5G Rural Integrated Testbed

D5.12 Interim Final Report - UAS

Acronym:	**5GRIT**
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1 Executive Summary

The report is designed to deliver an overview of the implementation and use of the 5G infrastructure by Blue Bear and show the limits and capabilities that can be delivered for unmanned use in practical applications associated with the WP 3 - Agriculture.

After many delays for technical reasons associated with the non-performance of the TVWS 5G equipment, a 5G network has finally been installed and commission to connect the BBSR offices with its nearby test site. Blue Bear has been preparing unmanned aerial vehicles that will be 5G enabled, working with Quickline who have provided network connectivity at Blue Bear's site. This solution is based on equipment from Cambium Network.

Following extensive speed testing and network proving trials the first 5G controlled flight has been completed, just at the end of Phase 1 of the 5GRIT programme. More details are presented in this report.

In preparation for this situation BBSR has been in discussions with the CAA regarding the licensing and other requirements which would be necessary to enable a drone to be flown under BVLOS conditions and thereafter potentially under remote control – this in turn could lead to the further development of commercial services for rural customers.

In addition to the equipment at the BBSR test site, identical equipment is being installed and commissioned by QL at the different use case test sites (Blue Bear in Bedford, Precision Decisions in York, and a farm in Alston).

Once all testing has been completed and mock use-case test flights have been completed, BBSR and the other partners will be able to begin real flights for the delivery of the outputs of WP 3. These flights will be run throughout the Phase 2 period.

Drones to be used will involve multi-rotor aircraft, but the primary use case will use Blue Bear's specially developed Agri-Start drone, which is based on Blue Bear's versatile Blackstart platform. Agri-Start is designed to be quick, simple to launch, easy to operate, durable and highly transportable.

Going forward, Blue Bear will continue discussions with mobile cell manufacturers to secure a suitable piece of technology to mount on the drone. This will allow data collection and transmission over the 5G network.

2 Introduction

Unmanned technology is advancing at an unprecedented rate and being adopted across diverse industries. Tailoring the existing cutting-edge technology to support agriculture, which has traditionally advanced at a much slower pace has been a key task to enable farmers to have easy access to this technology.

5G hardware could enable a new era for unmanned technologies and future regulation.

As part of the Department for Digital, Culture, Media and Sport 5G Testbeds & Trials Programme, this report presents the developments that have been made in the last two-month period on the 5GRIT BVLOS (Beyond Visual Line of Site) use cases.

3 Research Question - what we set out to achieve

Can 5G deliver heartbeat and data for Unmanned Aerial Systems to allow the Civil Aviation Authority to permit them to fly beyond line of vision?

- BBSR has already successfully begun this process
- An initial meeting with the CAA was so well received that a follow-up meeting was held at the request of the CAA. This second meeting was attended by more than one dozen CAA personnel from many different departments, all of whom would need to be involved and approve commercial BVLOS flights.
- It was agreed that the next steps involve the demonstration of flights under 5G control, and thereafter a programme to formal approve BVLOS flights
- Now that 5G controlled flights have begun, BBSR can liaise with the CAA to start this assessment and approval process.

4 Implementation

Quickline communications installed a Cambium 5G configuration at Blue Bear's offices in Oakley.

The setup then required Blue Bear to install a 17m tall mast at the Blue Bear offices, and a 17m mast being installed on top of the control tower, at the Blue Bear Twinwoods flying test site. Blue Bear installed the masts with the best information available, to achieve the best possible line of sight needed.

The Cambium equipment must have line of site to ensure a strong and reliable signal.

Figure 1: Installation of the masts at Blue Bear offices and Twinwoods

Figure 2 : Blue Bear Site Overview

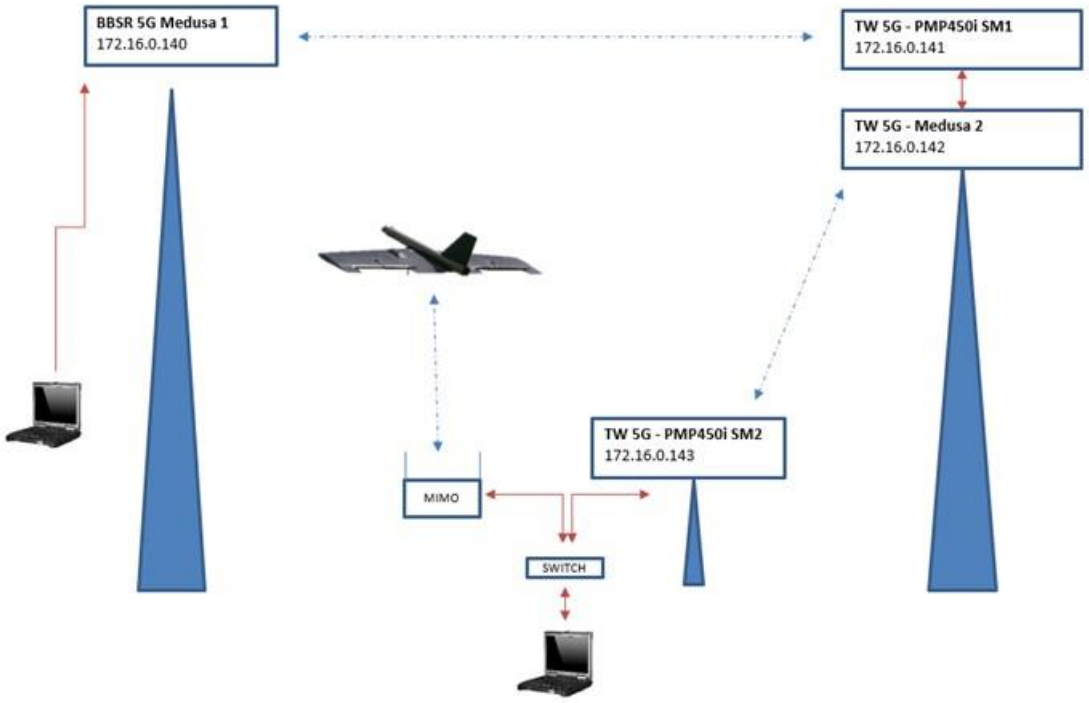

Figure 3 : Blue Bear Technical Overview

5 Key Learning Points

Following the first successful flight under 5G control, following learning points have been identified and are equally applicable to the BBSR test site and the designated use-case sites.

- Line of sight is a requirement for reliable connectivity
- Speed degradation is significant when behind structures and trees
- CAA Very supportive, and keen to learn more how 5G can support drone use cases.
- Weight and Size of Cambium kit is not suitable for UAV Mounting.

6 Results

Blue Bear conducted a series of speed test before undertaking the first 5G flight with the Agristart fixed wing. Below are the results of each test.

Test 1 : BBSR 1 - Fixed Subscriber - BBSR 2

With Blue Bear's current configuration, and not having a clear line of sight to achieve a signal improvement of 70dB+, speeds were as low as 17mb per second from point to point service. The connection was not stable enough and consistently wavered between 74-95dB

This seemed to increase the dB in strong winds, pushing towards 95dB which would tie in with the tree movement, the signal was having to pass through.

At 95dB our units lost connectivity. When in flight, if this was being utilised for an unmanned system, its fail safe would trigger and the current mission would be aborted, so no flights were conducted during this test.

Blue Bear took the field based subscriber unit, outside of the offices and pointed it directly at the medusa unit. This demonstrated that on having clear line of site, stable high speeds were achievable.

The below test showed with clear line of sight over 5 miles allowed us to achieve 139Mbps connection with a 35dB Signal strength

Figure 4: Fixed subscriber connection

Speed Test Results

Downlink	Uplink	Aggregate	Signal To Noise	
9	7	17Mbps	74dB V	95dB H

Downlink	Uplink	Aggregate	Signal To Noise	
20	24	44Mbps	75dB V	74dB H

Test 2 : Portable Subscriber Connection - BBSR 1

Blue Bear carried out a test line of site outside of the building to ensure that connectivity was working as expected.

Figure 5: Portable subscriber connection

Speed Test Results

Downlink	Uplink	Aggregate	Signal To Noise	
96.75Mbps	42.31Mbps	139.06Mbps	40dB V	39dB H

Test 3: Portable Subscriber Connection - BBSR 1

On test three, we were comfortable with stable connection, and conducted the first 5G Flight. The results showed a consistent stable connection of 44-53dB. We were happy with connectivity and proceeded with the below flight.

Figure 6: Portable subscriber connection

Speed Test Results

Downlink	Uplink	Aggregate	Signal To Noise	
101.44Mbps	36.74Mbps	138.19Mbps	53dB V	52dB H

The configuration used was to take the subscriber unit to the bottom of the flying field with a clear line of sight to Blue Bears Antenna and connect it to our ground station antenna. The technical layout is shown below.

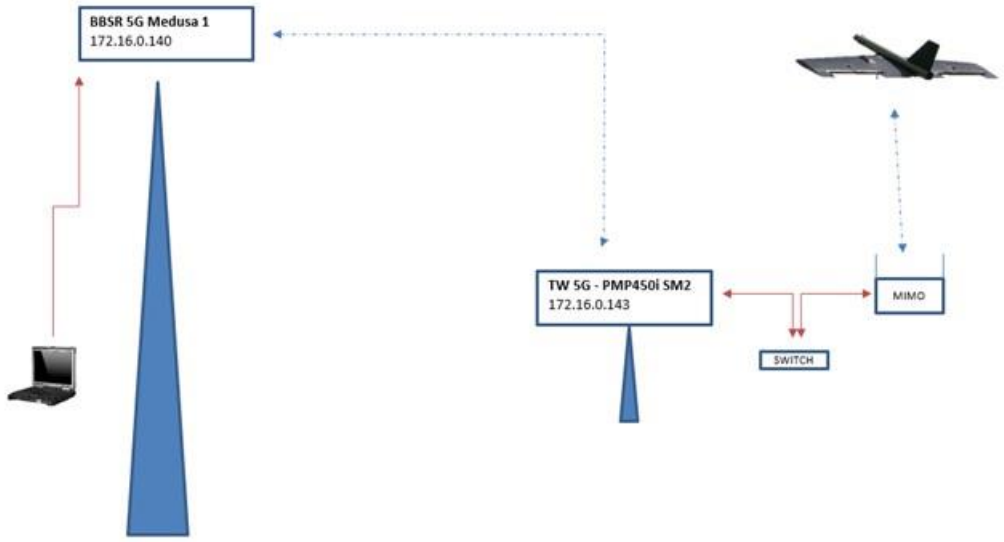

Figure 7: technical layout of configuration

Figure 8: Blue Bear's ground station connected to 5G with the Agristart fixed wing

Figure 9: Blue Bear's Agristart fixed wing ready to launch on catapult

The Flight Review

With the Ground Control Station operator based in Blue Bears offices and connected to the aircraft over the 5G, the operator created the flight plans to mimic an agriculture survey. Once uploaded, the aircraft was launched with a safety pilot on standby and tasked to its first waypoint. During the flight over the 5G Connection, the GCS Operator in command of the vehicle monitored the entire flight from the Blue Bear office and tasked the aircraft accordingly.

The GCS Operator's screen displayed the current vehicle displays, the vehicle health sensors, its current speed, altitude and the aircraft heading, pitch, and roll axis. It is essential for the GCS Operator to have a solid, stable connection with enough bandwidth to support the requirements of the UAS and mission task.

The Flight lasted approximately 30 minutes, with no data drop-outs during flight.

Figure 10: The GCS Operators Screen Pre Launch, with the Flight Plan Loaded

Figure 11: The GCS Operators Screen Pre-launch, with the Agristart in flight

Figure 11: Blue Bear's 5Grit Agristart in Flight

Figure 12: Blue Bear's 5GRIT Agristart flight track

7 Future Work

The next stage of the 5GRIT project is to run the trials throughout Phase 2 and demonstrate the potential for drones to provide cost effective benefits for farmers – both arable and livestock. Also to potentially develop new tools for assessing crop yield etc – data which is immediately of real benefit to DEFRA and commercial organisations.

The 5G Connectivity is hoped to be a hardware solution that can deliver connectivity and provide support for further drone initiatives at Blue Bear, such as the NBEC. The National Beyond Visual Line of Sight Experiment Corridor enables testing and verification of technologies, software, and hardware, and pushing the boundaries of regulation and airspace management

8 Conclusions

5G Infrastructure has a significant way to go, but it has shown there is a definite place for it in the unmanned world. The systems will need to maintain visual line of sight of each node in the 5G Infrastructure, and components will need to be reduced in size to allow aircraft to communicate directly to the nodes whilst in flight. Whilst providing significant bandwidth, the current configuration will deliver some real benefits, but the current use cases and locations will be limited while the system expands and rolls out.