Aura project closure report

March - 2025

Version History

VERSION	DATE	DESCRIPTION OF CHANGE	AUTHOR
1.0	March 2025		DSGC

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1 INTRODUCTION

Executive summary

The Aura project has met the vast majority of its goals:
A low-power Active Antenna Unit (AAU) and a high-power AAU were designed in the UK, and prototype runs of each have been successfully tested and are currently under evaluation with several Customers, one of which is BT.
The AAU designs have been shown to draw less than 70% (and in some cases less than 50%) of the currently deployed offerings, with the same throughput and illumination levels. This makes an outstanding case for a 'strip and replace' approach to existing equipment.
The AAUs have been designed in a modular way so that variants using different bands or output power levels are easier to produce.
Several additional hardware engineers have been employed at Parallel Wireless and have a full forward-looking workload designing platform variants for global MNOs.

Introduction

This document is a closure report for the Aura project, executed under the UK DCMS/DSIT *open network ecosystem* (ONE) program. In this report we provide an overview of the project's design and operational elements, as well as an assessment of the project's success against its objectives and intended benefits, which were summarised in the project's application form:

Project AURA (Agile Universal Radio Architecture) will develop a cost reduced, energy efficient and flexible Open RAN radio Unit (O-RU) product range based on modular architecture. The AURA O-RUs will be developed with an emphasis on flexibility to target different frequency bands and form factors. With configuration requirements being provided by Parallel Wireless' Program Line Management as well as BT, and with input from Real Wireless based on a review of target deployment scenarios, the focus is on manufacturability for real world 2G/4G/5G commercial deployments.
AURA brings together Parallel Wireless Ltd UK (PW), BT Plc, CSA Catapult Semi-Conductors and Cardiff University, to improve the AAU through research and innovation in three core areas:

a. ***The RF front end – including the power amplifier and front-end filtering, notably including an innovative resonator filter to be developed by Parallel Wireless and aiming to eliminate the requirement for a costly and complex cavity filter in the RF front end.***

b. ***The power amplifier will be transitioned from the initial commercially available silicon technology towards customized GaN integrated amplifiers optimized for the power classes needed for Parallel Wireless architecture.***

c. ***The tight integration and control of RF transceivers – providing conversion between digital baseband and low power RF – within the architecture of the radio, led by Parallel Wireless, again with the objectives of simplifying the overall design, improving performance and manufacturability.***

d. ***The Baseband module – including baseband processing, O-RU control software and the fronthaul interface – which will be developed or integrated by Parallel Wireless in a flexible manner to enable the first-generation products.***

The new components will not be limited to silicon development but will include GaN and GaAs elements.

Our goal is to create a new range of active antenna units (AAUs), a low power minicell and a high-power macrocell. These two configurations will use common sub-assemblies and firmware/software. They will have innovative architecture and sub-assemblies that will be developed by the partners during the project.

The Aura partners: Parallel Wireless, BT, University of Cardiff and CSA catapult, are extremely grateful to DCMS/DSIT not only for their financial support but also for the guidance of their teams through the delivery of the project.

1.1 References

Ref	Doc number and version	Title
[1]	Aura MS01	Product requirements and product designs
[2]	Aura MS02	Macro product components complete
[3]	Aura MS10	Low power product integrated with O-DU
[4]	Aura MS15	Macro product operational and integrated with PW DU
[5]	Aura MS24	Final project evaluation

1.2 Abbreviations

Term	Definition
ASIC	Application Specific Integrated Circuit
BBDev	Baseband Device (in DPDK)
CLI	Command Line Interface
CN	Core Network
CP	Control Plane
CPE	Customer Premises Equipment
CPU	Central Processing Unit
CU	Central Unit
DCMS	Department for Digital, Culture, Media and Sport
DL	Downlink
DPDK	Data Plane Development Kit
DU	Distributed Unit
FAPI	Function Application Platform Interface
FEC	Forward Error Correction
FECA	Forward Error Correction Accelerator
FFT	Fast Fourier Transform
FH	Fronthaul (DU-RU interface)
FRANC	Future of RAN Competition

Term	Definition
GM	Grand Master (PTP reference clock)
GP-CPU	General Purpose CPU
gNB	5G basestation
GUI	Graphical User Interface (RFC 6241)
LDPC	Low Density Parity Check
NETCONF	Network Configuration protocol
NIC	Network Interface Card
NR	New Radio (5G)
O-RAN	Open RAN
OTA	Over The Air
PCIe	Peripheral Component Interconnect express
PDCCH	Physical DL Control Channel
PDSCH	Physical DL Shared Channel
PRACH	Physical Random-Access Channel
PTP	Precision Timing Protocol (IEEE-1588)
PUCCH	Physical UL Control Channel
PUSCH	Physical UL Shared Channel
RAL	(Arm) RAN Acceleration Library
RAN	Radio Access Network
RISC	Reduced Instruction Set Computer
RRH	Remote Radio Head
RU	Radio Unit
SCF	Small Cell Forum
SDK	Software Development Kit
SIMD	Same Instruction Multiple Data (vectorisation)
SoC	System on a Chip
SOW	Statement Of Work
SRS	System Requirements Specification
SRS	Sounding Reference Signal
SSB	Synchronization Signal Block
TDD	Time Division Duplex
TTI	Transmission Time Interval
UL	Uplink
UP	User Plane
VBBU	Virtualised Baseband Unit

2 CONTEXT

Over the past 15 years the wireless communications industry has begun a profound transformation, triggered by technological improvements. This transformation started with advances in CPU and datacentre technologies, driven by industries of the internet era including video on demand, social media and banking, and resulted in the commoditisation of compute platforms.

In 2016 Facebook, Intel and Nokia founded the Telecom Infra project to federate the efforts of technology vendors, RAN equipment manufacturers, integrators and operators, towards a goal of reducing the cost of communications infrastructure and make these accessible to most.

In 2018, 5 operators (AT&T, China Mobile, Deutsche Telekom, NTT DOCOMO and Orange) founded the O-RAN Alliance industry group to define standard interfaces and "organise" the ecosystem to be more open and interoperable.

The benefits of these approaches are clear: Open interfaces enable more players to enter the RAN infrastructure market, increase competition and as a result accelerate innovation and change. Generic COTS platforms enable economies of scale and a reduction in Capex. Standard tools, virtualisation and cloud-based technologies enable scalability, agility and reduced Opex.

The first part of the network to undergo this change was the core network. Industry focus has now turned towards the more technically challenging RAN.

Parallel Wireless was founded in 2012, with a vision to embrace technological evolution to transform mobile networks and make them more efficient, sustainable, and cost effective. Parallel Wireless initially developed base-station equipment utilising telco specific system-on-a-chip (SoC) components and started its transition to COTS platforms by facilitating the integration of these base-stations towards the core of the network, with products such as its HetNet Gateway (HNG). The company then became an early adopter of Intel's FlexRAN and began its evolution to a full vRAN approach. Uniquely Parallel Wireless had the vision to adopt this approach not only for 4G and 5G but also for legacy technologies such as 2G and 3G, understanding the importance of a full portfolio in brown-field deployments. Over the past 10 years Parallel Wireless has developed a recognised competency in the understanding of CPU architecture, in particular GPP-based platforms, and the application of this knowledge to the RAN. In the last couple of years Parallel Wireless has begun to make its own FlexRAN hardware and the Aura project represents a significant step forward in this direction.

In addition to the hardware development, the Aura project aims to address two secondary objectives:

The University of Cardiff is developing a capability and intellectual property in the high efficiency power amplifier area. CSA catapult is looking at potential UK manufactured GaN devices for commercial use such as the AAUs developed under Aura.

3 AURA ARCHITECTURE AND DESIGN

To validate and demonstrate the Aura low power and high-power AAUs, a full end-to-end architecture was developed and integrated during the project. This is presented in the project's High-Level Design (HLD) document [1]. The main components comprise:

- A novel architecture wherein the power is generated next to the relevant antenna elements to maximise AAU efficiency
- A range of sub-assemblies: RF front ends (RFFEs), RF multiplexers/filters, software defined radios using FPGA based RF SoCs, all built using new ideas and techniques which outperform the leading edge of what is available off-the-shelf.
- Build and test the two fundamental AAU architectures (low power and high power)

Figure 1: Picture of low-power and high-power Aura AAUs

3.1 High power AAU architecture

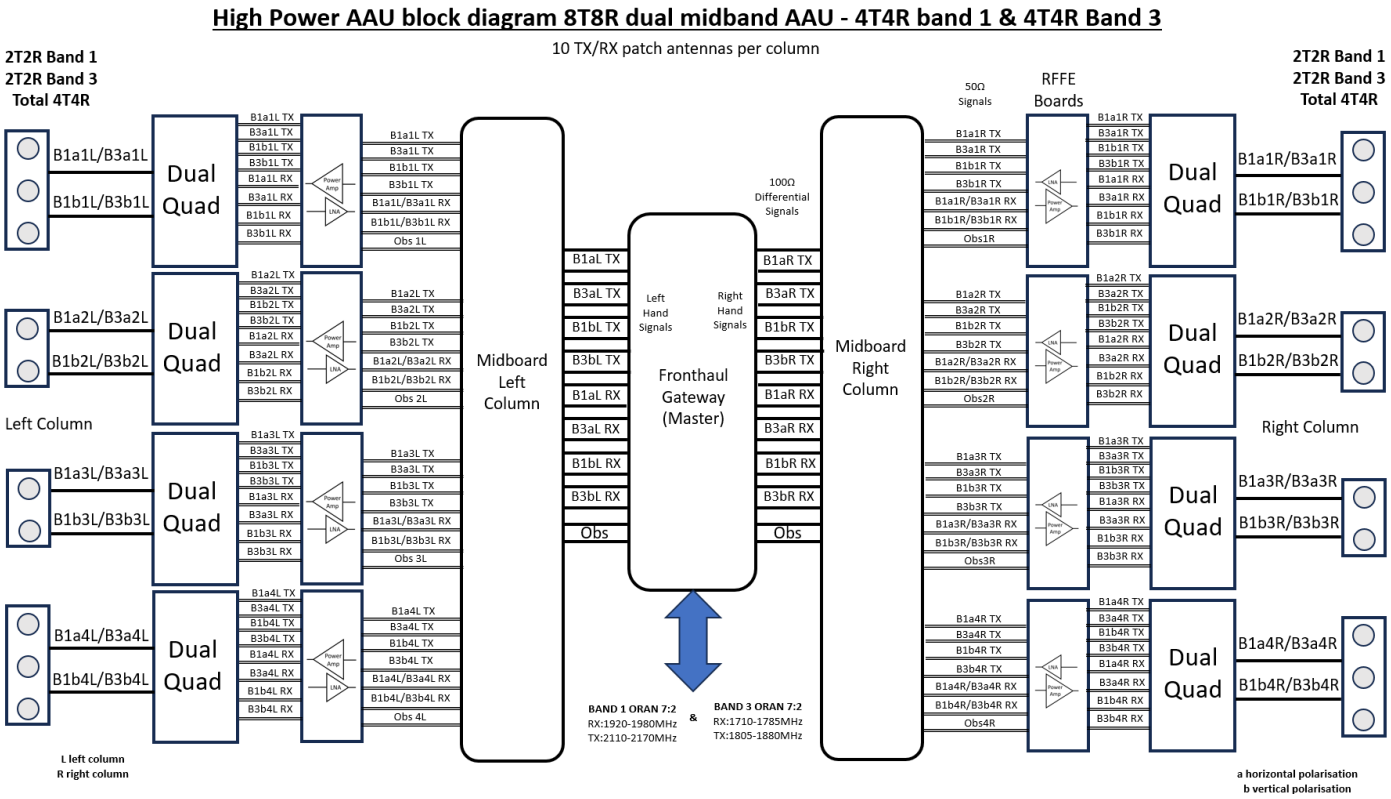

Figure 2: Block diagram of high-power AAU

The key elements adopted by the Aura team as the basis lowering the amount of DC power required to illuminate a given area are:

- Move the PA closer to the antenna element:
  remote radio head deployments at mid band typically have more than 3dB loss between the power amplifier output and the radiating elements, at low band this drops to 1.9dB but it is still significant. By re-laying out the system the required dc power to generate a given field strength is substantially lowered, since nearly all the power generated is directly delivered to the radiating elements.

- Reduce the filtering loss:
  Parallel Wireless will introduce a new type of microwave filtering structure called cylindrical dual mode (CDM). This will have a similar size, weight and cost to traditional all metal filters, but it will have much lower insertion loss.

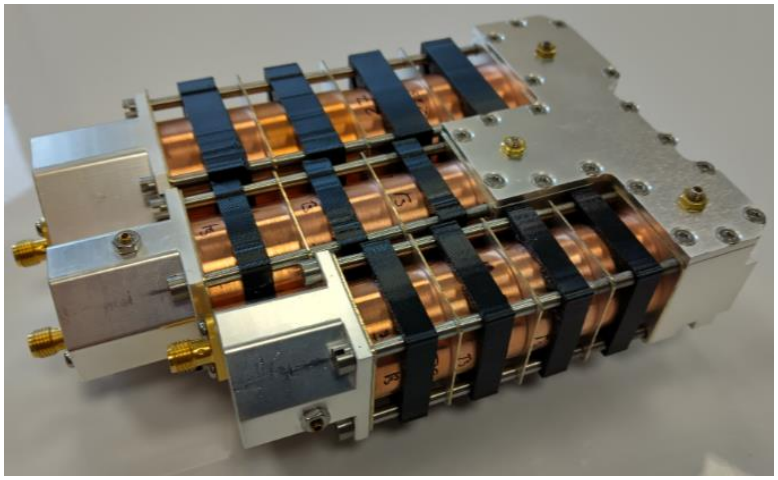

Figure 3: PW CDM triplexer

- Improve efficiency of power amplifiers:
  new higher efficiency power amplifiers will be developed between Cardiff University, CSA catapult and Parallel Wireless.

3.2 Prototype build process

Five prototypes of each of the two types of AAU have been built by Parallel Wireless for the purposes of test and verification.

3.3 Test and verification

A comprehensive verification and validation framework has been developed – again as per Parallel Wireless standard development process. This is documented in the project's test strategy document [5] and covers the following stages:

- Module level unit tests:

  These are a series of RF and DC tests performed on each sub-assembly to ensure compliance to the relevant specifications.

- Conducted system tests:

  Once the AAU is assembled the whole system is initially test without connecting the antenna to show compliance (3GPP and internal requirements)

- Anechoic chamber tests:

The antenna is connected, and the AAU is mounted on a pole inside an anechoic chamber for detailed radiation pattern and field strength measurements.

- Drive tests:

  The unit is mounted on an exterior pole and tested by connecting several UEs (pieces of user equipment or phones) at various locations and in cars. This allows an end-to-end functional validation to be performed.

The final level of integration in the project is an end-to-end deployment using commercial phones. This was achieved initially at the Parallel Wireless lab, then reproduced at the University For these tests the commercial phone used was primarily a Samsung S22 handset, capable of operating in the n77 band used in the testbed.

4 SUB SYSTEM IMPROVEMENTS

4.1 Filter technology

During the last 35 years most of the base station filtering has been done using metal cavity filters. This is a very useful medium: it covers a wide range of frequencies and bandwidths, it is scalable (loss vs size) and it is robust and can be made to meet the stringent passive intermodulation requirements of modern diplexed (FDD) systems.
Parallel Wireless has developed an alternative filtering medium – cylindrical dual mode – that gives better loss per unit volume than the all-metal equivalent, whilst being comparable in size, weight and cost.

4.2 Power amplifier efficiency

At this point the project begun most deployed power amplifiers had full chain efficiencies of around 40% when amplifying OFDM (high PAPR) signals. During the project the team came up with a variety of different approaches multi-level Doherty, asymmetric Doherty, balanced load pull

4.3 Front Haul Gateway (FHGW)

During the Aura project the hardware and software for the FHGW was developed.

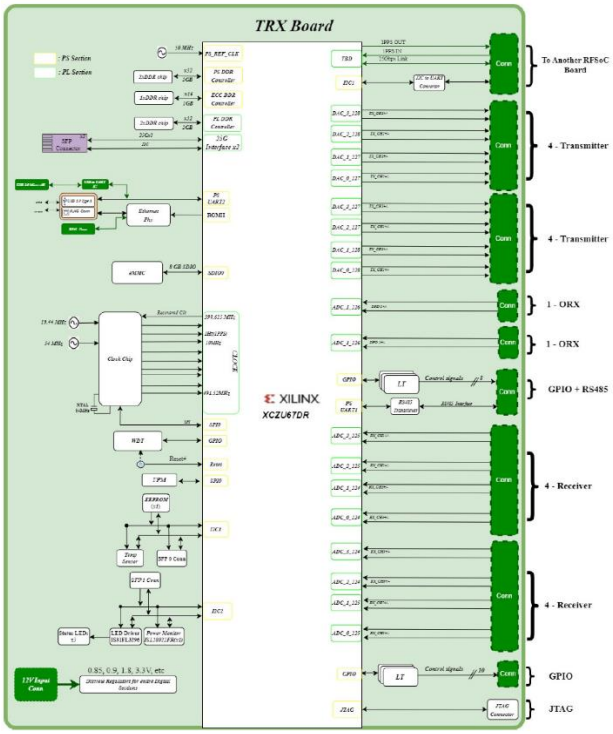

Figure 4: Block diagram of FHGW

4.4 All-in-one unit using a single board computer

The AIO concept was introduced in AURA's CR2 change request and developed to TRL3. A single board computer (SBC) board has been designed based on PW's requirements through a 3rd party design house in India, with prototype boards expected back to PW UK in July 2025. In the meantime, PW is continuing the platform and application software enablement work in collaboration with SUSE and Ampere, using COTS platforms. Our goal is to integrate the SBC with the AURA radio in Q4'25 and to then enable a product in an AIO enclosure by Q1'26.

5 TEST RESULTS FOR LOW-POWER AND HIGH-POWER AAUS

One of the key results from the high-power macro testing is the dc power consumption (from MS25 [5]):

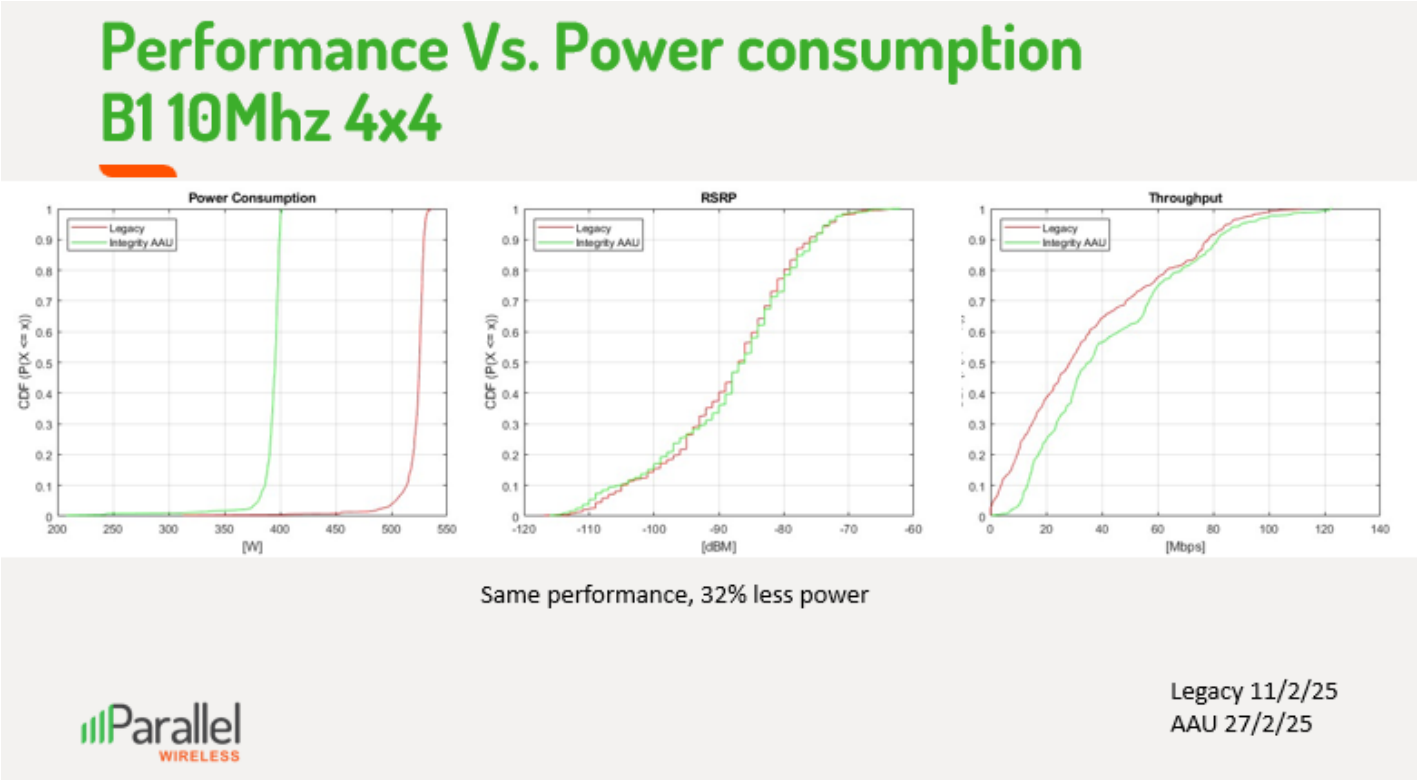

Figure 5: Drive test data for high-power Aura AAUs showing 32% dc power saving for the same rf performance

These results give the AAUs designed as part of the Aura product a compelling unique selling point; a much lower operating expenditure, typically saving the initial cost of the units in less than three years. This should turn into a good number of orders for these AAU's and a steady flow of work for the expanded UK design team. The work to lower the power requirements still further continues and the goal is to reduce all dc power reqirements to one quarter of the level of currently deployed units.

6 PARALLEL WIRELESS PRODUCT PORTFOLIO

The high-power macro-AAU and the low power mini-AAU are both due to undergo testing at key Customers in the next three months. Parallel Wireless aiming to get good size orders for these products in the next twelve months
The module-based approach taken in the Aura project allows Parallel Wireless to offer a range of different AAUs, using custom combinations of bands and unit sizes to appeal to all MNOs.

7 PROJECT OPERATION

The Aura project was an ambitious project which mobilized a large team over a long time. Over the 21 months of its execution, we enjoyed a close level of collaboration with DSIT and with our partners, in particular the University of Bristol, BT, and CSA catapult.

What worked well:

- The regular monthly technical and quarterly project meetings provided an appropriate cadence during the first half of the project.
- As we approached the full AAU testing phase of the project, increased face-to-face interaction with the team at the University of Cardiff and CSA catapult was important, and face-to-face meetings were very helpful.
- The DSIT team have been extremely supportive, and it has been impressive to see how involved they remained throughout. This has been particularly important as we have dealt with problems such as the changes catalogued in the change notices.
- The DSIT funding received through the project provided a great incentive for Parallel Wireless to further its investment in our UK team. We have four additional people in our dedicated hardware team in Harrogate.

What didn't work so well:

The main issue faced in the project was Kandou dropping out, and this was coped with by the change to the goals and the addition of the University of Cardiff and CSA catapult to the program.

7.1 High level summary of project costs

Partner Cost

Partner / Claim		1		2		3		4		5		6		Total
Parallel Wireless UK Limited	£	124,538.12	£	152,653.80	£	109,436.12	£	170,155.92	£	262,121.35	£	485,559.74	£	1,304,465.06
BT plc	£	944.78	£	320.37	£	3,463.50	£	6,507.35	£	-	£	-	£	11,236.00
Compound Semiconductor Applications Catapult	£	-	£	-	£	-	£	-	£	-	£	-	£	-
	£	125,482.90	£	152,974.17	£	112,899.62	£	176,663.26	£	262,121.35	£	485,559.74	£	1,315,701.06

DSIT Cost

Partner / Claim		1		2		3		4		5		6		Total
Parallel Wireless UK Limited	£	186,807.18	£	228,980.71	£	164,154.19	£	255,233.87	£	393,182.02	£	728,339.62	£	1,956,697.58
BT plc	£	629.86	£	213.58	£	2,309.00	£	4,338.23	£	-	£	-	£	7,490.67
Compound Semiconductor Applications Catapult	£	-	£	-	£	41,450.73	£	283,074.81	£	256,887.58	£	328,835.79	£	910,248.91
	£	187,437.04	£	229,194.29	£	207,913.92	£	542,646.92	£	650,069.60	£	1,057,175.41	£	2,874,437.16

Total Cost

Partner / Claim		1		2		3		4		5		6		Total
Parallel Wireless UK Limited	£	311,345.30	£	381,634.51	£	273,590.31	£	425,389.79	£	655,303.37	£	1,213,899.36	£	3,261,162.64
BT plc	£	1,574.64	£	533.95	£	5,772.50	£	10,845.58	£	-	£	-	£	18,726.67
Compound Semiconductor Applications Catapult	£	-	£	-	£	41,450.73	£	283,074.81	£	256,887.58	£	328,835.79	£	910,248.91
	£	312,919.94	£	382,168.46	£	320,813.54	£	719,310.18	£	912,190.95	£	1,542,735.15	£	4,190,138.22

8 COMMUNICATION AND ECOSYSTEM ENABLEMENT

For a significant part of Aura, communicating around the project proved difficult due to the desire of Parallel Wireless to protect its commercial plans regarding the offering of AAUs to the global MNO community. Towards the end of the project publicity began to ramp up, starting at the Mobile World Congress show in March 2025.

9 ASSESSMENT OF SUCCESS AGAINST INTENDED BENEFITS

From our perspective the project was very successful and achieved or exceeded all its intended benefits:

1. It allowed PW to design a set of building block modules which can be used to configure AAUs suitable for use in all parts of the world. This in turn allows Parallel Wireless to offer a range of AAUs to the market that will allow customers to 'rip out and replace' existing equipment and form the basis of a compelling argument for using PW hardware and software throughout their mobile phone network.
2. Aura provided a route to deepen our existing ties with
    a. BT R&D team – important as BT is a Parallel Wireless strategic customer.
    b. DSIT team – through engaging with the DSIT teams as a project lead for the first time
    c. University of Cardiff – important for recruitment, local Bristol / South-West ecosystem involvement

9.1 Key Lessons Learned

- It is important to consider and optimise the whole system not just minimise individual modules power drain, don't focus on local goals
- Other vendors will certainly copy the PW approach it is important that development continues – 'by the time the competition catches up, PW needs to be another step ahead'
- Next steps:
    - All-in-one work
    - Deploy first units
    - Develop different bands and power levels
    - Maximise the power savings that can be made in software (AI plus)

Conclusion

Aura has been an outstanding success, low power consumption AAUs designed and developed in the UK are being brought to market during 2025. Know how has been developed in the UK and an ongoing design pipeline has been established to ensure that the design team will grow and prosper.