIGN

This article is from Mini Circuit's design notes. As I've said before, we occasionally need material from other subjects to broaden our knowledge. This topic seems good because it gives us a little history about an important scientific invention. So, if you've never heard of a push pull amplifier before, this is good reading. ..WA8RMC

Jun 5, 2023 | Amplifiers, Engineering Resources, RF Transformers

Remarkably, the concept of the push-pull connection spans three centuries. William W. Dean of the Bell Telephone Company of Missouri first described the push-pull-connected telephone transmitter in Patent No. 549,477, dated November 5, 1895.[1] Next, Sir John Ambrose Fleming invented the first vacuum tube in 1904[2] and while Lee De Forest added the grid to Fleming's "valve" in 1906, calling it the "audion," it was Fritz Lowenstein in his April 24, 1912 patent application who first discovered that applying a negative bias to the grid of De Forest's tube turned it into an audio amplifier.

Edwin Henry Colpitts of the Western Electric Company was awarded Patent No. 1,128,292, for an "electric wave amplifier" on February 16, 1915, which covered the push-pull circuit by connecting two vacuum tubes like De Forest's audions like a primitive precursor to the transistor.[3,4] Over a hundred years ago, Colpitts recognized that "a certain amount of distortion in the output waves is avoided"[3] by utilizing this configuration.

Fast-forward over 100 years and transpose kHz with GHz; we find the push-pull amplifier configuration everywhere. This article describes a simple, modern-day, push-pull amplifier configuration along with its performance advantages. Several practical construction methodologies for the main components are reviewed, and an example of a high-power, broadband application is presented. Finally, applications of the push-pull amplifier configuration are discussed.

Basic Push-Pull Amplifier Configuration

More than a century after the invention of the push-pull amplifier, a myriad of different configurations has been developed, some of which require prerequisite knowledge of the operation of complex transformers. The focus of this application note is on the push-pull amplifier itself. An example showing a pair of generic devices combined with simple transformer baluns is shown in Figure 1.

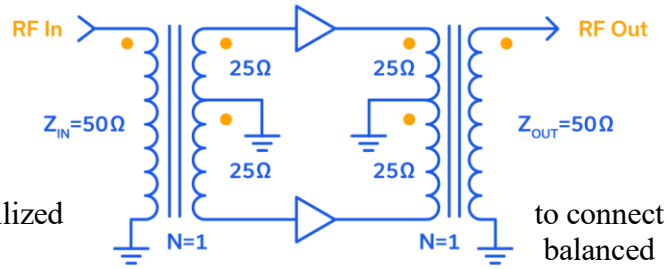


Figure 1: Generic block diagram of a push-pull amplifier using a 1:1 balun transformer.

A balun transformer (short for balanced-to-unbalanced) is utilized to connect an unbalanced (single-ended, ground-referenced) signal to a balanced (differential, ±180º) pair of signals, or vice versa, to combine a differential pair into a single-ended signal. The baluns shown in Figure 1 are also transformers (hence the term "balun transformer") which provide isolation in addition to impedance transformation. In this example, we have chosen to illustrate perhaps the simplest of impedance transformations by setting the turns ratio $n_{OUT}/n_{IN} = N = 1$. Note that by n_{OUT} we mean *all* the turns on the center-tapped winding. Therefore, as shown in Figure 1, the impedance of each half of the center-tapped winding is equal to $Z_{HALF} = (N^2)(Z_{IN})/2 = (N^2)(Z_{OUT})/2 = (1/2)(50\Omega) = 25\Omega$. A turns ratio that differs from unity would also change the primary-to-secondary impedance ratio.

Push-Pull Amplifier Operation

The balun transformer with a center-tapped secondary in Figure 1 is a fundamental element of the push-pull amplifier configuration, and the dot convention is shown to make the figure comprehensive. (Recall that the dot convention specifies that the polarity is the same at all terminals marked with a dot). Since the amplifiers themselves are generic, they can be assumed to be ideal, perfectly-matched in gain and phase, and noninverting. The push-pull amplifier works by taking the unbalanced (single-ended) primary signal, splitting it into a balanced pair of two signals that are 180º out-of-phase, then driving two amplifying devices, one at an effective phase shift of 0º and the other at -180º.

The input balun transformer is then mirrored at the output of the amplifier pair such that the balanced or center-tapped winding may be considered the primary, and the single-ended winding the secondary. The amplifier output signals are applied to the center-tapped primary, and since the devices are perfectly out-of-phase when one amplifier is driving current, the opposing amplifier is sinking current. Stated differently, when one amplifier operates at maximum voltage, the other amplifier will operate at minimum voltage, per the dot convention. This pushing and pulling action across the center-tapped secondary (hence the name, "push-pull amplifier") results in the devices combining to yield the sum of their powers, or twice the power of each amplifier at the single-ended winding of the output balun transformer. Typically, the device with the highest output voltage (appearing to source current) can be viewed as "pushing" and the one with the lowest output voltage (appearing to sink current) as "pulling."

In addition to the inherent power combination that occurs in the push-pull amplifier, one of its primary advantages is the cancellation of even-order harmonics. Just as the fundamental input signal is split into two signals 180º out-of-phase, the second harmonic, or $2f_0$ is split into two signals that are 360º out-of-phase, which is equivalent to in-phase. Imagine the center-tapped primary of the output balun transformer being excited by two signals of identical phase at a frequency of $2f_0$. In an ideal case, there would be no current flow in the winding, no transformer flux, and no second harmonic output. Essentially, any even-order harmonic signal will result in purely common mode excitation of the balun transformer.

Receiver LNAs and broadband power amplifiers that span greater than an octave of bandwidth benefit from this harmonic cancellation. That's why this fundamental and longstanding amplifier configuration is so ubiquitous, having found its way into everything from low-power LNAs to ultra-high-power transmitters.

Balun Transformer Variants in Push-Pull Amplifier Designs

While the example in Figure 1 shows a generic push-pull amplifier configuration, real-world application circuits vary widely. The input and output baluns in particular offer the designer many options depending on the requirements and desired performance parameters for a given system. In the 127 years since Dean first described the push-pull configuration, and the 107 years since Colpitts invented the push-pull amplifier, volumes have been written about how to match pairs of amplifier devices and how to construct the various combining mechanisms. The full breadth of design techniques and topologies goes beyond the scope of this article, but let's discuss a few examples by way of introduction.

One of the most compelling developments in RF component design of the 20th century was the invention of the Guanella balun (see Figure 2).[5] Gustav Guanella, a Swiss Radio Engineer, discovered that a balun transformer could be constructed from coaxial transmission line. Another article on the Mini-Circuits blog discussing RF transformer types explains, "This 1:1 type of balun transformer creates a high choking reactance on the outer conductor of the coaxial cable, effectively reducing common mode signals while allowing the internal currents of the coaxial transmission line to pass unimpeded."[7] Guanella filed for his patent on April 5, 1945, and many physical balun transformers designed today make use of this early work.

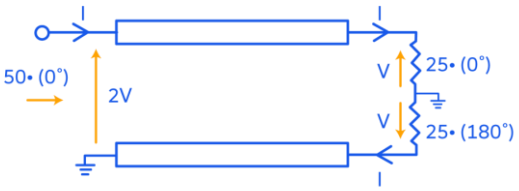


Figure 2: The 1:1 unbalanced-to-balanced transformer that Gustav Guanella first described in 1944.[5,6]

Notice how the Guanella balun shown in Figure 2 closely resembles the generalized balun transformers of Figure 1. This topology is inherently shielded and can achieve over a decade of bandwidth, making it ideal for wideband push-pull amplifier designs that might otherwise be constrained by the frequency range of the baluns used.

Just as push-pull amplifiers in the VHF/UHF frequency range long ago achieved well over a decade of bandwidth, the frequency, bandwidth and power level of push-pull amplifiers will continue to increase with advances in

planar balun technologies, such as the Marchand balun. GaN semiconductor technology has already been combined with Marchand baluns to achieve octave-bandwidth push-pull amplifiers in S-band (0.5 GHz to 2.2 GHz)[9] and X-band (6 to 12 GHz)[10] operating frequencies. A pair of distributed GaAs amplifiers has even been combined using Marchand baluns to achieve a bandwidth of 4-20 GHz.[11]

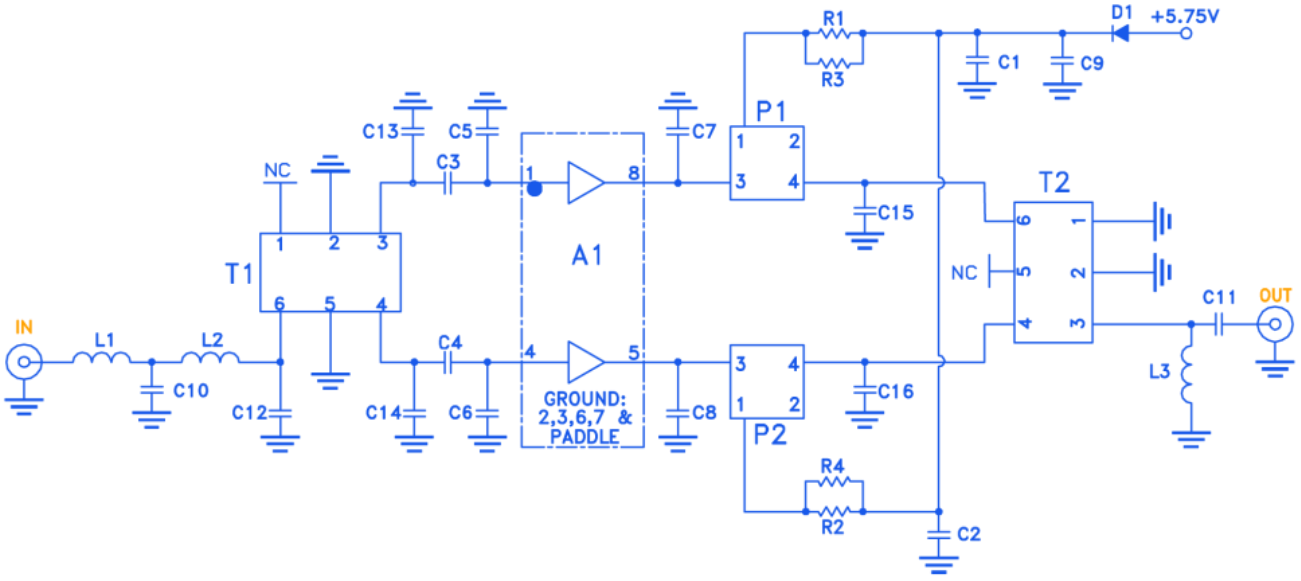
Again, these are only a few examples of how different baluns can be used to achieve desired performance in push-pull amplifier designs. Readers are encouraged to learn more about the various types of baluns here on our blog and to explore the wide selection of baluns in stock on our website.

IP2 & IP3 Performance of Dual-Matched MMIC Amplifiers in Push-Pull Configuration

Practical implementation of push-pull amplifier designs requires a matched amplifier pair with as little variation in gain and phase as possible. While this can be achieved using two discrete gain stage elements, fabricating both amplifier circuits on a single MMIC is perhaps the most effective way of minimizing performance variation while significantly reducing physical board real estate. Mini-Circuits offers a broad selection of dual-matched amplifiers optimized for push-pull operation over a wide bandwidth. As a convenience to designers using these devices in push-pull, many models include test board schematics and data for push-pull operation, replete with IP2 measurements.

PHA-11+ is among Mini-Circuits' most popular dual-matched MMIC amplifier designs and has become a staple component for many designers in the industry. Mini-Circuits has characterized this model in three different push-pull configurations.

Evaluation boards for each of these circuits are available for testing at the customer's end as well. The schematic and eval board for one of these characterization circuits is shown in Figure 3 below.



Let's stop here. MiniCircuits goes into detail further, but I think you get the basic idea. If you want more, I suggest you check the MiniCircuits design notes for push pull amplifiers.
… WA8RMC

USA ATV REPEATER DIRECTORY July 2025

NOTES:

1. All repeaters are NTSC, VUSB-TV, 6 MHz channel, unless otherwise noted. Some repeaters use non-standard lower sideband inputs VLSB to reduce interference with FM repeaters in upper portion of band. The frequency listed is the video carrier frequency.
2. Digital TV lists center frequency. 6 MHz channel, unless otherwise noted.
3. For full details, go to the listed web site, or send an e-mail to the contact person.
4. Some ATV groups also post repeater info on www.qrz.com under their call sign.

Location	Call Sign	Output(s)	Input(s)	Modes	Web Site & Contact for info
ARIZONA					note: AZ is linked to W6ATN in S. CA & NV www.atn-tv.org
Phoenix, White Tank	W7ATN	 1253.25	434.0 434 / 2 2441.5	VUSB FM DVB-T FM	wb9kmo@gmail.com kwjacob@icsaero.com
Mesa	W7ATN	421.25 1289.25	 434.0 434 / 2 2441.5	VUSB VUSB FM DVB-T FM	wb9kmo@gmail.com kwjacob@icsaero.com
Tucson, Mt. Lemmon	W7ATN	1277.25	 434.0 434 / 2 2441.5	FM VUSB DVB-T FM	wb9kmo@gmail.com kwjacob@icsaero.com
CALIFORNIA					W6ATN rptrs linked to AZ & NV
Orange Santiago Peak	W6ATN	 1253.25 5910	434.0 434 / 2 2441.5	VUSB FM DVB-T FM	www.atn-tv.org wa6svt@gmail.com
Los Angeles, central Mt. Wilson	W6ATN	1265.25	 434.0 434 / 2 2441.5	FM VUSB DVB-T FM	www.atn-tv.org wa6svt@gmail.com
Los Angeles, north Oat Mtn.	W6ATN	919.25 3380	 434.0 434 / 2 2441.5	VUSB DVB-T FM FM	www.atn-tv.org wa6svt@gmail.com
Jobs Peak	W6ATN	 1253.25	434.0 434 / 2 2441.5	VUSB FM DVB-T FM	www.atn-tv.org wa6svt@gmail.com
San Bernardino Snow Peak	W6ATN	1242 / 4	 434.0 434 / 2 2441.5	DVB-T VUSB DVB-T FM	www.atn-tv.org wa6svt@gmail.com
Santa Barbara	WB9KMO	1289.25	434.0 434 / 2 2441.5	VUSB, DVB-T FM	www.atn-tv.org wb9kmo@gmail.com linked with W6ATN
San Diego	KD6ILO	423 1243 1268	441 1286 5885	DVB-T DVB-T DVB-S FM	kd6ilo@yahoo.com also AREDN mesh
San Jose	W6SVA	427.25	 910 1255	VUSB FM FM	www.k6ben.com :w2nyc@pacbell.net
Clayton	W6CX	1244.5	1292.5 1273 915	DVB-S, FM	www.mdarc.org info@mdarc.org
Palomar	W6NWG	 1241.25	915	FM VUSB	w6nwg@palomararc.org mountain.michelle@gmail.com
COLORADO					
Boulder	W0BTV	423 / 6 421.25 5905	1243 / 6 441 / 6 439.25	DVB-T, DVB-T VUSB VUSB FM	www.kh6htv.com kh6htv@arrl.net
Pueblo	W0PHC	423 / 6t	441 / 6	DVB-T	billn@billnicoll.com www.puebloradio.org
DELAWARE					
Wilmigton	KC3AM	423 / 6	 439.25	DVB-T VLSB	KC3AM@verizon.net

Location	Call Sign	Output	Input	Mode	Web Site & Contact info
FLORIDA					
Cape Coral	W1RP	421.25	439.25	VUSB	paul@cardlink.com
Cocoa Beach	K4ATV	427.2	439.25	VUSB	www.lisats.org
Panama City	KV4ATV	434.0	919.25	?	kv4atv@gmail.com
S.W. Idaho	WI7ATV	1257 426.25		FM VUSB	ka7anm@yahoo.com
IOWA					
Davenport	W0BXR	421.25	439.25	VUSB	http://www.arcsupport.com/drac/

KANSAS					
Wichita	KA0TV	421.25	439.25	VUSB	k0wws@arrl.net
KENTUCKY					
Bowling Green	KY4TV	421.25 423.0 /2	439.25 1280	VUSB FM DVB-T	w4htb@ieee.org www.qrz.com www.atn-tv.org
LOUISIANA					
New Orleans	WD0GIV	421.25	439.25	VUSB	wd0giv@att.net
MARYLAND					
Laurel	W3BAB	421.25	434.0	VUSB	www.qsl.net/w3bab
Towson	W3BAB	1291 434		FM VUSB	www.qsl.net/w3bab
Baltimore	W3WCQ	439.25 911.25	426.25 1253.25	VUSB	http://bratsatv.org/ brats@bratsatv.org
MICHIGAN					
Jackson	KC8LMI	923.25	439.25	VLSB	KC8LMI@hotmail.com
Grand Rapids	K8DMR	421.25	439.25	VUSB	ron_fredricks@att.net
Flushing	KC8KCG	1253.25	439.25	VLSB	kf8ui@mscginc.org
Flint	KC8KGZ	1253.25	439.25	VUSB	www.mscginc.org kf8ui@mscginc.org
MINNESOTA					
Wabasha	KD0HWX	421.25	439.25	VUSB	jonmcpete@yahoo.com
MISSOURI					
St. Louis	W0ATN	426 / 4	440 / 4	DVB-T	k0pfx@arrl.net
NEBRASKA					
Omaha	WB0CMC	421.25	434.0	VUSB	wb0cmc@cox.net
NEVADA					
Las Vegas	N7ZEV	1253.25 912	434.0 434.0 / 2 2441	VUSB FM DVB-T FM	frank.n7zev@gmail.com linked to W6ATN S. CA & AZ
NEW JERSEY					
Vernon	W2VER	5885	5665	FM	jaythienel@yahoo.com
OHIO					
Columbus	WR8ATV	423 / 2 427.25 1258 1268 2397 10350	439 / 2 439.25 1288 1288 10450	DVB-T VLSB AM DVB-S MESH FM	www.ATCO.tv gkenmorris@gmail.com art.towslee@gmail.com
Dayton	W8BI	421.25 428 / 2 1258	439.25 439 / 2 1280 1280	VUSB DVB-T FM DVB-S	www.w8bi.org dpel@aaahawk.com
Van Wert	W8FY	434.0	923.25	VUSB	ka8zge@w8fy.org
OREGON					
Portland	W7AMQ	1257 426.25		FM VUSB	belles73@comcast.net
Portland	WB2QHS	 426.0	910 fm	FM VUSB	emellnik@emavideo.com
PENNSYLVANIA					
Delaware County	KC3AM	421.25	439.25	VLSB	KC3AM@verizon.net
PUERTO RICO					
Aguas Buenas	KP4IA	426.25	439.25 1252	VUSB FM	kp4ia@yahoo.com
WASHINGTON					
Seattle	WW7ATS	1253.25	434.0	VUSB	https://www.qsl.net/ww7ats/ ww7ats@gmail.com qrz.com

LOCAL HAMFEST SCHEDULE

This section is reserved for upcoming Hamfests. They are limited to Ohio and vicinity easily accessible in one day. Anyone aware of an event incorrectly or not listed here; notify me so it can be corrected. This list will be amended, as further information becomes available. To see additional details for each Hamfest, Control Click on the blue title and the magic of the Internet will give you the details complete with a map! To search the ARRL Hamfest database for more details, CTL click ARRLWeb: Hamfest and Convention Calendar …WA8RMC.

03/08/2026
Northern Ohio Amateur Radio Society Winter Hamfest
Location: Elyria, OH
Type: ARRL Hamfest
Sponsor: Northern Ohio Amateur Radio Society
Website: https://www.noars.net/hamfests/winter-hamfest/

03/15/2026
Toledo Mobile Radio Association Hamfest and Computer Fair
Location: Perrysburg, OH
Type: ARRL Hamfest
Sponsor: Toledo Mobile Radio Association
Website: http://www.w8hhf.org

04/11/2026
Cuyahoga Falls Amateur Radio Club 70th Hamfest
Location: Cuyahoga Falls, OH
Type: ARRL Hamfest
Sponsor: Cuyahoga Falls Amateur Radio Club, Inc.
Website: https://www.cfarc-hamfest.org

04/25/2026
Tusco Amateur Radio Club's 2026 Hamfest, Computer & Electro
Location: Dover, OH
Type: ARRL Hamfest
Sponsor: Tusco Amateur Radio Club W8ZX
Website: http://www.w8zx.net/hamfest

05/14/2026 - 05/17/2026
Four Days In May
Location: Fairborn, OH
Type: ARRL Convention
Sponsor: QRP Amateur Radio Club International
Website: http://qrparci.org/fdim

06/06/2026
FCARC SummerFest
Location: Delta, OH
Type: ARRL Hamfest
Sponsor: Fulton County Amateur Radio Club
Website: https://k8bxq.org/hamfest

07/19/2026
Van Wert Hamfest
Location: Van Wert, OH
Type: ARRL Hamfest
Sponsor: Van Wert Amateur Radio Club

ATCO TREASURER REPORT - de N8NT

OPENING BALANCE (10/20/25)……$4402.04
ATCO web hosting fee for 2026…… …($ 62.99)
CLOSING BALANCE (01/24/26)……..$ 4339.05

ATCO CLUB OFFICERS

President: Art Towslee WA8RMC
V. President: Ken Morris W8RUT
Treasurer: Bob Tournoux N8NT
Newsletter editor: Art Towslee WA8RMC
Secretary: Mark Cring N8COO
Corporate trustees: Same as officers

Repeater trustees: Art Towslee WA8RMC
Ken Morris W8RUT

ATCO publishes this Newsletter quarterly in January, April, July and October. It is sent to each member without additional cost. All Newsletters are sent via Email.
Your support of ATCO is welcomed and encouraged.

ATCO REPEATER TECHNICAL DATA SUMMARY

Location:	Downtown Columbus, Ohio
Coordinates:	39 degrees 57 minutes 47 seconds (latitude) 82 degrees 59 minutes 58 seconds (longitude)
Elevation:	630 feet above average street level of 760 feet ASL (1390 feet above sea level)
TV Transmitters:	423.00 MHz DVB-T, 10W FEC=7/8, Guard=1/32, Const=QPSK, FFT=2K, BW=2 MHz, PMT=4095, PCR=256, Vid=256, Aud=257
	427.25 MHz Analog VSB AM, 50 watts average 100 watts sync tip (cable channel 58)
	1258 MHz 40 watts FM analog
	1268 MHz DVB-S QPSK 20W SR=3.125MS, FEC=3/4, PMT=32, Video=162, Teletext=304, PCR=133, Audio=88, Service =5004)
	Two video channels on this output: Channel 1 is fed from all receivers. Channel 2 is fed from 439.25 analog receiver.
	2397 MHz Mesh Net transceiver 600 mw output (channel 1 minus 2). ID is WR8ATV-2
	10.350 GHz: 1W continuous analog FM
Link transmitter:	446.350 MHz: 5W NBFM 5 kHz audio. This output used for control signals & to repeat 147.48 MHz and 449.975 MHz input.
Identification:	423, 427, 1258, 1268 MHz, 10.350 GHz transmitters video ID every 10 min. with active video.
	423 MHz DVB-T, 1268 MHz DVB-S & 10.350 GHz FM - Continuous Tx of ATCO & WR8ATV with no input signal present.
Transmit antennas:	423.00 HHz - Single slot rib cage horizontally polarized 5 dBd gain "omni"
	427.25 MHz - Dual slot horizontally polarized 7 dBd gain "omni" major lobe east/west, 5 dBd gain north/south
	1258 MHz - Diamond vertically polarized 12 dBd gain omni
	1268 MHz - Diamond vertically polarized 12 dBd gain omni
	2397 MHz - Ubiquiti dual polarity omni 13dBi gain slot for channel 1 minus 2 MESH Rx/Tx operation
	2397 MHz - Comet Model GP24 vertically polarized 12 dBd gain omni (Used for experimental Mesh operation)
	10.350 GHz - Commercial 40 slot waveguide horizontally polarized 16 dBd gain omni
Receivers:	147.480 MHz - F1 audio input with touch tone control. (Input here = output on 446.350)
	439.000 MHz - DVB-T QPSK, 2MHz BW. Receiver will auto configure for FEC's. (Input here = output on all TV transmitters)
	439.250 MHz - A5 NTSC video with FM subcarrier audio, Upper sideband. (Input here = output on all TV transmitters & also direct output to 1268 MHz DVB-S- output channel 2.)
	449.975 MHz - F1 audio input aux touch tone control. 131.8 Hz PL tone. (Input here = output on 446.350).
	1288.00 MHz - F5 video analog NTSC. (Input here = output on all TV transmitters)
	1288.00 MHz - DVB-S QPSK SR=4.167MS, fec=7/8. PIDs: PMT=133, PCR=33, Vid=33, Aud=49 (In here=out on all Transmit.)
	10.450 GHz - F5 video analog NTSC. (Input here = output on all TV transmitters)
Receive antennas:	147.480 MHz - Vert. polar. Diamond 6 dBd dual band (Shared with 446.350 MHz link output transmitter)
	439.00/439.250 MHz - Horizontally polarized dual slot 7 dBd gain major lobe west (Shared with 439 digital & 439.25 analog receivers)
	1288.00 MHz - Diamond vertically polarized 12 dBd gain omni (shared with analog and DVB-S receivers)
	2398.00 MHz - Comet Model GP24 vertically polarized 12 dBd gain omni (inactive at this time because MESH is on 2397)
	10.450 GHz - Commercial 40 slot waveguide horizontally polarized 16 dBd gain omni

Auto mode Input control:	Touch Tone	Result (if third digit is * function turns ON, if it is # function turns OFF)
	00*	turn transmitters **on** (enter manual mode-keeps transmitters on till 00# sequence is pressed)
	00#	turn transmitters **off** (exit manual mode and return to auto scan mode)
	264	Select Channel 4 Doppler radar. (Stays on for 5 minutes) Select # to shut down before timeout.
	004	Select 10.450 GHz receiver. **(Always exit by selecting 001)**
	001	Select 2398 MHz receiver then 00# for auto scan to continue

Manual mode Functions:		
	00* then 1 for Ch. 1	Select 439.25 analog /439 digital (if video on digital, it is selected. Otherwise, analog)
	00* then 2 for Ch. 2	Select 1288 digital receiver
	00* then 3 for Ch. 3	Select 1288 analog receiver
	00* then 4 for Ch. 4	Select 2398 receiver
	00* then 5 for Ch. 5	Select video ID (17 identification screens)
	01* or 01#	Channel 1 439.25 MHz analog /439 digital rec. scan enable (01* to enable & 01# to disable)
	02* or 02#	Channel 2 1288 MHz digital receiver scan enable
	03* or 03#	Channel 3 1288 MHz analog receiver scan enable
	04* or 04#	Channel 4 2398 MHz scan enable
	A1* or A1#	Manual mode select for 439.25 receiver audio
	A2* or A2#	Manual mode select for 1288 digital receiver audio
	A3* or A3#	Manual mode select for 1288 analog receiver audio
	A4* or A4#	Manual mode select for 2398 receiver audio
	C0* or C0#	Beacon mode – transmit ID for twenty seconds every ten minutes
	C1* or C1#	No function at this time
	C2* or C2#	No function at this time

ATCO Newsletter
c/o Art Towslee -WA8RMC
438 Maplebrooke Dr. West
Westerville, Ohio 43082