Reflection and Practice on the Development of New Media Live Broadcast Vehicles Under the Wave of Media Convergence (Postprint)

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Abstract

The new media broadcast vehicle project of Hebei Radio and Television Station represents an important practice in media convergence. The broadcast vehicle is a comprehensive new media mobile platform whose construction encompasses multiple technical categories including video, audio, network transmission, and electrical control, and must be capable of adapting to characteristics such as all-terrain conditions across Hebei Province, large temperature variations between winter and summer, and significant urban-rural network disparities. This paper introduces the entire process from preliminary project investigation to later-stage design and construction, and provides a detailed analysis of the various functions and features of the broadcast vehicle.

Full Text

Preamble

Title: Reflections and Practice on New Media Live Streaming Vehicle Construction in the Era of Media Convergence

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Abstract: The new media live streaming vehicle project at Hebei Radio and Television Station represents a significant practice in media convergence. As a comprehensive new media mobile platform, the vehicle' s construction encompasses multiple technical domains including video, audio, network transmission, and electrical control. It must be capable of adapting to Hebei Province' s diverse terrain, extreme seasonal temperature variations, and significant urban-rural network disparities. This paper introduces the entire process from prelim-

inary research to final design and construction, providing a detailed analysis of the vehicle' s various functions and characteristics.

Keywords: 5G; 4K; new media; live streaming vehicle; media convergence

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On January 25, 2019, during the 12th collective study session of the Political Bureau of the CPC Central Committee at the People' s Daily, General Secretary Xi Jinping emphasized that media convergence development should adhere to an integrated direction. Through process optimization and platform reconstruction, effective integration of various media resources and production factors should be achieved to realize the interconnectivity of information content, technology applications, platform terminals, and management methods, thereby catalyzing qualitative convergence transformation and amplifying integrated efficiency to create a batch of new mainstream media with strong influence and competitiveness. As a traditional mainstream media organization in the province, Hebei Radio and Television Station has kept pace with the times, comprehensively implementing General Secretary Xi' s requirements for media convergence by integrating various new media technologies for information collection, production, distribution, and feedback to reshape the image of mainstream media and enhance its guiding power and credibility. In May 2019, the New Media Center of Hebei Radio and Television Station completed the construction of its first 8-channel 4K+5G new media live streaming vehicle through independent design and equipment selection. This vehicle can simultaneously provide integrated media professional services for television, radio, and online program production.

A new media live streaming vehicle is essentially a mobile new media broadcasting platform that encompasses multiple technical categories including video, audio, network transmission, and electrical control. It serves as a bridge facilitating the transition of radio and television media into the new media domain. Unlike traditional television OB vans and radio broadcasting vehicles, new media live streaming vehicles primarily target internet audiences for content production while also accommodating television and radio content production. Therefore, functional design must be tailored accordingly.

1.1 User Analysis

The primary users of new media live streaming vehicles fall into three major categories: television channels + online video streaming, radio frequencies + online video streaming, and pure online streaming.

Television Channel + Online Streaming: Traditional television broadcasting activities follow rigorous live streaming procedures with strict time control, offering the strongest timeliness and professional visual quality. However, broadcasts are typically relatively short in duration and rarely emphasize interaction beyond the screen, largely due to the linear broadcasting nature of television channels and limited resources. Under such circumstances, online streaming often serves merely as a replicated version of television channel content distributed online, with the only addition being real-time interaction with netizens.

Radio Frequency + Online Streaming: Under the demand for radio visualization, an increasing number of radio programs are eager to participate in "mega live broadcasts" of various events. While radio frequencies possess extensive experience in audio content organization, the communication capacity of single sound media is limited, requiring longer broadcasting durations to describe the content being expressed. The integration of online video streaming with radio frequency broadcasting requires new media live streaming vehicles to adapt to the characteristics of radio frequency broadcasting while leveraging new media tools to supplement multimedia information such as images, text, video, and interactive content beyond radio transmission. This approach fully exploits the advantages of combining radio media with new media, emphasizes program content interactivity, expands radio audience reach, and enhances broadcasting media' s communication power by reconstructing media content, adding interactive segments, and enriching the layers and breadth of media presentation, thereby giving radio frequencies new wings.

Pure Online Streaming: Pure online streaming content includes video streaming and graphic-text streaming. As a provincial media organization serving the entire province, Hebei Radio and Television Station' s New Media Center engages with a wide range of streaming clients, including party and government organs, schools, factories, and social culture companies. These social organizations have diverse streaming demands. For example: (1) Serving a cultural communication company' s "boxing" event, which required simultaneous streaming on our station' s official app while pushing data streams to 40 national sports online streaming media outlets. (2) Serving a "mobile game" competition that needed simultaneous streaming on IPTV and mobile devices, with multi-angle, multi-screen simultaneous broadcasting on IPTV. (3) Serving a "liquor" manufacturer' s annual meeting, which required multi-city interactive video streaming with encrypted channels. Numerous similar examples exist. These social organization activities are often time-sensitive, with short preparation-to-implementation cycles that severely test the team' s technical design experience and execution capabilities. Consequently, we

must design comprehensive streaming solutions based on the new media live streaming vehicle' s capabilities that accommodate pre-event graphic-text streaming warm-up, in-event video streaming, and post-event graphic-text and short video reviews to meet different client requirements.

1.2 Usage Environment Analysis

Hebei Province covers a vast territory with diverse terrain including mountains, deserts, coastlines, and plains. Summer temperatures can exceed 40°C, while winter temperatures can drop to -30°C. As equipment operating outdoors for extended periods, new media live streaming vehicles must be prepared for all terrains and extreme temperature differentials, with particularly stringent requirements for the vehicle' s electrical systems.

New media live streaming vehicles frequently travel on various road conditions, including national highways, bumpy rural roads, and congested urban streets. Therefore, vehicle body selection must be extremely cautious, requiring both high-speed capability and excellent passability to reach streaming locations throughout the province.

Power supply environments vary across the province. Based on past experience, voltage at rural-level power access points is often unstable, factory power access points tend to have excessively high voltage, while urban power access points are very stable and standard. As a special vehicle that must guarantee live streaming, new media live streaming vehicles require scientific power planning from the design stage to ensure both safe and reliable vehicle power supply and convenient power access.

Stable internet connectivity for signal transmission and independent networking represents the most important characteristic of new media live streaming vehicles. Internet signal transmission offers enormous price advantages over previous satellite or microwave communication. As a new media live streaming team serving the entire province long-term, we have also discovered that network access environments vary significantly between cities and rural areas under different economic conditions. Major cities have excellent 5G wireless network coverage from all operators, allowing direct 5G+4K wireless information transmission and video streaming without issues. However, in county and township environments, streaming may only be possible through single-operator 4G wireless or wired networks, posing significant challenges for new media live streaming. Equipment planning must be adaptable to various network environments, ensuring smooth streaming even through aggregation or multiplexing.

[Figure 1: see original paper] Actual photograph of vehicle exterior

2.1 Vehicle Body Selection

The selection of the carrier vehicle body for new media live streaming vehicles is the foundation of all design, directly constraining the planning of in-vehicle

facilities and the expansion of peripheral functional capabilities. Traditional television OB vans generally adopt Type B design patterns, using single heavy-duty trucks or heavy-duty truck heads with trailers as carriers. Type B OB vans are suitable for multi-functional area allocation and can carry larger quantities of equipment, creating conditions for more channel and functional design. However, such carrier bodies are inherently heavy, generally exceeding 8 tons, with vehicle lengths over 12 meters, making them unsuitable for rural roads, narrow and congested urban roads, or placement on urban squares (due to significant ground damage). Considering these factors, we selected Type C OB van design pattern, using a domestically produced 17-seat medium bus as the modified vehicle body. This vehicle measures 7.2 meters in length and 2 meters in width, with a 5-ton load capacity, powered by a 3.0T diesel engine with dual rear tires.

First, the 7.2-meter body provides sufficient space for multi-functional area modification. Additionally, the original vehicle' s passenger door was designed at the co-pilot position, saving some passenger space and providing possibilities for functional area expansion. The entire vehicle is divided into driving area, graphic-text dispatch area, video streaming area, and equipment transport area, with different functional blocks not rigidly separated to ensure optimal space utilization. Another important consideration is that the original vehicle was a passenger vehicle, and after modification, it can still comply with national standards to carry 7 people. This allows a small team of 4 cameramen, 1 director, 1 technician, and 1 driver to meet the operational needs of small-scale streaming without requiring additional equipment or personnel transport vehicles, increasing economic efficiency.

The non-load-bearing chassis design ensures sufficient load-bearing capacity, while dual rear tires guarantee stability even on poor roads, ensuring reliable equipment transport. Additionally, when parked, the vehicle body remains stable without significant shaking even without deploying support legs, increasing rapid response capability. The 7.2-meter length and 2-meter width also ensure maneuverability through narrow streets. The roof has been reinforced to support dual parking air conditioners, telecom-grade networking antennas, and camera platforms. A fixed climbing ladder has been added to the rear door for convenient engineer maintenance and equipment deployment.

2.2 In-Vehicle Infrastructure Design

In-vehicle infrastructure design for new media live streaming vehicles consists of two components: fixed power control systems and interior modification design. All equipment involved in both components adopts compact design solutions.

Fixed Power Control System: The power control system is the foundation for operation of other functional modules and must be permanently fixed in the vehicle' s equipment rack. Traditional television OB vans' 380V high-power consumption design does not meet our requirements, as 380V high-current access points are often unavailable when filming in small urban theaters or rural

conditions, rendering the streaming vehicle unusable. To address this, we separated the high-power-consuming 10kW dual parking air conditioners from the low-power-consuming 2kW streaming equipment group through different power supply links. The parking air conditioners are directly powered by municipal electricity without passing through UPS, while primary and backup 220V low-current supplies are connected to UPS to guarantee power for streaming equipment. This ensures that even when power is insufficient, partial air conditioning power can be disconnected to prioritize streaming equipment.

To prevent equipment damage from excessive or unstable voltage, after the vehicle parks and connects to municipal power, electricity first passes through an isolation transformer to the vehicle-mounted UPS (3KVA), then undergoes voltage stabilization and rectification before entering the distribution panel for allocation to streaming equipment. Without municipal power supply, the vehicle-mounted UPS can power all streaming equipment for 10 minutes. For installation convenience, a rack-mount UPS with separated head and battery pack was adopted. Additionally, a mobile emergency power supply system (inverter power) was designed, consisting of an inverter, DC power supply, and 12V/30A charger. The inverted power outputs 220V/50Hz pure sine wave with less than 3% distortion. The emergency power system can supply power to in-vehicle network access equipment and some computer equipment during vehicle operation, facilitating editing and reporting while mobile.

Interior Modification Design: Interior modification follows GB/T 12503-1995 General Technical Conditions for Television Vehicles. Notably, all fabrics, carpeting, paint, and wiring materials must be environmentally friendly products, and the post-modification interior environment complies with the national indoor environment standard GB50325-2010.

2.3 Real-Time Detachable Functional Module Group Design

The real-time detachable functional module group consists of live core module, video auxiliary module, audio auxiliary module, and network distribution module. This modular design approach allows flexible combination and separation of related modules centered around the core module to meet different streaming requirements under various conditions.

Live Core Module: Live core module equipment comprises video monitors, video switcher (with independent audio input), video matrix, TALLY intercom system (with optical transmission), hard disk recorder, and audio bridge equipment. Cameras connect via EFP (Electronic Field Production) mode. The live core module equipment is installed in a portable 8U rack that is normally fixed in the new media live streaming vehicle for director operation. When transportation is needed, two people can carry it out for independent directing work at other locations.

While traditional television OB vans using ESP (Electronic Studio Production) mode channel cameras do offer excellent signal quality and strong color tem-

perature consistency, with cameramen only needing to focus on composition and focusing while specialized technicians handle other controls, ESP mode cameras must transmit signals and receive power through hybrid optical cables and lack recording functions, severely limiting flexibility. For example, streaming programs from high-rise buildings makes it difficult to run bulky cables upstairs, and ESP mode camera cable lengths are also limited. Additionally, multi-channel external recording requires an independent recorder for each camera, which is difficult to implement. EFP camcorders avoid these shortcomings by connecting to the live core module equipment through ordinary optical fiber and using their own batteries for power. EFP camcorders of the same brand, model, and batch can also achieve basically consistent color temperature under the same white balance environment, with each unit capable of independent recording. Naturally, every advantage has its disadvantage: EFP mode adds aperture adjustment to the cameraman' s responsibilities of managing composition and focusing, which indeed challenges equipment operation proficiency.

Live core module equipment can be separated at any time and effectively combined with other modules for rapid deployment of new streaming units, satisfying quick deployment needs in different streaming environments.

Video Auxiliary Module: The video auxiliary module includes backup hard disk recorders for streaming, backup optical transmission equipment, independent embedding cards, de-embedding cards, 4-split cards, technical monitoring devices, waveform monitors, clocks, HDMI-to-SDI cards, and SDI-to-HDMI cards. These devices can satisfy precise time correction, external signal input (such as drone signals, laptop signals, and mobile phone screen mirroring signals), and enable external content output for various event scenarios (such as PGM signals to large screens and director return signals).

Audio Auxiliary Module: The audio auxiliary module centers on a compact rack-mount digital mixing console. This mixer supports 16 analog XLR/TRS hybrid microphone/line inputs, 1 analog RCA stereo line input, and 16 analog XLR outputs, featuring 40 input mixing channels, 20 Aux buses, and 1 stereo bus. The rack-mount digital mixer maximizes rack space savings and is easier to maintain compared to fader-type mixers. Through IP-based design, the mixer can be wirelessly controlled via iPad and laptops on the internal network, greatly increasing convenience. The digital mixer' s primary task is to supplement the switcher' s built-in audio input limitations. During field operations, live sound and accompaniment are often handled by the organizer' s front-end mixer, with the vehicle' s digital mixer mainly adjusting output volume, sound phase, and front-end gain, rarely participating in audio production. The digital mixer can provide extended audio sources for multiple embedding cards in the video auxiliary module during multi-camera simultaneous broadcasting and can also provide input for external audio sources such as CD players.

Network Distribution Module: The network distribution module functions to transmit produced audio-visual and graphic-text content via the internet to the station' s broadcasting and production units. This module includes inter-

net access equipment and information transmission devices. Internet access equipment comprises remote bridge access systems, remote fiber access systems, short-range 5G/4G access systems, and in-vehicle data exchange and Wi-Fi control systems. The remote bridge system can provide linear network access within 30 kilometers, ensuring the streaming vehicle can operate in 5G/4G blind spots. The remote fiber access system can independently erect fiber systems for direct program content and data transmission. Short-range 5G/4G access systems allow the streaming vehicle to directly use multi-operator network systems for program content transmission. The in-vehicle data exchange and Wi-Fi control system enables all in-vehicle equipment to coordinate within a unified local area network to complete tasks such as signal switching, subtitle loading, sound adjustment, and video color correction.

Information transmission equipment includes transmission workstations, vehicle-mounted 5G streaming devices, and 4K real-time encoders, which will be discussed in detail later.

[Figure 2: see original paper] Live core module wiring diagram

2.4 4K+5G Live Streaming System Design

4K Video System: (1) UHD cameras equipped with 4K image sensors and fiber extension modules can transmit 12G video 4K content through bidirectional single-mode ordinary fiber systems, with single-mode fiber transmission distances reaching over 20 kilometers. (2) 4K signal comprehensive scheduling equipment can achieve TALLY signal loading and 4K signal input/output, ensuring 2160P60 program signal input to the switcher or 4K video matrix, and enabling 4K return signal viewing from connected 4K cameras. The 4K signal comprehensive scheduling equipment can use channels 15 and 16 of embedded audio to implement SDI two-way intercom functions for multiple cameras. (3) The 4K video matrix features 12G-SDI transmission interfaces, fully supporting all SD, HD, and Ultra HD video formats. It is equipped with 40 inputs and 40 outputs, including video synchronization functions and dual power supply interfaces. It can connect all 4K video equipment through a single 12G-SDI cable to handle signal assignment and switching from switchers, cameras, recorders, and monitors. (4) The 4K compact switcher is compatible with various new formats and high frame rates, supporting Ultra HD up to 2160p60. It features 16 built-in Keyers (4 per M/E level), includes two Ultra HD multi-view splitters, comprehensive 2D DVE, a built-in compositing engine with 4 picture-in-picture DVEs, and comprehensive resynchronization on each 12G-SDI input. The switcher has independent audio XLR input interfaces and can use multiple laptops on the LAN for separate switching control, audio control, subtitle loading, and video color correction. (5) The 4K hard disk recorder is equipped with 12G-SDI and HDMI 2.0 interfaces, compatible with SD, HD, and UHD format recording, and features VTR-style recorder controls, broadcast-grade compression, and uncompressed 10-bit 4:2:2 recording. (6) The 4K-compatible format converter can perform real-time conversion between analog composite

YC signals, SD, HD, and UHD digital format signals to obtain high-quality images comparable to the original, achieving data transmission at 12Gb per second. The converted signals can satisfy different user requirements. (7) 4K-compatible video embedders, video de-embedders, technical monitors, and other peripheral equipment. (8) The 4K real-time encoder can encode a single 12G-SDI 4K signal into IP data streams transmittable over networks in real time, supporting TS over UDP/RTP/HTTP/RTSP; FLV over HTTP/RTMP; HTTP live protocols, and can simultaneously capture 5 HD-SDI signals to encode into real-time transmission data streams of multiple bitrates.

5G System: (1) 5G wireless data terminals (CPE). The new media live streaming vehicle is equipped with two 5G wireless data terminals. These terminals feature domestically produced 7nm process Balong 5000 5G multi-mode chips, with 5G peak download speeds reaching 2.3Gbps, dual-band Wi-Fi chips, and four signal amplifiers to expand Wi-Fi coverage. Inserting a 5G SIM card provides 5G gigabit broadband, supporting multiple operators including China Mobile, China Unicom, and China Telecom, with backward 4G compatibility and wired network support via two full gigabit ports. The 5G wireless data terminal' s built-in full-band multi-polarized butterfly antenna ensures 360-degree signal capture. (2) Vehicle-mounted 5G streaming device. The vehicle-mounted streaming device supports 4K video transmission, can simultaneously bundle multiple network links for optimized video stream transmission, and achieves optimal transmission performance and image quality. The device is compatible with H.264 and H.265 (HEVC) compression standards, supports 5G integration, can achieve sub-second latency transmission, and supports network time synchronization.

2.5 Emergency Plan Design

The emergency plan for new media live streaming vehicles shares similarities with traditional television OB vans and radio broadcasting vehicles while possessing its own characteristics.

Power Supply: Power employs primary and backup 220V municipal electricity access with a transfer switch on the distribution panel. When the primary municipal power circuit fails, the streaming vehicle automatically activates online UPS power supply and releases an audible alert. Within the 10-minute guaranteed duration, manual switching of the power transfer switch to the backup circuit ensures equipment power supply.

Video System: The core of the video system is the switcher and matrix. Traditional television OB vans typically implement live hot backup through dual-link backup of identical equipment. While this configuration significantly reduces the probability of broadcast interruption due to equipment failure during live streaming, dual-backup equipment inevitably leads to substantial capital waste and requires additional space. We address this through mutual backup between different signal devices. Taking the existing 8-channel input signal design as an

example, 6 channels enter the switcher through the matrix for switching output, 1 channel directly enters the switcher for switching, and 1 channel directly connects to the monitor' s maintenance channel. If the matrix fails, 1 channel can still be switched through the switcher for padding. If the switcher fails, the matrix can directly output any of the 6 channels to signal transmission equipment for padding. Single-channel streaming failures can be quickly diagnosed through the monitor' s maintenance channel without stopping transmission.

Live Equipment: The 4K real-time encoder and vehicle-mounted 5G streaming device serve as mutual backup for streaming transmission. The two streaming devices are connected to the switcher output and matrix output respectively, and their transmission channel content can remain consistent when no faults occur.

Network: The new media live streaming vehicle adopts different operators' 5G, 4G, bridge, and fiber access methods to the internet. We can select any two according to different network conditions, fully ensuring network security in different environments.

The new media live streaming vehicle project represents an important attempt by Hebei Radio and Television Station in media convergence. Integrating 5G and 4K technologies will greatly promote innovative program formats, enrich communication methods, and optimize user experience. To achieve faster mobile response and all-weather, region-independent service throughout the province to complete streaming tasks, sound technical solutions play a crucial role. We will accumulate more experience, utilize various new technical means, and push Hebei' s media convergence to deeper levels to create new mainstream media with strong influence and competitiveness.

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Note: Figure translations are in progress. See original paper for figures.