Report

BEACH ONP Final Project Report for Dissemination

version 3.0

ONP Final Project Report: This report is expected to be publishable externally and provided to DSIT in an accessible format. The details are outlined in point 98 of the "DSIT Guidance for Live Open Network Projects". This template looks to outline the key sections we'd expect to see in projects final reports and provide prompts and guidance around the content for each section.

We are pleased to announce that as of 21st May 2025, the company formerly known as Dense Air Limited/Dense Air Networks US, LLC will now be known as IONX Networks Limited / IONX Networks US, LLC.

We've rebranded to better reflect who we are and what we do: delivering Integrated, Optimized Network Experiences that bring seamless cellular connectivity to enterprises, infrastructure partners, and mobile operators.

We're still solving the biggest cellular challenges—indoor and outdoor—with scalable, rapidly deployed, and cost-effective small cell, multi-carrier solutions.

Please note that our email addresses have changed in line with the name change. Although we will continue to receive redirected emails from our Dense Air emails for a short time, please update your records to reflect that xxxx@IONXnetworks.com.

Feel free to reach out to me for any clarification or follow up. For more information on this exciting time, visit our new website: www.IONXnetworks.com.

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Reference Documentation

#	Document Title	Reference
N/A		

Acronyms/Abbreviations

This document contains the following acronyms:

4G	Fourth Generation Mobile Technology
5G	Fifth Generation Mobile Technology
API	Application Programming Interface
BEACH	Beach Energy efficient Access Clusters for High demand
CMP	Certificate Management Protocol
DNO	Distributed Network Operator
DSIT	Department for Science, Innovation and Technology
GFA	Grant Funding Agreement
HDD	High Demand Density
IKE	Internet Key Exchange
ITU	International Telecommunication Union
JOTS	Joint Operator Technical Specification
MNO	Mobile Network Operator
NQT	Network Quality Test
ONE	Open Networks Ecosystem
O-RAN	Open RAN
PFI	Private Finance Initiative
PKI	Public Key Infrastructure
RF	Radio Frequency
ROC	RAN intelligent controller
RU	Radio Unit
TSA	Telecoms Security Act
UKPN	UK Power Networks
WSCC	West Sussex County Council

Name of Project: BEACH	
List of partners	IONX (formerly Dense Air limited), West success County Council, Sitenna, University of Glasgow, Sitenna
Total funding amount	£8,946,626.23
Locations	Marlow, Millbrook and Worthing

1 Executive Summary

This is the official closure document for the **B**each **E**nergy efficient **A**ccess **C**lusters for **H**igh demand (**BEACH**) project which forms part of the Open Network Ecosystem (ONE) Department for Science, Innovation and Technology competition. It was launched by the UK Government during 2023. The Beach Project consortium was led by IONX (formerly Dense Air) while partnering with West Sussex County Council (WSCC), Radisys UK Limited, University of Glasgow (UOG) and Sitenna. The strategic aim of the BEACH Project was to create an optimised and scalable solution for High Demand Density (HDD) deployment scenarios based on shared small cell networks, constructed within an O-RAN (Open Radio Access Network).

The JOTS specification has just been completed by UK mobile operators and set out a set of security requirements and recommendations for Neutral Hosts to align to. The BEACH project took paper specifications and built a physical implementation of the JOTS framework and included the required security framework and functionality.

Research and development were planned to take place in several areas:

1. Create a 5G small cell prototype for testing neutral host sharing technology. It aimed to incorporate a new 5G chipset to meet small cell requirements.
2. A new neutral host platform: “cellShare” to enable hosting of multiple Mobile Network Operators (MNOs) on shared infrastructure to provide coverage for all MNOs across a deployment.
3. Develop energy efficiency simulation and bench testing to evaluate energy efficiency of 5G Networks. Taking ORAN and traditional network energy efficiency models, RAN intelligent controller (RIC) simulation.
4. Enhancement to IONX’s denseWare platform with an interface linking Sitenna’s asset management to accurately identify assets with an overlay of current network.
5. A network performance application with ability to provide data on cell installation, network performance and user numbers.

2 Beach Deployment Summary

To enable the deployment of the small cell networks within Worthing Town Centre and Seafront, WSCC and WBC were required to provide public sector assets capable of hosting telecoms infrastructure, enabled with power and fibre for the deployment of small cells on each column. WSCC led public procurement processes to secure suppliers for fibre, civil and installation activities.

The deployment phase of Beach spread over several months with a number of defined activities with critical timings necessary to deliver the project. In parallel to civil works in Worthing to prepare and site multipurpose street columns and RF planning, IONX began equipment staging and physical preparation in their lab environment. Prior to commencing work a site-specific risk assessment, site-specific hazard forms and assessments were completed.

All columns in Worthing were required to be delivered through a “find and replace” approach which identified existing street furniture performing a public service function. This necessarily limited the scope for where assets could be delivered based on an existing footprint of street furniture. In discussion with the Planning Authority, it was agreed that WSCC and WBC exercised their Permitted Development rights (Part 12 of the Town and Country Planning (General Permitted Development) (England) Order 2015) to install the assets on the publicly maintainable highway.

The asset selection was a collaboration between WSCC, IONX and Sitenna to ensure that the location was suitable to deploy a small cell and meet the requirements by WSCC and the local Planning Authority. Once sites had been selected the Principal Designer undertook designs of all columns. Following the completion of the design, civil works were undertaken in Worthing to install the new multipurpose street columns.

Fibre connectivity was deployed, wherever possible into PIA to minimise cost and disruption for the project. New ducting was free issue by Global Reach and installed from the OpenReach chamber to the base of each column by LandBuild. This was always done, where possible, alongside the UKPN ducting for the power connection. Global Reach attended site once the ducting was installed to blow and patch all the fibres into the base of each column. Global Reach also delivered racks and connectivity within the Worthing OpenReach exchange for IONX to complete installation of Core networks.

The power for the column was required to be delivered by a Distributed Network Operator (DNO), for Worthing this is UKPN. Designs were agreed with UKPN for the location of the ducting and all civils work was undertaken by LandBuild, the duct was then adopted by UKPN. UKPN delivered the power connection into the base of the column. Once the UKPN power connection was delivered, electricians from Clarks Telecoms completed the electrical installation work ensuring that the power connections could be used.

IONX provided network equipment, radios and designs, configured and staged the core and RAN equipment, supported deployment activities, commissioned and optimized the networks in Worthing.

3 Results and Benefits Achieved

Beach was an innovative project improving connectivity for small businesses in Worthing and acted as facilitator for new commercial models. Beach deployed 4G/5G networks on existing and new local authority assets in Worthing to prepare for scale roll out.

Specifically, Beach undertook research and development activities to address challenges associated with mobile network deployment for seasonal and event-based HDD scenarios from economic, energy efficiency and end-user service experience perspectives.

Key results and benefits:

1. Developed a new 5G small cell prototype motherboard for test building on technology originally developed in the CoMP-O-RAN Project, to incorporate a new 5G chipset developed by IONX and EdgeQ, which will in the long term be integrated into new form factors to meet small cell physical requirements.
2. A new neutral host platform: 'cellShare' that will enable hosting of multiple Mobile Network Operators (MNOs), Private Networks on one cell, and when clustered, will provide coverages for all MNOs across the number of cells deployed.
3. The network design allowed the integration of at least one UK MNO and will be open to other MNOs post project. The implementation of the Open Network HDD solution was based upon compatibility with the nascent UK JOTS (Joint Operator Technical Specification) for multi-MNO outdoor deployment (NHOD).
4. The WSCC and WBC assets have been designed to be future ready to ensure that multi radios can be installed onto them. There is sufficient space within the cabinet base that, with added cooling, could host more equipment.
5. Developed open access code agreements with WSCC and WBC which shaped a route to engage third party operators with code powers to commercialise the legacy of the BEACH Project.
6. Developed an energy efficiency simulation and bench testing methodology to evaluate the energy efficiency of 5G Networks. Taking ORAN and traditional network energy efficiency models, the RAN intelligent controller (RIC) simulation projected high and low efficiency demand.
7. An enhancement to IONX's denseWare platform with an interface linking Sitenna's asset management platform with denseWare to accurately identify useable local authority assets with an overlay of current network cell performance. A baseline was created and correlated data post deployment to validate the effective planning of the network.
8. A network performance application was created to report the performance of the network with the ability to provide data on cell installation, cell and network performance and user numbers.
9. Delivered a sustainable user experience improvement for the citizens of Worthing which includes the 'My Worthing' mobile application, developed by West Sussex County Council as part of the project. This application allows users to agree to have

their connectivity experience monitored for the purpose of understanding the performance of the public mobile network they are using.

10. The security framework provided at the outset a good model for future projects across the security space. Taking the risk-based approach allowed the project to ensure that the adopted products and solutions came from a fundamentally sound set of vendors.

4 Beach Security Framework and Strategy

A security framework was established with set deliverables and a timeline encompassing each of the areas responsible across all consortium partners. The security framework covered four core areas matching the key open Networks Ecosystem (ONE) for High Density Demand (HDD) requirements: product, development, deployment and working level security. This framework was implemented for the initial three phases of the project. It was based on a risk treatment model, and to underpin it the initial delivery was to assess each of the consortium partners security posture using the NCSC March 2022 Vendor Risk Assessment Document. Building networks by known partners and vendors, who have previously demonstrated their approach to product lifecycle management reduced the risk the project was carrying. Having good quality high-level and low-level designs also reduced the risk from a security perspective.

A process was created that examined the quality of the security being applied to the design, deployment, test and optimization of cellShare platform, JOTS compliant venues, network and physical access controls. A security audit was carried out by a third-party security consultant who provided a series of advice, recommendations and requirements for a secure product designed to be deployed in vulnerable environments.

A Terms of User Agreement was established with the concessions outlining the relevant conditions for using the equipment. Pen testing was conducted in the following areas: external pen testing, internal pen testing, configuration review, build review, API testing, remote and physical access scenario testing.

Physical security of external assets was delivered with locked mounting of the nodes in the Worthing area. Had there been any issues with tampering of the nodes, this would have raised alarms to the Lead Partner's internal NOC directly. This is part of the Incident response approach to the Beach network security.

The Beach security framework was also combined with operational integrity, including a security operational (SecOps) framework, which intended to cover monitoring, detection and response, all to ensure project meet both the project product development security process, and industry security standards, including meeting the requirements of the Telecoms Security Act 2021 (TSA).

To mitigate the impact of Cyber security incidents, an incident response plan (IRP) was in place during the life of the project. Threat Assessment and Remediation Analysis (TARA) was undertaken across all partners. This TARA was based on NCSC March 2022 guidelines.

The BEACH project sought the use of standardized security practices in the project to both enhance the total solution security and also support interoperability between system components and organisations. The following sources were used:

- The JOTS working group has a defined set of architectural and organizational security mandates required by UK operators in order to provide service.
- The Internet Engineering Task Force (IETF) guidelines were used in a number of areas
  - Public Key Infrastructure (PKI)
  - Certificate Management (CMP)
  - Key Exchange (IKE)
  - Secure Boot

The International Telecommunication Union (ITU) standards were used for certificate and cryptographic key formats and handling.

5 High level summary of project costs

5.1 High level summary of Beach project costs

Total Project cost by Category	IONX (Formerly Dense Air)	Radisys	Satara Technologies	University of Glasgow	West Sussex County Council	Total
Labour	3,877,069	2,955,597	40,853	196,194	596,790	7,666,503
Overheads	775,414	591,119	8,171	266,741	82,803	1,724,248
Materials	1,373,326	0	138,512	0	582,267	2,094,105
Capital Usage	0	0	0	0	918	918
Sub Contract Costs	1,072,363	612,645	47,924	0	1,064,631	2,797,563
Travel and Subsistence	31,186	150,667	900	10,784	1,534	195,071
Other Costs	354,095	0	349	154,832	27,232	536,508
Total project cost	**7,483,453**	**4,310,028**	**236,709**	**628,551**	**2,356,175**	**15,014,916**
DSIT Funding	**2,993,381**	**1,724,011**	**142,025**	**502,841**	**2,356,175**	**7,718,433**

Baseline project cost	**7,500,003**	**5,845,422**	**236,708**	**628,939**	**2,963,280**	**17,174,352**
Baseline DSIT Funding	**3,000,001**	**2,338,169**	**142,025**	**503,151**	**2,963,280**	**8,946,626**

Over / (Under) spend vs baseline

Project cost variance	**(16,550)**	**(1,535,394)**	**1**	**(388)**	**(607,105)**	**(2,159,436)**
DSIT Funding variance	**(6,620)**	**(614,158)**	**0**	**(310)**	**(607,105)**	**(1,228,193)**

	Baseline	Latest	Variance
DSIT Funding	8,946,626	7,718,433	**(1,228,193)**

Table 1 – Project Costs

5.2 High level Summary of Beach Equipment Costs

Summary	Amount	DSIT Funding
Claim 1	516,563.09	228,625.24
Claim 2	21,992.34	13,195.40
Claim 3	245,076.64	245,076.64
Claim 4	946,977.60	489,776.69
Claim 5	273,733.90	177,171.08
Claim 6	89,762.04	60,860.12
Total	**2,094,105.60**	**1,214,705.17**

Table 2 – Equipment Costs

5.3 High level Summary of Beach Deployment Costs

Item	Total Cost (Capex)	Total Cost (Opex)
Deployment of Assets (inc. design, power and traffic management etc)	535,210.98	N/A
Energy Usage	N/A	9,653.94
Worthing Fibre and Data Centre Facility	462,967.76	22,600.00
Small Cell Deployment	58,019.79	N/A
Legal Agreements*	34,350.89	N/A
Lease Fees**	N/A	3,121.32
Use Case Deployment	15,266.12	N/A
Total	**1,105,815.54**	**35,375.26**
* *Includes legals fees for both WSCC and WBC.* ** *Lease fees were pro-rata for the duration the radios were deployed*		

Table 3 – Deployment Costs

6 Project Highlights

The Beach project was announced to the public and industry on 14 September 2023 in a press release jointly issued by DSIT and WSCC on behalf of IONX (formerly Dense Air) and the consortium in accordance with the Media Protocol.

A correspondence process was established to drive public enquiries online through the Beach website. A comms process flow was agreed between IONX, WSCC, WBC and subcontractors LandBuild to manage any enquiries received additionally through the two council's Contact Centres and directly to contractors working on the ground.

The 5th November 2023 firework display event on Worthing seafront was used to baseline the characteristics of an operator networks during a High Demand Density (HDD) event. The purpose of the data collection activities was to build up quantitative and qualitative evidence that high density events cause degradation in the extant operator networks. The hypothesis was that during the fireworks display MNO networks would show a significant degradation in their performance. Performance was measured though NQT, IONX's mobile application used to collect network performance measurements and Ookla Speed test.

In February 2024 the Beach team met the UK Minister for the Department for Science, Innovation and Technology at Mobile World Congress in Barcelona. During this meeting, although very early on the project, they jointly discussed the significance of the project, the goals and future opportunity in the telecoms space for UK industry.

In April 2024, WSCC and IONX Air jointly presented the BEACH project at the Small Cells World Summit event, held in London. They presented the goal of the project and the use of

small cell technology to deliver digital transformation in areas of High Demand Density (HDD).

Cenex 2024 provided the Beach project team an opportunity to disseminate the significant progress that had been made during the project to the public and invited representatives from both DSIT and the MNOs. The team put together print, video and presentation collateral to showcase the scale of the deployment in Worthing and the progress that had been made in the development of the small cell technology.

In March 2025, the Beach closure event hosted by WSCC took place in Worthing. During this event partners discussed Beach originally looked like, what it was intended to achieve, and the key benefits realised through the project. An overview of the private 5G use case for the West Sussex County Council Private Network in Worthing was provided with the focus on providing robust connectivity for point-of-sale transactions during a high-density demand period where public networks have challenges. Site planning and deployment challenges, development of the 5G streetCell V2 and validation process to achieve a ground-breaking integrated board capable of hosting more than one MNO were highlighted. Discussion of challenges faced, and successes were celebrated, notably the integration of an MNO to use the cellShare platform during the project.

Informing all challenges is the goal of a JOTS compliant outdoor capability, and the realisation of a long-term sustainable commercial model for accelerated commercial investment by operators in the town.

7 Project Conclusions

The BEACH project scope was ambitious in that it encompassed research, development, deployment and integration phases. In hindsight the reality of aligning and completing execution of these phases within a constrained timeline presented a challenge. The reality of external timelines influenced the project in a number of key areas. Future similar projects should be based on a 24-to-36-month funding period. Recognition that these projects are in the live environment and subject to change. Agility should be built into the project culture and founders should recognise the value of stretched targets and outcomes.

The development of the streetCell concept, design, build of prototypes and subsequent integration of the prototype with an operator 5G core represents a major step forward in the support of neutral host services in the UK, executed in a relatively short period. The integration also represents validation of the JOTS framework to promote cost effective neutral host service extension to the operators at a time when their budgets are constrained, and they are investigating alternative means of servicing their customer base.

It should be noted that many assets in Worthing town centre fell under the Private Finance Initiative (PFI) contracts for utilizing lighting columns. Due to the PFI contract restrictions these were not available to Beach.

The administrative overhead on the project was significant. Claim processes were cumbersome and heavily reliant on repeated manual submission of information, utilized excels sheets, resulting in a very inefficient process. The changes which were applied to the

ONE Projects to simplify the reporting process compared to the original FRANC Competition process made the administration more complicated. Particularly separating the milestones from the claim payments. Any minor errors cascaded through the project administration and took time to discover and remedy. Interpretation of these amendments caused confusion. The process should be automated.

Beach was an innovative project aimed at improving connectivity for everyone and small businesses and getting Worthing small cell network ready. Project allowed assets already existing in Worthing to be replaced for multi-purpose use for signage, future proof IoT, and to enable UK operators to deploy small cells to improve connectivity.

Beach also developed an open-access code agreement in partnership with WSCC and WBC to allow cell installation for more than one operator. The code agreement creates an ease of engagement with both WSCC and WBC. It has shaped a route to engage third party operators with code powers to commercialise the legacy of the BEACH Project.

In addition to the above, Beach proved to be a valuable reference network for adoption of JOTS neutral host outdoor infrastructure within the UK. The Beach project acted as a springboard for new commercial models that allow the market to provide investments into new areas. Worthing now finds itself at the front of the queue for 4G and 5G commercial investments.

8 Next Steps

Beach deployed two discrete networks within the Worthing Sea-front area in two phases:4G and 5G private Networks. The BEACH consortium members including West Sussex County Council partnered with Adur & Worthing Councils to deploy an HDD network along the beach front, town centre and main road coverage of Worthing in West Sussex, to support multiple use cases for the town's tourism management and cultural events. The planned network was to be developed and integrated with at least one UK MNO with the possibility of further MNO utilizing the network at a later stage.

The deployment of phase 3 was rescoped during the project based on an external prototype not being available in the timeline. The deliverable changed to delivering a network in a box, a pilot using the 5G streetCell version two PCB incorporated in a box to trial against MNO sandbox core. A key aspect of the project has been the creation of shared Open RAN, which would host UK MNOs and Private Networks using both MOCN and MORAN 3GPP sharing schemes. At the time of the GFA award there was no such technology or solution in existence for this type of outdoor deployment. The original intent was to deploy 5G prototype cells in Worthing to accommodate one MNO and the 5G Private Network.

BEACH has provided a legacy of SMART infrastructure, both a 4G and Private 5G network deployment for MNO's and Operators to expand and build upon. A pathway to commercialisation including the commercial agreement templates for MNO's, Operators, and JOTS compliant Network infrastructure has been created. All networks were deployed in a challenging environment, providing the opportunity to replicate and scale the model for

other challenged seaside towns with similar topography and connectivity issues, thus creating a market solution and sustainable business opportunities.

The BEACH Project has left a legacy for a route to sustainability. These are:

- Legacy infrastructure, Columns fibre power all in place
- Radio units for further development
- Legal pathways for commercialisation for other third parties
- A user application promoting connectivity in Worthing
- The basis of a portfolio of future Multi Host RU Technology
- A multi-host MNO cellShare platform

The following benefits are expected to be realized post BEACH closure.

- Worthing Commercialisation of the WSCC assets
- Worthing 4G network integration with MNO live core network in Worthing
- Millbrook JOTS compliant venue integration with MNO live core
- Commercialisation of the WSCC Private 5G network
- Development of further public and private sector use case development
- Commercialisation of the StreetCell Version 2
- Commercialisation of cellShare platform

IONX will continue working on the creation of a flexible arrangement that, in the future, could allow the RAN solution to be deployed on both larger international and smaller UK/European vertical street assets.

9 Media Library

The Connected BEACH Wrap

The Connected BEACH Wrap Final

Figure 1 -The Beach Wrap Video

The Connected BEACH Project

http://www.theconnectedbeach.co.uk

A correspondence process was established to drive public enquiries online through the Beach website. A comms process flow was agreed between IONX (Formerly Dense Air), WSCC, WBC and subcontractors LandBuild to manage any enquiries received additionally through the two council's Contact Centres and directly to contractors working on the ground.

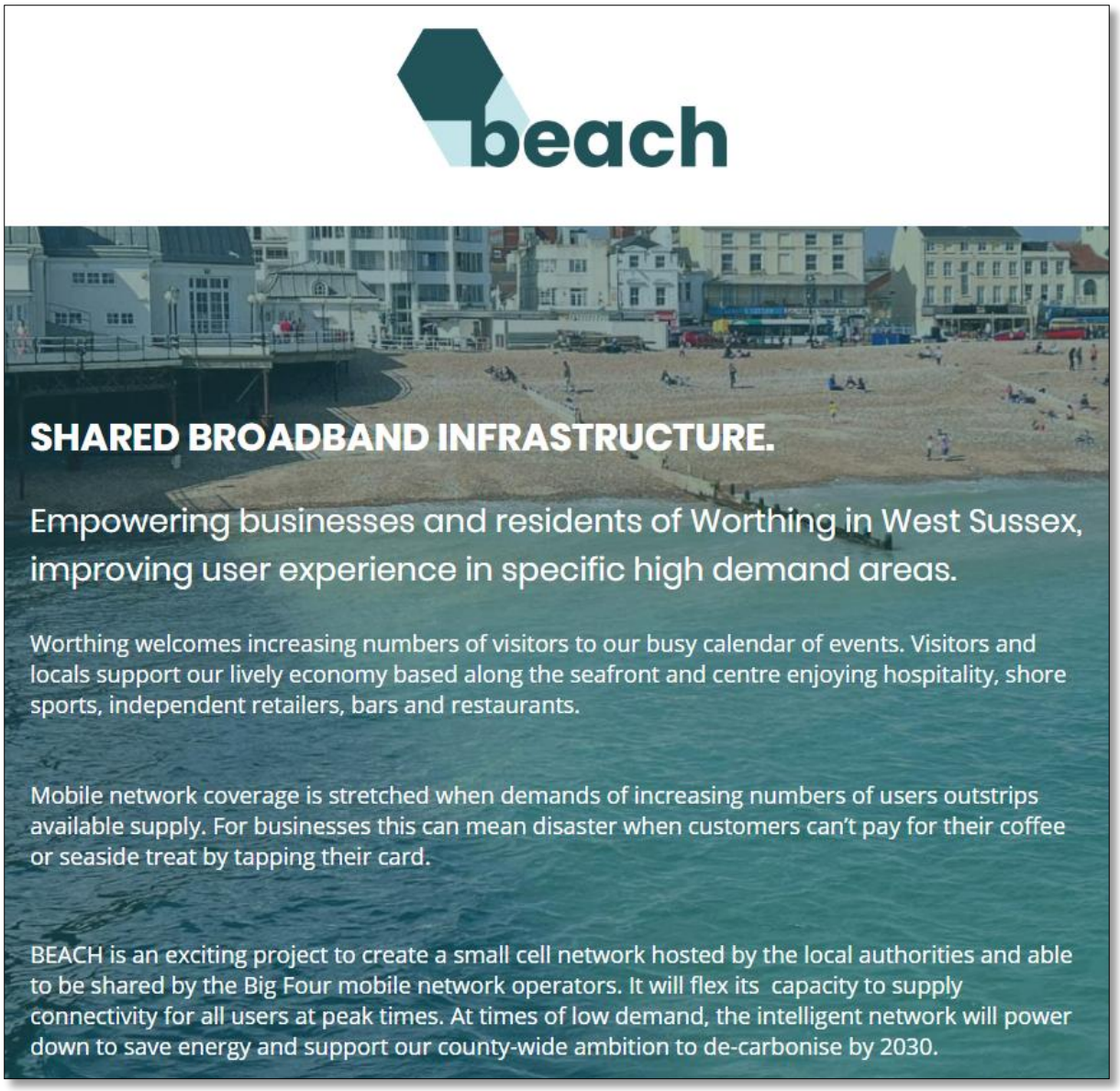

Figure 2 -The Connected Beach website

Worthing 'gets better connected': 4g/5g small cells technology to be installed - Sussex Express

Sussex Express

Plans have been put in motion to bring high speed 5G access to more than 100000 people in Worthing.

Local authorities win funding for 5G connectivity projects - UKAuthority

UKAuthority

West Sussex Council is among those to be involved in a project, in this case BEACH (Worthing), which has received £3.1 million to deploy low ...

Government Awards £88m to 19 UK 5G Open Network Projects - ISP Review

ISP Review

BEACH is led by Dense Air, with partners West Sussex County Council and technology providers Radisys UK, VM Ware, Sitenna, and the University of ...

Stadiums and tourism hotspots to test new 5G networks in £88 million scheme | The Argus

The Argus

The Government has announced 19 projects and locations around the country will trial new innovative types of 5G networks to boost connectivity.

UK Government invests £88m in Open RAN 5G research and development - Mobile Europe

Mobile Europe

Dense Air, West Sussex County Council, Radisys UK, University of Glasgow, Sitenna and VMware received £9m to implement an energy-efficient shared

10 Photo Library

Figure 3 - 4G radios under test during staging process

Figure 4 - Pole foundation steps

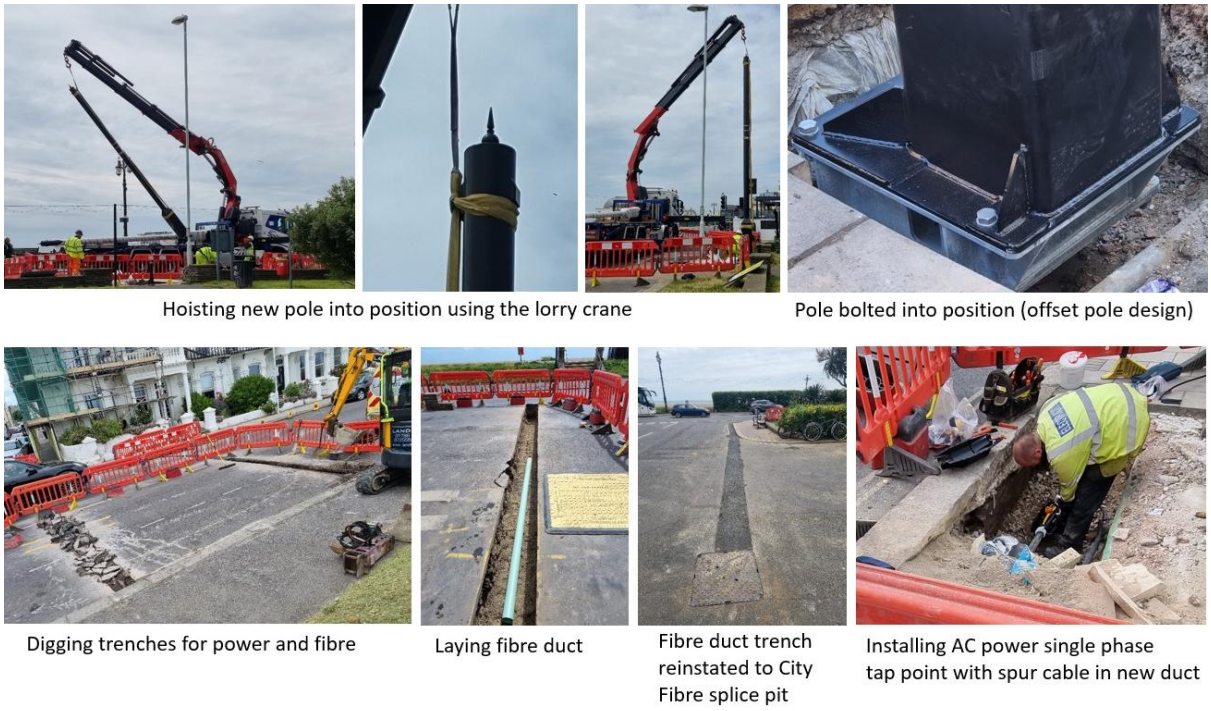

Figure 5 - Hoisting and securing the poles and cable duct work

Figure 6 - Completing the ducting and re-instating the pavements

Figure 7 - Pole base preparations and electrical testing

Figure 8 - Securing the site and initial radio installation steps

Figure 9 - Completed pole sites with 5G radios (also with 4G radios)

Figure 10 - Examples of the 4G radio poles in Worthing

Figure 11 - Close up comparison view of the 5G radio assemblies before and after fitting black camouflage antenna panels

Figure 12 - Comparison view of poles with and without antenna camouflage as seen from street level

Figure 13 - My Worthing App poster

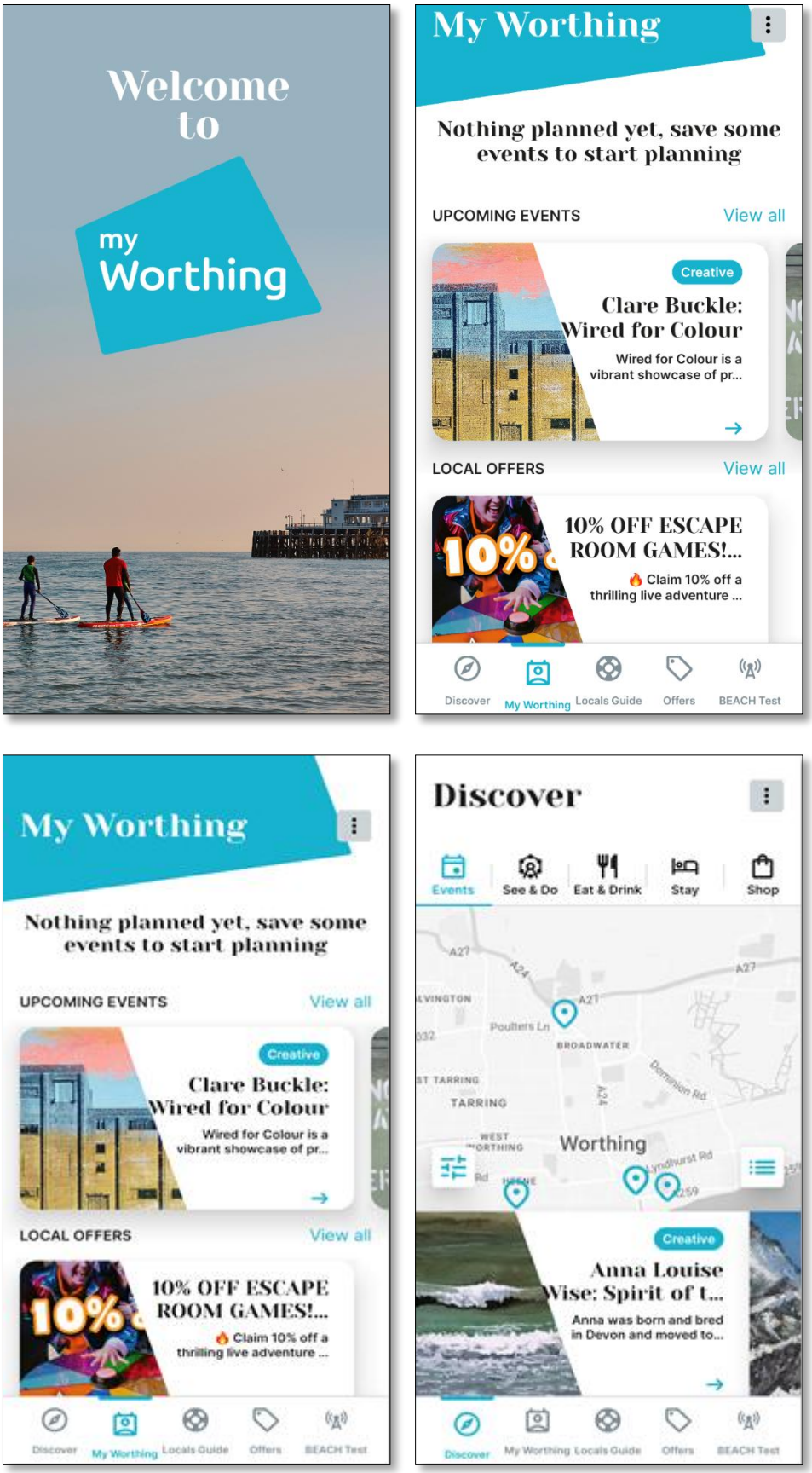

Figure 14 - My Worthing App

11 Key Achievements and Lessons learnt

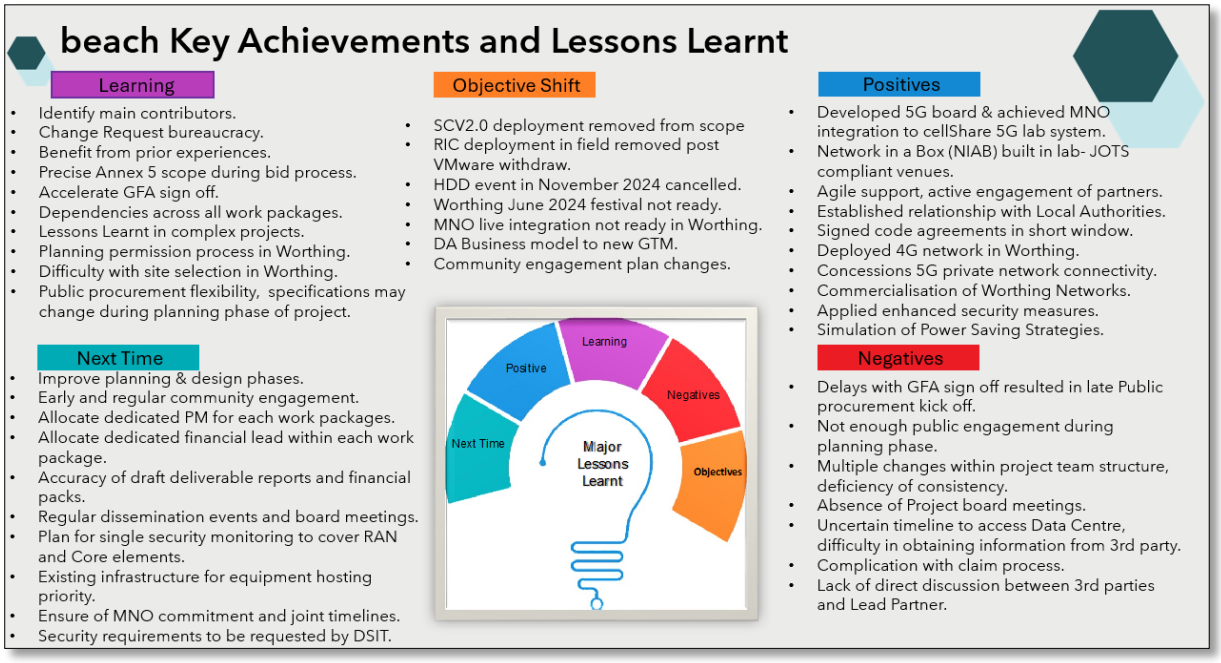

Figure 15 - BEACH Key Achievements and Lessons learnt