SPORTS BROADCASTING'S FIRST 5G WIRELESS CAMERA AND ON-BOARD SYSTEM: AN IN-DEPTH REVIEW

The sights and sounds of motorsports create a live TV event that engages audiences like no other. From fast-paced action and informed analysis of team tactics, for many racing fans, live video programming tells a multilayered story of the battle for racing supremacy.

What really gets fans immersed in the racing action is the deployment of wireless camera technology to ride on-board with the race leaders and watch the battles for position to play out from the driver's point of view.

With social media playing an increasing role in fan engagement and in extending viewer participation beyond the duration of the race, latest research shows that just a 30 increase in video content in social media posting increases engagement by over 100%.

Vislink have been leading deployment of on-board and wireless systems to great effect for many of years. Vislink systems have continued to be enhanced and now have capability to deliver multi-camera transmission, 4k, high dynamic range and 360 degree images. The RF infrastructure that supports the wireless transmission has proven to deliver robust data transmission and has scaled to allow more cameras on more racing vehicles.

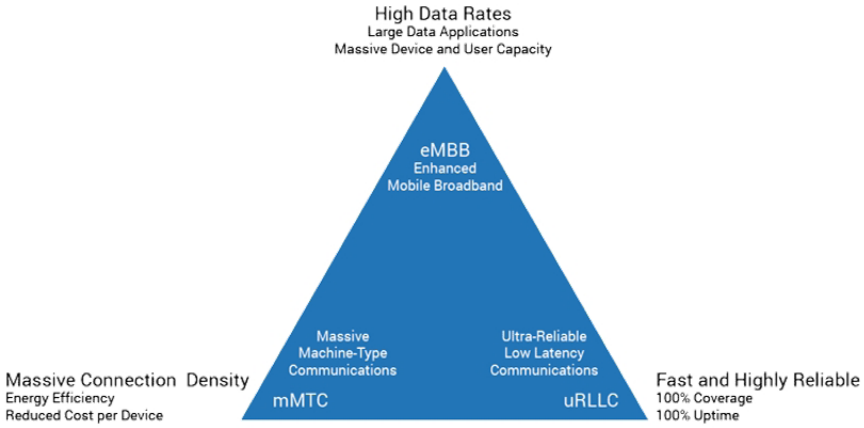
But new RF technology is on the horizon. The vision for 5G networks has received much discussion for many applications within video broadcasting. Vislink wanted to create a trial to see if the 5G promise could deliver and learn what practical and technical issues may need to be resolved.

Public infrastructure for 5G is rolling out across the globe at pace, with consumer devices widely available and 5G network deployments operational in many cities worldwide. 5G development continues with the 3GPP standards body continuing to evolve 5G capabilities.

The 5G networks that are being rolled out to the public today are tailored to the needs of consumers and their usage of mobile phone handsets. The limits of the 5G infrastructure are governed by technology provider's roadmaps – which are primarily driven by a consumer commercial focus.

Leading 5G technology providers have widely discussed how 5G systems can be balanced in different ways to balance an optimization towards high data rates, low latency or to allow large numbers of connected devices.

In the build up to Vislink's trials, Vislink undertook investigations into how consumer 5G networks are currently architected and balanced to understand the suitability of public networks to deliver the high quality, guaranteed quality, low latency video that is needed for major event video productions.

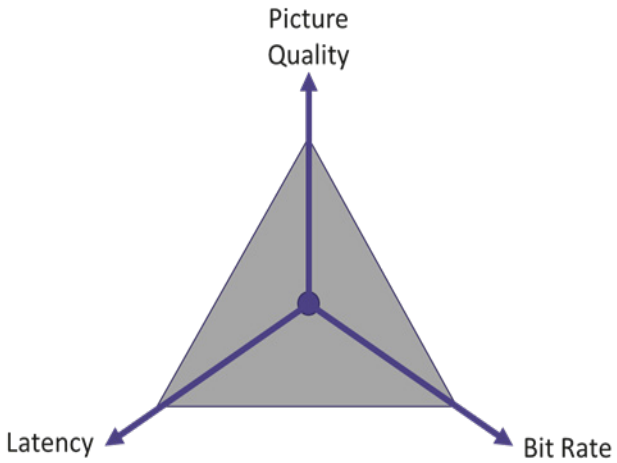


5G Usage Scenarios Design Triangle

Critical Issues in High Quality Wireless Video

Vislink on-board and wireless camera systems are frequently selected by customers on the basis of the video quality that they provide, the transmission robustness and the end-to-end system latency.

Latency can be key to production of video program. To tell the story of the race, the director makes creative decisions to switch between wireless cameras - which carry a video compression and transmission delay and wired, line-cameras track side which are near latency free. Switching between wired and wireless cameras can become problematic if there is too great a time difference between the camera systems - viewers don't want to see a continuity jump across a camera switch.



In content production, high quality video is key. Good quality video at source clearly impacts video quality presented to the consumer. And where video feeds are used at length within the program production, the video quality of source content needs to be maintained throughout the program run time.

For compressed video transmission systems, bit rate and occupied bandwidth are governing factors in limiting the video quality that can be achieved across the link. Picture quality, bit rate and encoding latency are therefore inherently intertwined.

Challenges with Public 5G Networks

In analysing the suitability of public 5G networks it became clear that their current capability does not match the needs of high-quality live video contribution that is required for primary video feeds.
Today's public 5G networks are optimized towards delivering high downlink data rates – to enable consumers to stream content to their hand-held devices. Network latencies are relatively high for various reasons, but in part because, whilst the network edge devices are 5G systems, the overall networks are currently built around an existing 4G core.

When considering the use and suitability of today's public networks for broadcast contribution services, it is also important to consider network traffic prioritization. With the transmission rights to the broadcast

event being potentially worth millions of dollars, with global audiences viewing the event potentially totalling millions of viewers and the reputational damage to the content producer at risk should a critical moment be missed, it is commercially vital that there are no outages on the contribution feed.

In considering relying on the public cellular networks at major public events where there may be thousands of people present it is not yet possible to guarantee the prioritization of high value video broadcast services above consumer data consumption without significant custom network node configuration - Network Slicing technology which may eventually resolve this issue is not yet deployed in today's public 5G networks.

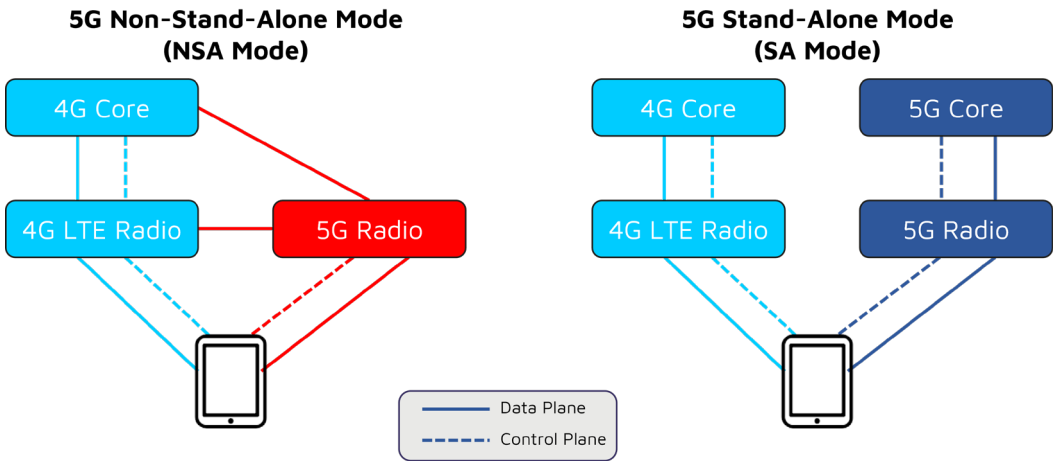
A Note About Channel Bonding Systems

Video broadcasting systems that utilize cellular networks have been available for many years and are readily available with 5G capability as part of Vislink's Mobile Viewpoint portfolio of products. These solutions implement channel bonding, strong FEC and re-transmission requests to achieve the necessary data rates and robust video delivery. These bonded mobile devices operate within a best-efforts philosophy, allowing changes to transmission latencies and throttling of bit rate and video quality to ensure the video feed gets through. These systems fill a valuable need in applications such as breaking news or providing additional content at sporting events. However, the demands of primary camera feeds at major events for guaranteed quality and low latency can be a challenging match for bonded mobile solutions.

Vislink needed to look beyond public 5G networks to construct a 5G solution that met the needs of low latency, guaranteed quality video, guaranteed availability production.

The Case for Private Networks

Private networks offer the potential to tailor the capabilities of a 5G cellular system free of the hindrances that todays public 5G networks enforce by deploying a stand-alone 5G core as opposed to the non-standalone architecture of today's public networks.



A stand-alone network can be specifically tailored to provide lower latency and high upload rates where the non-stand-alone 4G part of the network may be dominating those capabilities. The stand-alone network can be partitioned away from access by the general public removing and contention issues, and the core and RAN can be configured and biased to provide high up-link data rates as well as potential adjustments to better handle doppler issues – critical if the system is supporting wireless camera feeds from high-speed motor racing vehicles.

Finding Bandwidth at Range and Achieving Licencing

RF bandwidth is a scarce resource. Those looking to operate ad-hoc or private cellular networks may have to seek frequency allocations that are outside of the traditional cellular bands where the public cellular network operators have invested billions of dollars globally in securing transmission licencing rights from governments worldwide.

Vislink and its partners selected the 5G n77 band for use in the trials. The n77 band is standardized to the frequency spectrum range 3300Mhz to 4200Mhz (higher frequencies restricted in the US). Use of the n77 band is advantageous because in the UK, the sub band 3800MHz to 4200MHz is licensed via a shared access local licence. The channel bandwidths defined for the n77 band by the 5G NR standardization allow up to 100MHz channels, enabling the potential to carry hundreds of Mbit/s of data payload – Providing a good match for multi-camera high quality video wireless camera applications.

Sitting within the C-band, high bit rate connectivity can be maintained over distances of hundreds of meters. This band therefore has good potential to match the needs of wireless camera systems at major events – be they within sports stadiums or covering motor racing circuits with a minimum of cell hand-overs.

The Vislink Trial and Proof of Concept System

The Vislink Trial was a partnership for the 2021 Silverstone MotoGP event with BT Sport, Dorna, Qualcom and the University of Strathclyde who were collaborating to optimize a 5G soft core from Amarisoft.

The aim was to explore the capabilities of stand-alone 5G networks and test their suitability for video contribution for live broadcast applications.

Vislink developed proof of concept wireless camera equipment that would allow simultaneous transmission of video feeds utilizing current OFDM technology and constant bit rate, constant quality 5G technology so as to provide a side-by-side comparison of both systems.

Vislink produced a 5G camera transmitter that could be mounted to a standard studio camera that provided BT Sport with capability to provide track-side interviews and roaming coverage around the pit lane. Vislink also produced a 5G transmitter that was specifically designed to work alongside the OFDM transmitter and camera mounted to a MotoGP bike.

The trial partners were keen to verify the performance of the 5G system against critical broadcast criteria – video quality, link robustness and range, transmission latency and for the on-board system mounted to the bike – link performance at speed.

With the benefit of many years of experience, Dorna were keen to identify how best to optimize antenna positioning and deliver the best range. Just one 5G radio head was available for the trial. It was important to cover the Pit area for the event. After testing a few antenna sites, the antenna was located in the stands opposite the British Racing Driver's Club.

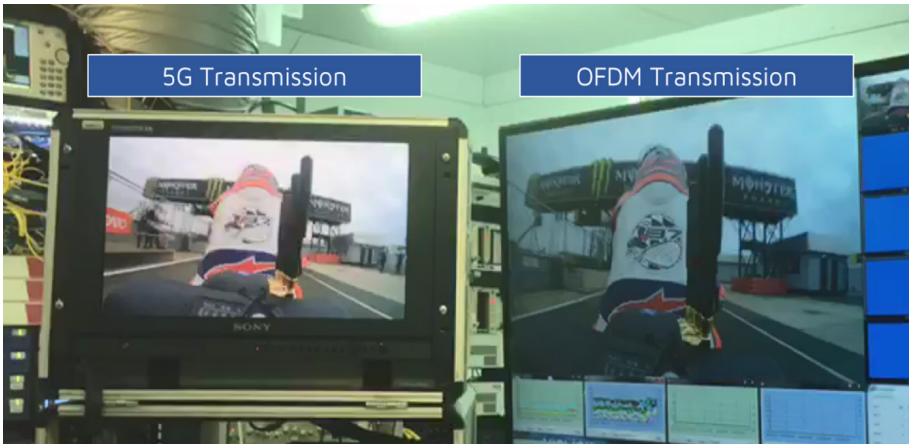
Range tests were performed with the shoulder camera. The range was proven to be significant, allowing the camera to continue to provide reliable transmission back at the TV compound in excess of 500m distance from the 5G radio.

It was critical to understand the performance of the system within highly reflective environments, within non-line-of-sight environments. Tests were performed to see if the 5G transmission was robust enough to work within the pit lane and the inside the team garages. The test proved successful.

To ensure that the video quality achieved over the 5G link was directly equivalent between the OFDM and 5G transmissions, Vislink used the same HEVC, 4:2:2, 10-bit encoder to drive both RF systems. The video encoding engine was configured the same as Dorna's normal race system.

Siting of the 5G Radio head

End-to-end system latency of the 5G system was compared to the existing OFDM network. The 5G link was optimized and overcame the long latency issues that are currently holding back the suitability of public networks. The system latency was found to be very similar to the OFDM infrastructure.



In terms of the 5G systems delivering required performance from the MotoGP bike travelling at speed, test runs were made to find the best on-board antennas to give optimum transmission performance to account for the bike leaning into the corners.

The on-board pictures were considered to be impressive, with excellent range and with the benefit of more time to further optimize it was felt that additional improvements could be made to tailor the network configuration for the high speed bike and further experimentation could be performed to test with multiple antenna sites.

So, could the trial be considered a success? All parties were in agreement. Andy Beale, Chief Engineer BT Sport, said, "This was a successful collaboration between partners showcasing the power of a standalone 5G network to enhance sports production." As proof, live pictures where broadcast to a worldwide audience from a 5G handheld camera which was on the grid before each of Sunday's races.

As a world's first trial of live 5G wireless broadcasting, the technology developed, and the lessons learned provide valuable understanding of the evolving 5G ecosystem. The knowledge gained is now enabling Vislink to move forward and enhance parts of the system that will allow the trial conducted with MotoGP to become a widely deployable future reality.

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