5G VISTA Project Closure Report

31/03/2022

Contents

Version History

Version	Date	Comments	Author
Draft V1	29/03/22	First draft for review	AB

Executive summary

5G VISTA was funded as part of the 5G Create portfolio and aims to test and demonstrate the potential of 5G Broadcast/Multicast to deliver new and exciting digital experiences to spectators at live events.

The project uses Further-evolved Multimedia Broadcast and Multicast Service (FeMBMS) technology to support innovative use cases - to both enhance customer experience at events, and increase engagement. Whilst most mobile and internet communications are modelled on a “one-to-one” system, FeMBMS is a “one-to-many” service; it will take a single stream and send it to multiple users.

By providing live, multi-angle HD video streams and interactive content direct to devices in stadiums and across the UK, the 5G VISTA project aims to deliver new dimensions for live events. Showcasing new in-stadia digital experiences, VISTA aims to not only enhance customer experience but to increase existing channels of engagement for live sport’.

VISTA primarily addresses the frequently-cited problem of a lack of bandwidth at live events to deliver important and relevant content to large audiences. By using FeMBMS rather than one-to-one Unicast, VISTA delivers multimedia content efficiently and effectively from a single source to many users, whilst maintaining quality of service (QoS) regardless of the number of users.

5G Broadcast/Multicast is an efficient and environmentally low-impact solution that augments the capability of heavily-congested cellular and Wi-Fi networks such as those found in sports events and music concerts. VISTA looked at the technical deployment, consumer demand and commercial viability of the solution in two exemplar markets: football and motor racing.

This is in line with the customer, market, and business research results which suggested that the two prime use cases were Large Stadiums Sports (football, rugby, cricket) or music events (concerts), and Distributed Venue Sports (motor racing, golf, Olympics) or music events (festivals).

The project has illustrated that both products are commercially viable even with relatively low audiences (~30K) and less than £5/monthly subscription for the football app, or around 8% top-up to ticket price for the motor racing app.

Additionally, though streaming services are extremely competitive in the market, unicast video distribution has up to ten times the environmental impact* of 5G Broadcast, due to its one-to-one model.

The lack of compliant receivers is a major barrier to deployment however through the business analysis and trials that the project has carried out, this has driven Qualcomm to work with VISTA to create a 5G-Broadcast capable test device which the project now has samples of.

Moving forward, a more detailed business plan could be prepared with the aim to clarify and resolve key challenges raised during the project including:

- Larger field trials in real operating environment
- Availability of compliant receivers
- Content rights management
- Suitable deployment scenarios
- Exploration of alternative business models
- Price sensitivity analysis

*The LoCaT Project: https://thelocatproject.org/

Introduction

The vision of 5G VISTA when it was initially set out was to create a '5G Powered Sporting Event' providing:

an alternative in-stadia viewing experience of national sporting events. The project will explore the technical and commercial elements of the provision of this service using 5G New Radio & Further enhanced Multicast Broadcast Multimedia Services (FeMBMS aka 5G Broadcast). With the end goal of demonstrating that these services can and will enhance live 'sporting event' audience experiences, by providing; live multi-angle HD video streams and interactive content from the event direct to devices in stadiums and across the UK.

The end goal of the trial project was to deliver:

- a demonstration of this technology in a live event environment providing a demonstration of 5G's ability to create ground-breaking audience experiences in stadia, major event venues, and in multiple locations simultaneously. The objective is to create exceptional consumer experiences which drive value to venues, audiences, live performers/live sports, and content owners.

The key objectives of the VISTA project were:

To derive new value propositions from network level down to consumer built on 5G-Broadcast, encompassing MNO business cases, venues and direct to consumer propositions to be exploited by the partners and the wider ecosystem. The learnings will have wider impact for similar environments where B2B2C 5G propositions are being considered, from shopping centres to airports, retail to arts, cultural institutions to universities and other large entertainment venues.

Context

5G broadcast technology can provide a richer live experience that will include: - multi-angle views of the action; views from areas that cannot be seen or behind the scenes; and additional information about the event.

Live events currently provide a real service challenge for mobile network operators, with demand for data being particularly problematic at key moments, meaning that fans cannot access content. The investment required to overcome this issue by increasing bandwidth does not stack up financially as the venues are not in permanent use.

The 5G broadcast technology that VISTA uses overcomes this problem, as it delivers content from one source to many users, rather than one to one, meaning that the quality of service is maintained regardless of the number of users.

This means that with 5G broadcast technology fans can all access the same content and information at the same time, getting them even closer to the action and enhancing their enjoyment of the event at that moment.

Description of what the project did

The key deliverables outlined were:

1. A series of demonstrations of the proposed functionality: Launch event providing an insight into the partners their experience and the technology

2. A test lab launch of the technology in the Digital Catapult lab, providing hands on experience of the technology, and the end user experience, using multiple cameras FeMBMS

3. A demonstration of an exemplar service in stadia and at secondary locations

4. Commercial use cases defined for the use of FeMBMS in mobile networks and devices

5. B2B engagement events, interviews and surveys to aid the development of credible business models

6. Consumer engagement events, interviews, surveys and testing to ensure we build experiences which are valuable to the market and its users

7. A series of “easy to digest” highlights and briefings to educate the market on the value of the experiences developed, the technical learnings and potential exploitation opportunities in stadia and beyond

8. Mid and end of project reports highlighting the main outcomes and opportunities, technical learnings, recommendations and next steps

To achieve this the VISTA project was divided into 3 phases:

1. ***Phase 1*** was a technical demonstration of the FeMBMS platform as the core of the 5G VISTA solution. The purpose was to help educate all project partners familiar with the way it works and the potential it offers. The demonstrator set-up was using pre-stored content.

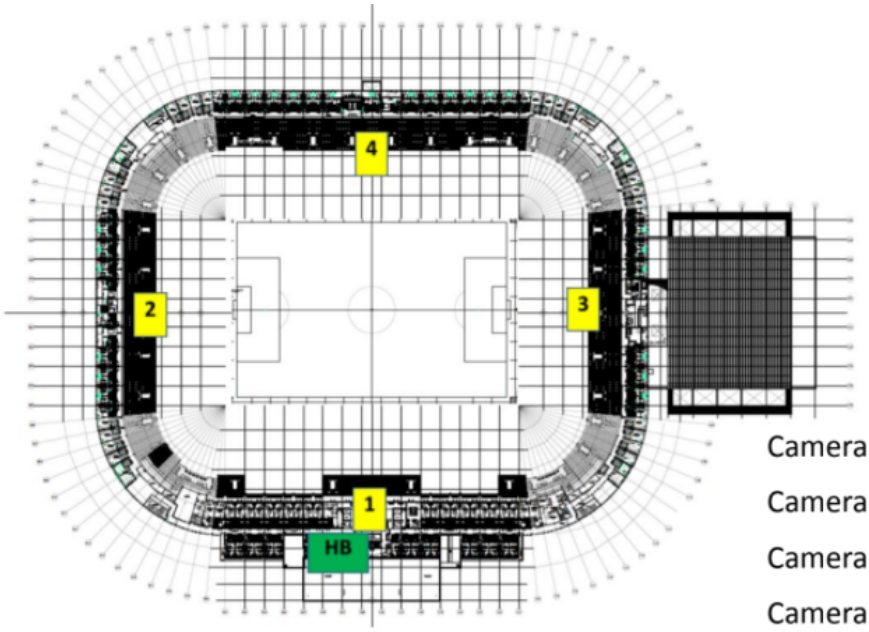
2. ***Phase 2*** built on this to integrate live content into the set-up. This includes live cameras, production & master control, MEC and necessary processing before transmission over FeMBMS. Stored content can still be used as reference. In this phase an app was made available and tested which is close to the final user experience.

3. ***Phase 3*** demonstrated the full end-to-end solution during a live event to industry stakeholders and a customer focus group. This included the content generation as tested in phase 2 and an extended FeMBMS platform installed on site, covering the venue. The tests used FeMBMS capable software defined receivers which then relayed the content to handheld devices on which the VISTA App was installed.

The project carried out the above as described culminating in the MK Dons trial in Feb 2022. This deployment was an example of a private network using 5G Broadcast that could be rolled out at live event venues. The premise being that venue owners can use the broadcast network as a way of delivering a suite of content to their fans and potentially other venue equipment such as big screens.

During the trial there were 6 channels of content delivered to the VISTA application, these were:

- One channel containing “Special BTS content” supplied by MK Dons. This became a replay or delayed live channel during the game.
- One channel EFL football league live stream of the game.
- 4 of our cameras in the stadium shown below in the stadium plan. The 4 positions were chosen to be able to look at almost any area of the pitch and the action.
- Two cameras were manned and two had some remote control over iris, focus, and zoom. Below is a picture of the type of camera to be used



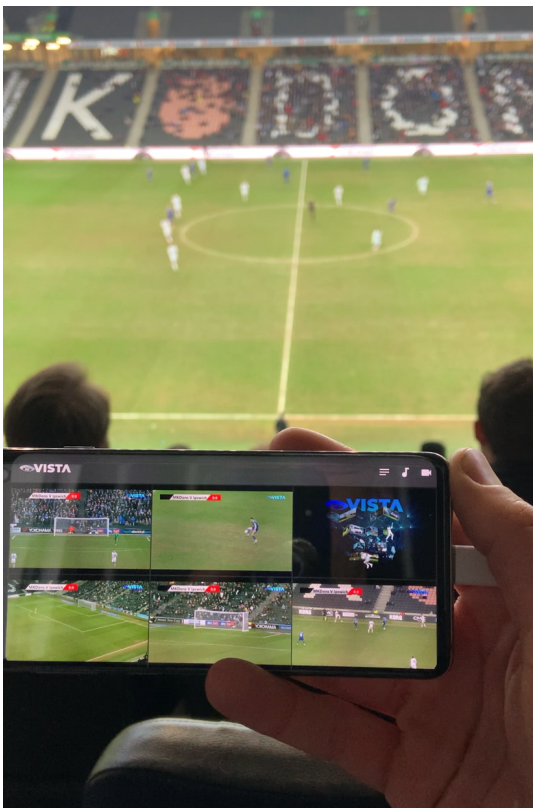
Camera 1 - Centre Line

Camera 2 - High Behind LH Goal

Camera 3 - High Behind RH Goal

Camera 4 - High Opposite Cam 1 (Reverse Shot)

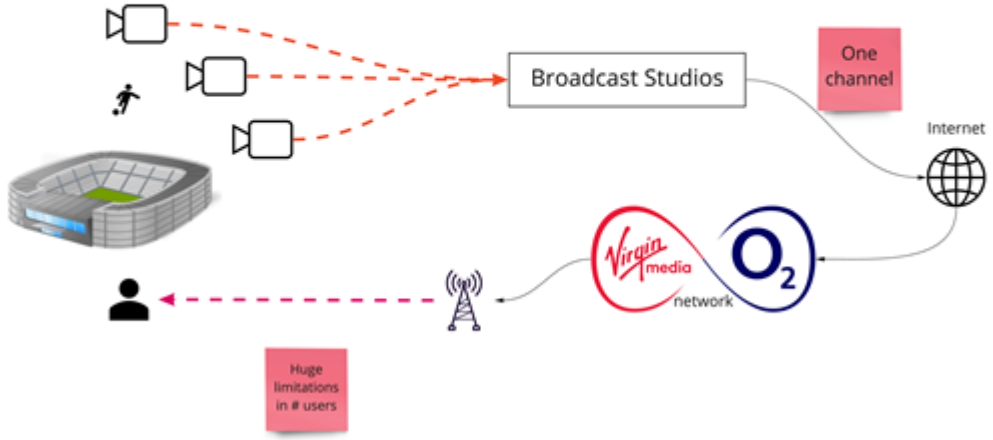
Below is what the application looked like when in use:



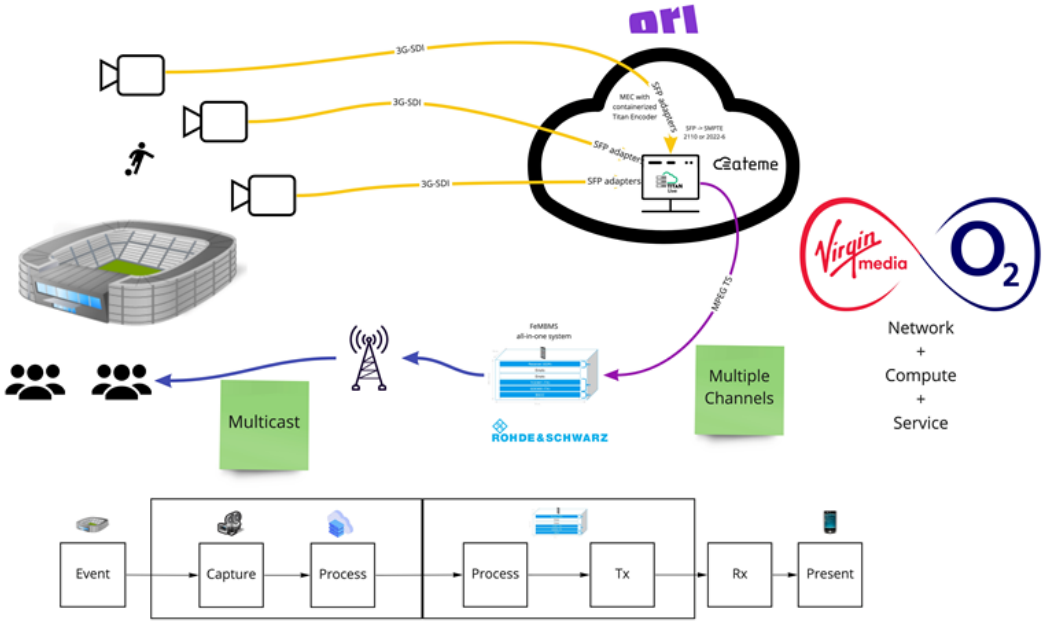
- The app can display audio and video currently. Features such as Push notifications, user controlled replays or user interaction beyond selecting a channel were not possible in this POC app.

The project also used Multi-Access Edge Computing (MEC) technology to deliver content processing at the MK Dons stadium. This means that instead of having dedicated video encoding hardware needed at all venues where the 5G broadcast solution is deployed, a version of the technology can be deployed as an application on generic hardware which can then be brought into service when needed. The hardware can then be used for other applications when it is not being used for video encoding and makes the solution more cost effective and efficient. Below are two diagrams which illustrate the before and after deployments:

Impractical to deliver real-time content in stadiums to fans



Delivering real-time pop-up channel content in stadiums to fans



Approach to security

The security of the content from the origin through to the handsets was a project led by the 5G Innovation Centre (5GIC) at the University of Surrey.

The project looked at 4 main requirements:

- Protecting the integrity and confidentiality of end to end multicast connections
- Protecting the integrity and confidentiality of links between the broadcast core network (BSCC) and the MEC
- Key management systems between the network and the user equipment (UEs)
- Requirements for re-keying policies to manage users leaving and entering the system i.e. so new users can't access historical content they are not entitled to or users who's access has expired can't continue to see the content

The foundation of the above requirements is a protocol called Datagram Transport Layer Security (DTLS).

The project outlined lightweight mechanisms i.e. not creating computation and latency overheads in the system, that can be deployed flexibly depending on the use case. The flexibility is key when trying to cater for a large number of people requiring access. The logical key hierarchy structure meant that even changing access status for 1 person out of over 100 million would be possible in less than 0.5 seconds.

5GIC worked with R&S to integrate the solution into the labs at the University of Surrey and the next step would be a full implementation in a live trial.

All the reports from the security project are available here:

MS16 - Security threat analysis

MS17 - Security report multicast key management

MS18 - Secure multicast design and deployment

Additionally, the VISTA website contains information and videos with the "easy to digest" news and videos that were part of the project deliverables and describe the progress and achievements during the project: https://5gvista.co.uk/news/

Description of the results

The project results can be grouped into the following categories:

- Customer
- Business case
- Technical

Customer results

VISTA carried out a customer focus group at the MK Dons vs Ipswich Town live demo in February 2022.

The objectives of which were:

- Provide football fans with an opportunity to trial the prototype
- Test the 5G VISTA app while attending a live game
- Gather and evaluate their responses to the experience after the game

Information gathered from the trialists included:

- Views on their overall experience
- Feedback on functionality and UX/UI
- How they used the app during the game

- Strengths and weaknesses of the app and using handsets
- Potential improvements and ways to optimise these
- Explore a range of other issues relating to 5G VISTA
- Opportunities away from the pitch, including stadium information and in-home use
- Commercial options for possible future development

The trialists were chosen using the following criteria:

- All MK Dons fans
- Regular, at least once-a-month, attendees at home games at Stadium MK
- Some season ticket holders
- 5 men (20s to 50s)
- 2 attending with teenage sons
- 3 women (20s to 50s)
- All smartphone users, routinely streaming content on their devices

Results

There was a positive response across trialists – and across age/generation/gender

It was considered that the VISTA App (with content supplied to it via 5G Broadcast) was an enhancement to the match experience

The trialists also felt that there was a lot of potential and opportunities to further enhance the service

A summary of the experienced benefits/positives included:

- The lag: built-in replay function
- Replay panel
- Four different perspectives on game
- Close-ups on key moments, especially for set pieces
- Easy and intuitive to use
- Users quickly find natural way of using app vs. watching pitch
- Excellent picture quality
- Enhancement of experience, and not a distraction

Please see a full customer experience report from focus groups in the Appendices.

Conclusions

In order for products such as the one trialled at MK Dons to be a success, it is crucial these products respond to the established valid customer needs:

- **The product should augment and improve the live experience**: The key draw for attendees is being there in person, if they wanted to watch on TV they could stay home. The application must ensure that it feeds directly into the real-time experience, immersing the audience in exclusive content that complements the environment.

- **The product should allow further access to the action**: sports and events where you

cannot see all the action from one position have a more obvious appeal for the outlined use cases. Allowing the attendee to both experience what is in front of them and follow better the action happening elsewhere expands the experience beyond the parameters of one viewpoint.

Feedback from the workshops undertaken make it clear that VISTA's application is broad and has high demand variability across multiple use cases, as well as potential fringe opportunities in other locations accessed by fans during their journey on the day of the event (food stalls; queues etc.).

Business case results

The project carried out business focus groups to complement the customer focus groups as well as carrying out research into use cases for 5G broadcast at live sports and music events.

The project's Sustainability Report provides a comprehensive evaluation of the market opportunities, key factors in Go-To-Market, business propositions, and conclusions & recommendations

The use cases at live sports and music events
In highly crowded places such as football matches and large music concerts, the primary challenge is to keep up with the ever-increasing demands of mobile multimedia consumption by large volumes of people at any one given time.

5G Broadcast/Multicast alleviates such challenges and offers the potential of new, value-added services that appeal to attendees of live events, including:

- Live super high-definition (SHD) video from the pitch or the stage, with fans able to choose from multiple camera angles in real time.
- Show data overlays and stats about musicians or players on the audience's mobile or wearable devices.
- Sell merchandise or additional services on the fly to customers using mobile devices.
- Support pop-up retailers with secure wireless connections for payment processing.
- Extend market reach, by offering the same live video and information feeds to fans who couldn't get to the venue.

Though streaming services are extremely competitive in the market, unicast video distribution has **up to ten times the environmental impact** of 5G Broadcast, due to its one-to-one model.

The environmental impact

The Low Carbon TV Delivery Project (LoCatT) is a collaborative initiative backed by leading European broadcast and technology players, to assess the energy and carbon impacts of the delivery of TV content (both linear and on-demand) across Europe and across Digital Terrestrial Television (DTT), Internet Protocol Television (IPTV) and Over-The-Top media services (OTT).

LoCaT estimates that unicast streaming (OTT or managed IPTV) requires a considerably higher energy consumption, and thus, carbon equivalent emissions, than linear DTT delivery - see table below:

EU28 average	Broadcasting (DTT)	Unicast (OTT)	Unicast with live TV (IPTV)
Energy consumption associated with one device viewing hour (in Wh)	14 Wh	109 Wh	153 Wh
Carbon dioxide equivalent emissions (in CO2e)	3.3 gr	26.2 gr	37.0 gr

The implementation

5G Broadcast/Multicast services can be deployed in two ways:

A. By upgrading existing cellular sites using supplementary downlink transmitters
B. By deploying an overlay network, a computer network which is built on top of another network, using a high-power transmitter

VISTA has focused on deployment option A as the most optimum method for using pre-existing infrastructure in stadiums across the UK.

This method will utilise FeMBMS to enable the simultaneous delivery of a single video stream to multiple users (Multicast/Broadcast). The technology overcomes the problem of a lack of bandwidth at live events by delivering the content from a single source to many users, rather than one to one, meaning that quality of service is maintained, regardless of the number of users.

Overall market opportunity

The market size of Long Term Evolution (LTE) and 5G Broadcast is expected to grow at a steady compound annual growth rate (CAGR) of 12.3% in the next five years, and reach over 1 billion USD by 2028*.

The market is primarily driven by the increasing 5G and LTE mobile user base, the penetrating sales of smartphones and the rising popularity of on-demand content. Moreover, the growing need for increased connectivity of devices due to the Internet of Things (IoT) revolution is likely to further promote the market growth.

The project carried out financial modelling for a Football stadium:

- Financial modelling assumptions:
  - 30% of fans subscribe to the basic service and 15% to the premium service
  - Basic TV service is priced at £3 per month while Premium TV service priced at £5 per month (both comparable to other similar apps in the market)
  - Capital expenditures (CAPEX) of £150k is amortised over 5 years and does not include costs (CAPEX/Operating expenses- OPEX) of the private 5G network
  - Hosting cost in public cloud is £5/month/server
  - Apple and Google platform hosting costs at 30%
- Financial model run for clubs with 15K, 30K, 50K and 100K total number of fans
- The model indicates that the business is viable even for small size clubs (down to around 20K) which produces a modest 26% gross margin. Anything smaller is not commercially viable as it barely covers its costs.
- For club sizes of over 30K the model produces a reasonable gross margin of 40% which increases to a healthy 60% for larger clubs with over 100k fans.

Conclusions

5G broadcast/multicast is an efficient and environmentally low-impact solution that augments the capability of heavily-congested cellular and Wi-Fi networks such as those found in sports events and music concerts.

VISTA's Sustainability Report validates the consumer demand and commercial viability of the solution in two exemplar markets: **Football** and **Motor Racing**.

The report has illustrated that both products are commercially viable even with relatively low audiences (~30K) and less than £5/monthly subscription for the Football App or around 8% top-up to ticket price for the Motor Racing App.

Moving forward, a more detailed business plan could be prepared with the aim to clarify and resolve key challenges raised in this report including:

- Larger field trials in real operating environment
- Availability of compliant receivers
- Content rights management
- Suitable deployment scenarios
- Exploration of alternative business models
- Price sensitivity analysis

Broadcast vs Unicast - Technical results from the demo

The project carried out technical measurements at the O2 Arena of broadcast vs unicast during a live show.

The unicast measurements were taken from the 4G network at the O2 Arena.

The concept is that the broadcast network will remain stable throughout the show regardless of the number of users that are in the arena.

In contrast the unicast network will suffer from fluctuations in performance as more people try and access the network

Overview of the testing

A temporary FeMBMS (Further enhanced Multi-Broadcast Multicast Service) was set up at Suite 209 in The O2 on 15/02/2022.

The signal was transmitted with these parameters:

- Centre Frequency: 763MHz
- Bandwidth: 10MHz
- Sub Carrier Spacing (SCS) 1.25KHz
- 2 x HD streams
- The initial transmit power was -40dBm, this was changed to 0dBm (1mW) later in the test

Readings were measured with the Kathrein surveying software using a TSMW (Serial No 102042) as a receiving scanner.

The survey took place before and during a show at the O2. This was to see if existing uplink noise would affect the readings or performance.

Customer Experience for data was measured at the same time (LTE preferred) using bit rate measurement equipment on handsets which were streaming 6 videos.

Summary

The initial signal was not of sufficient power to provide a decodable FeMBMS signal.

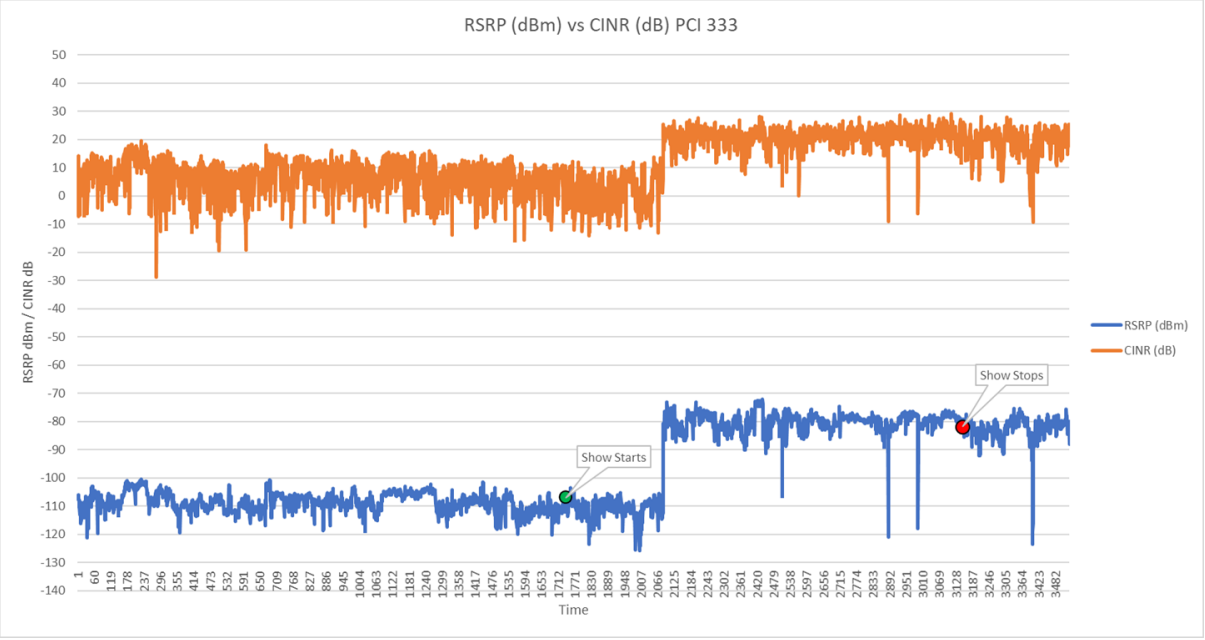
After the power change the scanner showed a good signal of sufficient quality to broadcast a multi-stream broadcast (in this case 2 streams).

The Carried to Interference and Noise Ratio (CINR) remained high during the show for the FeMBMS signal

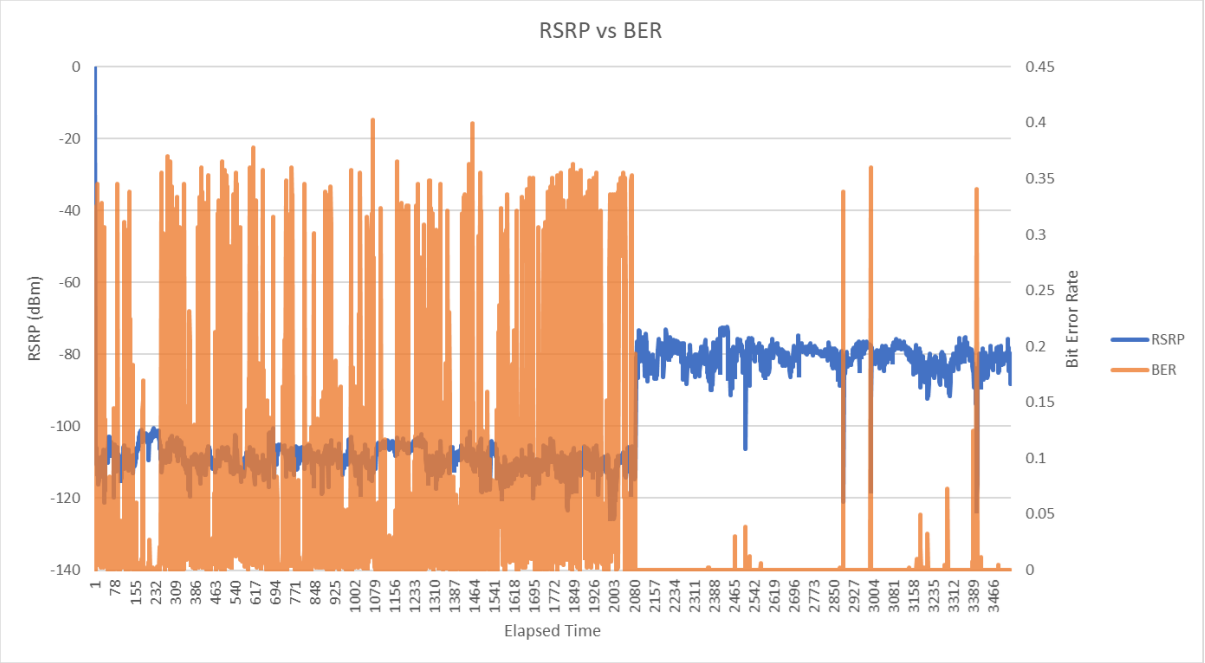
The LTE data rate fluctuated during the show.

Results

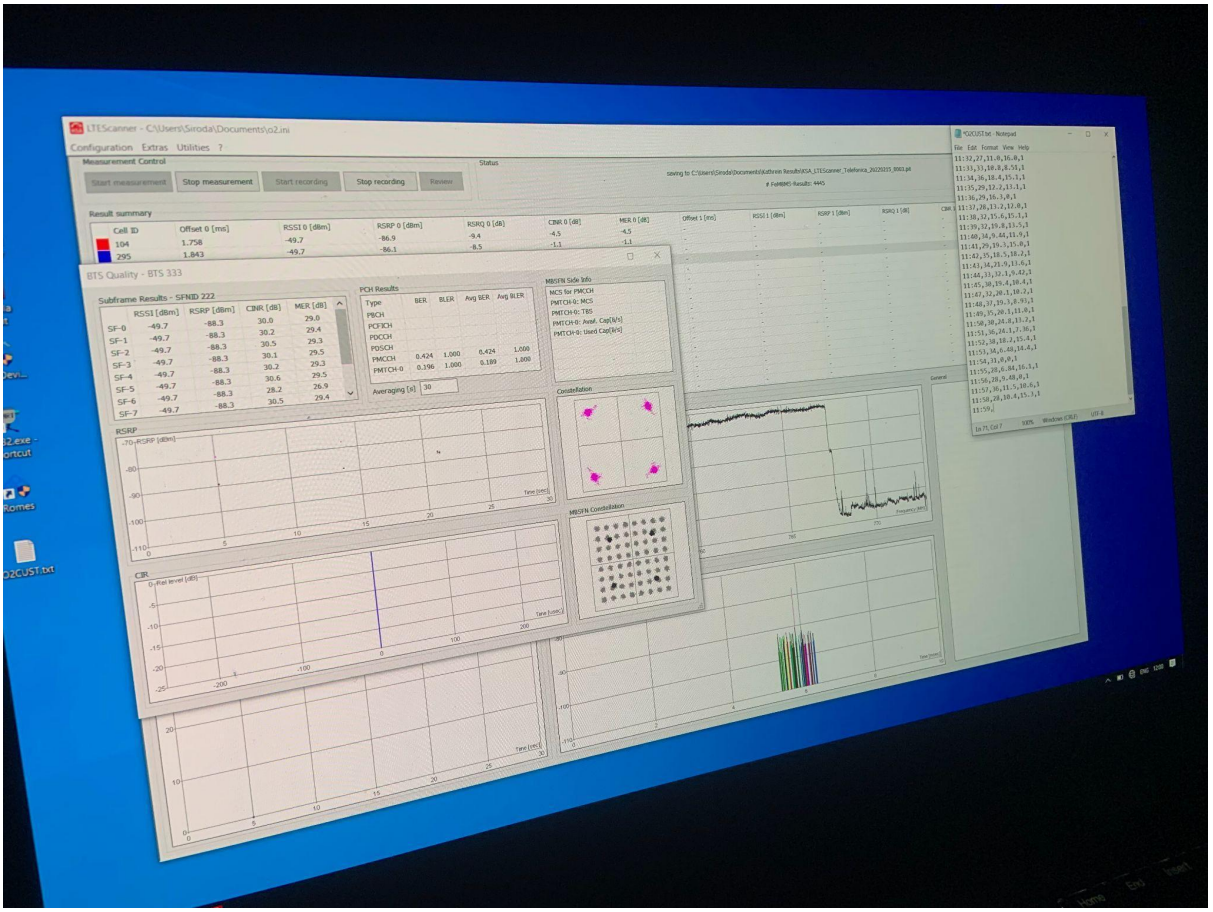
This plot shows decoded FeMBMS received signal power (RSRP) and CINR before and during the show. As can be seen, the customer generated noise had no noticeable effect. The transmit power change can be seen clearly.



This plot shows that when the transmit power was increased the Bit Error Rate (BER) fell and stayed low. This is relevant as BER will have to be low to support a good quality of service.

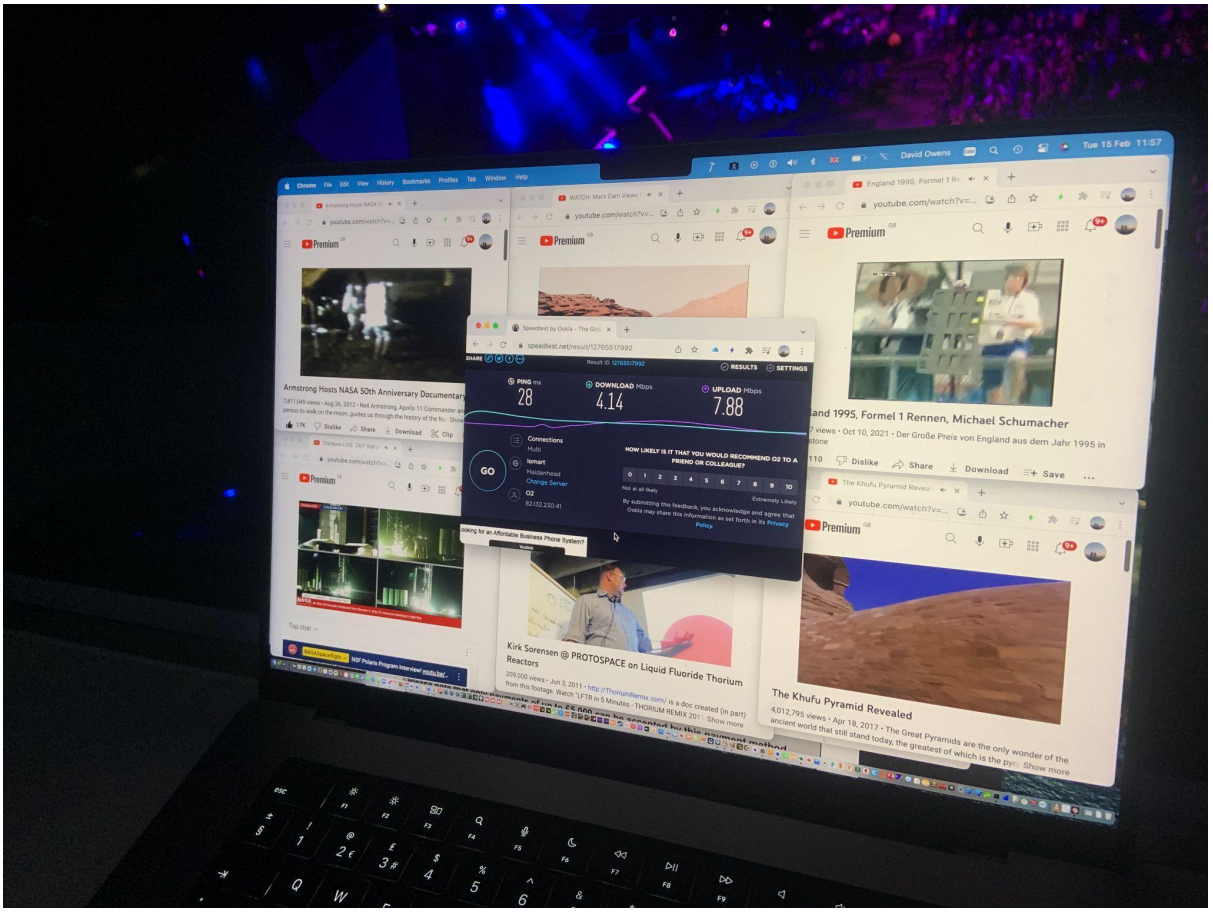


As can be seen from the modulation plot below taken during the testing, the FeMBMS signal was able to support 64QAM modulation throughout the show. The higher the order of modulation the higher data throughput can be supported on the cell and 64QAM a modulation rate that can easily support the 25Mbps to distribute the video content in the stadium.

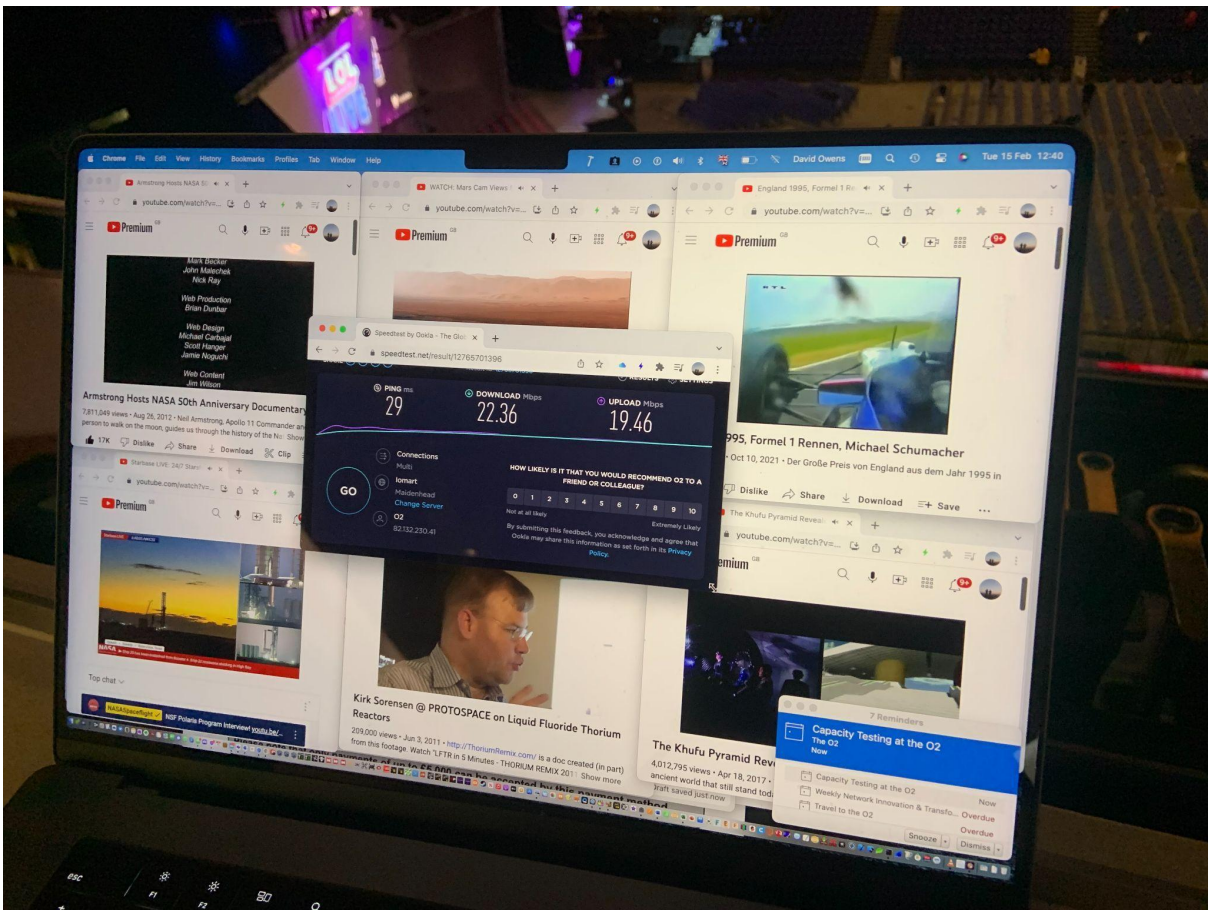


For the LTE signal the data rate ranged from 22Mbps once the stadium was empty, to 4Mbps while the stadium was busy. The average was around 12Mbps during the show with measurements taken every two minutes and this manifested itself in buffering of the video streams.

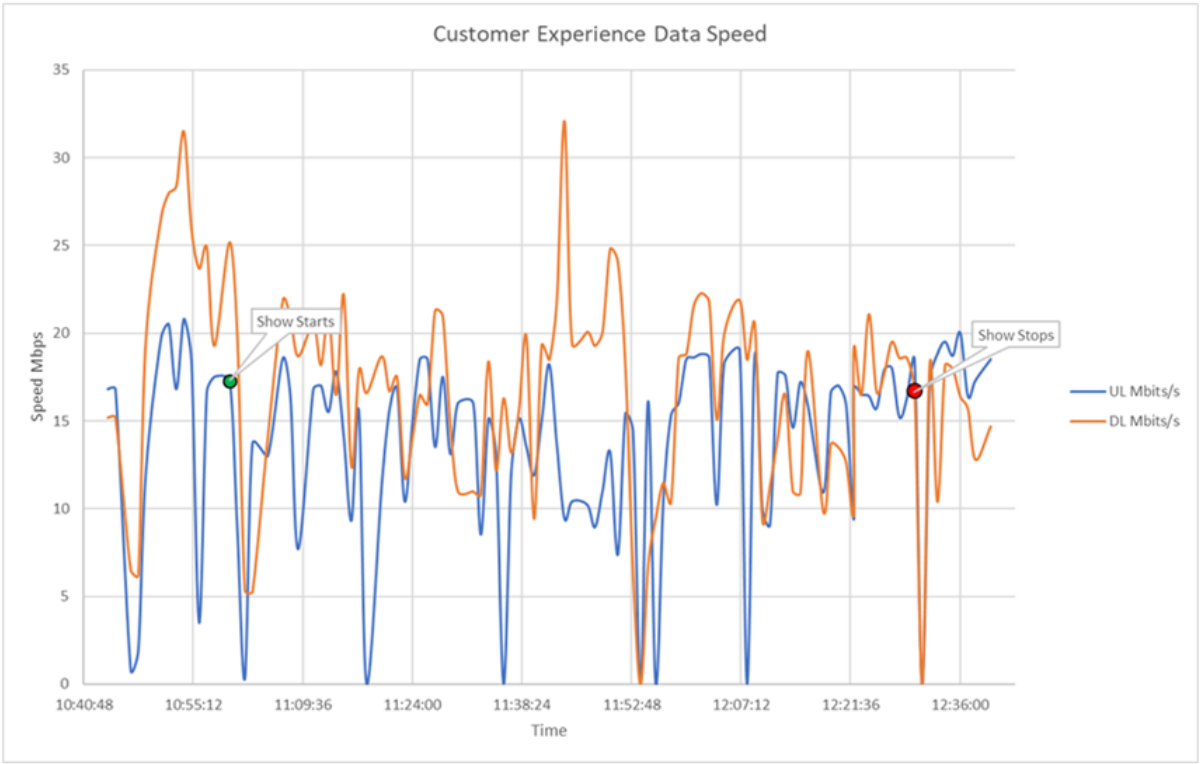
The photo below was taken at the same time as the picture of the constellation diagram from FeMBMS above and is an example of where the data rate has dropped particularly low during a point in the show where there was a break and the audience were therefore more likely to be using their phones.



This is contrast to the data rate measured at the end of the show when everyone had left the arena and the show had ended:



The graph below shows the variation in the data rate throughout the show:



Conclusion

The FeMBMS (5G Broadcast) signal was stable throughout a busy show in a live arena while the 4G signal fluctuated in line with audience members using their devices during the show. This shows that 5G broadcast would be a good solution for providing additional capacity for things like video content even in crowded areas, and that the quality would remain consistent for end users.

Impact of the results

Through our customer and market research it shows that there is appetite to pay for a multi-angle viewing experience that 5G broadcast could offer.

The fans we asked about this see the solution as the future.

The benefits realisation showed that 5G broadcast can provide consistent coverage in busy stadiums meaning that fans at venues understood the concept and saw it as the future of watching live sports.

There are also many other opportunities such as with distributed sports events (golf, motor-racing) and music events.

The business modelling showed that to be commercially viable doesn't require huge subscription numbers (around 30% of fans for a 30k fan base)

The infrastructure requirements are a gain of 1-10 meaning huge capex, opex and energy savings compared with delivering the equivalent video content in stadiums over unicast networks

The project has proved that 5G Broadcast is a cost effective and environmentally efficient way of providing mobile network capacity in crowded venues.

This has the potential of providing sports venues, content owners, and rights holders with a new way of engaging with fans.

It also has the potential for bringing fans closer to the action by combining the sofa experience with the live experience.

Key learnings

The project has achieved great success in working with Qualcomm to realise the first 5G broadcast chipsets which have been implemented in reference devices obtained by the VISTA project.

The project has also generated interest with major sporting events interested in doing trials with a view to live deployments.

Next stages are to continue with further showcases of the 5G broadcast solution with a view to bringing in stakeholders who would be key to bringing the solution to market. These are handset OEMS, more mobile network operators, and content owners.

The overall solution is around 18 months to 2 years from being commercially ready but the project has unlocked a key impasse with the chipset availability.

The project has outlined a product roadmap to cater for two use cases of Motorsport and Football, which can be seen below.

This will require an initial phase of a “Core Technology Development” which will split into two paths, each targeting a specific vertical.

Initially the “must-have” features of the products must be supported and the “nice to have” features should be developed as a product roadmap strategy. Additional client-customisation should be offered for different clients as illustrated below.

This is a scalable approach to business development which allows the product offering to be extended to other use cases beyond Football and Motor Racing in Phase 2 and would be able to leverage the network capacity outside match day events in Phase 4, depending on the available funding.

In parallel during this period rights conversations would need to take place about access to content and using 5G broadcast as a deployment method.