Title	**DU-VOLUTION CLOSING REPORT**
Versions	**V1.0**

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.

NAME OF PROJECT UK 5G DU-Volution (FRANC)	
List of partners	Adtran (Merged with ADVA early 2023), AccelerComm, BT, CommAgility (left project in early 2023, now e-space), Parallel Wireless (joined project midway through 2023), University of Strathclyde – Scotland 5G Centre, University of York
Total funding amount	£6.07Mn
Locations	York, Bristol, Southampton, Glasgow and Ipswich

Executive Summary

Project Goals:
DU-Volution's primary goal was to promote the UK as an attractive source of 5G Open-Radio Access Network (O-RAN) solutions and development capability. DU-Volution aimed to improve supply chain options for the Distributed Unit (DU), perhaps the most complicated aspect of O-RAN supporting infrastructure, promoting the use of local vendors wherever possible.

Background:
As the project started in early 2022, the DU, the device which handles and manages radio signal processing, had typically been deployed using commercial compute platforms known as x86 COTS (Commercial Off The Shelf) servers. A lack of carrier class features was holding UK operators back from adoption of this promising technology.

A number of challenges/barriers to entry were identified with the deployment of O-RAN technology into operator and 5G networks such as vendor lock in, form factor, replication of functions across compute platforms, power consumption, cost of equipment and added integration fees.

Key activities / outcomes:

As an R&D project, the development of components used within O-RAN architectures have been a key part of the project

Notable developments:

- Requirements capture and network modelling towards future 6G architectures were undertaken by BT, AccelerComm and University of York
- State-of-the-art FEC acceleration performance on a different type of Acceleration card – helping to broaden the supply chain, enabled by AccelerComm
- ARM platform development was initiated by Adtran and CommAgility. This was transitioned to Parallel Wireless when they joined the program in mid-2023 where they leveraged the success of the FRANC Project Proteus into the DU development. During the project they improved the options available for DU implementation on CPUs, expanding from Intel x86 only to ARM and AMD x86 CPU types.
    - CommAgility left the project in early 2023 due to acquisition by espace and focus towards Non-Terrestrial networks
    - Parallel Wireless joined the project in summer of 2023 and were a great collaborative fit with DU-Volution following the success of their FRANC Project Proteus. During the project they improved the options available for DU implementation on CPUs expanding from Intel x86 only to ARM and AMD x86 CPU types.
- Development of a new interface card for the DU for potential inclusion into Adtran portfolio, with increasing emphasis on Neutral Host features.

Deployment Summary

As an R&D project, DU-Volution focused less on a full scale deployment and more towards development activities. Hence, deployments are targeted towards initial lab testing rather than end-to-end deployment of the overall solution.
The detailed development activities and the outcomes of each are as follows:

1. FEC Acceleration and progression towards in-line
    a. AccelerComm took their Look-Aside FEC Acceleration algorithms, compliant with 3GPP, and O-RAN BBDEV compatible functions and refocused deployment of these on the AMD T2 FPGA card. AccelerComm provided Atran with debug tools and evaluation tools written specifically to help integrators use the AccelerComm solution.
    b. AccelerComm also investigated Advanced FEC Look-Aside and in-line functions which required some DU Phy components to be implemented in Hardware/FPGA. Candidates included optimisation to the PDSCH (downlink) processing chain and PUSCH (Uplink) Estimator. To test and verify these functions, a proof of concept using Open Air Interface was modified by AccelerComm. This was eventually deployed by AccelerComm in a well-documented deployment NTN (Non-Terrestrial

Network) Satellite use case with Lockheed Martin (See https://www.lockheedmartin.com/en-us/news/features/2023/lockheed-martin-prepares-first-5g-mil--payload-for-orbit.html)

2. Parallel Wireless diversified and improved the scale of O-RAN deployment options
    a. CPU Options diversification – PW predicted, and later evaluated, the CPU core and memory resource requirements needed by various CPU vendors including the Intel 68, AMD x86 and ARM chipsets. The results closely matched predicted values. Importantly, this demonstrates the flexibility introduced to customers by partnering with PW, as the ability to support different CPU types allows customers to test O-RAN solutions with confidence that they are not locked into a specific vendor
    b. Scaling up from one-to-many L1 instances was another key objective. This included scaling up towards 100MHz per RU (radio unit) and supporting a minimum of 3 RUs per compute blade.
    c. PW also explored improvements to their Service Management and Orchestration tools across the server range which their software supports.
3. Evolution of DU types and specific designs on DU/RU interfaces
    a. Adtran's portfolio for mobile has previously supported Ethernet solutions for mobile backhaul, midhaul and eCPRI fronthaul, most commonly in the aggregation of such traffic flows onto higher speed bearers and integration of synchronization. DU-Volution was an opportunity to explore wider innovation on the RU-DU interface combining fronthaul gateway and DU NIC card capabilities to ensure lowest latency, lowest power DU interface options which can be scaled up towards multi-tenant deployments likely to be used more frequently as neutral host concepts mature.
    b. A prototype Transport/NIC card was designed and built that allows verification of RU/DU interface performance. The final stages of this technology demonstrator are in preparation as the project draws to a close, with demonstration expected in Q1'2025.
    c. We also demonstrate in Q1'2025 use of the Transport/NIC card within a multi-node Neutral Host Proof of concept. This provides customers with an emulation of the behaviour of a neutral host platform that they can expect to deploy using Adtran in future.

(500 words)

Results and Benefits Achieved

In addition to component development activities, the project included a more academically and use case lead theoretical work package exploring architecture evolution towards 6G. University of York, BT and AccelerComm lead this activity with an intention to provide input regarding future requirements, in particular the need for connectivity between DU components which underpin a number of 6G architectures including Distributed/Cell-Free Massive MIMO.

The theoretical work package provided a number of key insights that can be taken into account beyond the current project:

1. Uplink performance improvement trade-offs, Massive MIMO will increasingly drive hardware acceleration
2. Analysis of Channel estimation and equalization impact on compute performance within the DU (consuming >80% of the DU compute resource today and the potential implementation resources on CPU, FPGA and ASIC/Chiplet), in particular identifies that AI/ML may offer preferable acceleration options for the estimator and equalization function thereby reducing overall compute resources needed
3. Provides load estimates of CPU types, and acceleration options including FPGA based and AI/ML
4. Need to identify and enable acceleration resource reservation to users of compute platforms at a more granular level, e.g.down to the selection of accelerator type and PCIe bus options.

Wider benefits arising from the project:

Benefit	Impact	How is this better than what has come before	How will this affect business	Replication options
Increased supply chain options and vendor diversity for O-RAN Acceleration	AccelerComm developed an alternative FEC Look-aside acceleration function that can run on an AMD FPGA card.	Prior to this most O-RAN vendors were forced to use a card compatible with Intel FlexRAN. Adding more supply chain options implicitly provides greater resilience, ability to navigate supply chain issues for adopters of O-RAN. Opens up potential for further innovation.	AccelerComm reached commercial relationship for AMD to resell their function on AMDs T2 card. Adtran and other vendors can now deploy either Intel or AMD Acceleration card, greater supply chain resilience.	This innovation uses standardized BBDEV interfaces defined by O-RAN Alliance. This means in theory any vendor could adopt this, an example of why open networks gives customers benefits.
Expansion of CPU options for running O-RAN workloads on a more diverse compute ecosystem	Parallel Wireless have proven and scaled up their O-RAN software on three different CPU types within the project, including Intel x86, AMD and ARM. Scaling up to multiple RU support per DU platform is underway.	Most O-RAN Vendors had adopted Intel FlexRAN. Early wins, but limited supply chain options. Lacking differentiation. Now, with Parallel Wireless software being so adaptable, a customer can request a specific CPU vendor based on their own preferences. For example, O-RAN may not be the only use case for the estate of compute that will be deployed. Giving the customer more freedom allows the customer to deploy with less risk. The adoption of other CPU types such as AMD and ARM enable lower power and cost in comparison to alternatives.	Parallel Wireless success in enabling their software to run on three CPU families is completely aligned with Adtran's proposed DU hosting platforms. Adtran intends to offer customers the ability to select their own compute for use in the Adtran portfolio. This is a complicated integration story but one that we feel is necessary in order to drive the success of open networking. Carbon footprint reduction can also be incorporated in the proposition. Adtran and Parallel Wireless can plan on availability of platforms from the other vendor that reflect the flexibility they plan to bring to their customer.	We believe this will become the norm eventually. Hence this provides customers with a strong intention to enable open networking.

Reimagination of the transport/compute interface bringing multiple benefits to customers	Tighter integration of Transport and Compute functions brings multiple benefits leading to a new range of DU Infrastructure hosting platforms including small private focused DU platforms and larger multi-tenant platforms facilitating neutral host models.	Historically, a network deployment, requires multiple layers of technology to be built into a network including: • Compute • NIC • Transport Switch • RUs Each stage impacts latency budget, which limits distance and hence economics of large scale roll-outs, each layer also increases power consumption, and replication of components and functions across the layers, that could be optimized by combining and consolidating specific layers. The new model combines the NIC and Transport Switch to facilitate those benefits. It also enables the sharing of transport and NIC infrastructure across a neutral host platform.	Adtran can expand its business beyond transport solutions into the network edge. It also expands Adtran's ability to enter the O-RAN ecosystem.	Adtran intends to explore routes to industry adoption of our Transport/Compute interface innovation and opening this up to the wider community via industry bodies/standards groups such as TIP and OCP.

Security

Although security was not the focus of developments within DU-Volution, it became obvious due to geopolitical concerns that we needed to explore security within the project. The rationale used to define our security strategy identified two broad domains:

1. Project security – ensuring that the project remained free from external manipulation or use of malicious code, and that innovation and content was held securely by Adtran as the lead partner
2. Understanding the customer requirements of infrastructure and software hosted by an Open RAN DU platform

Below we summarise the activities and outcomes of each domain.

Project Security:

- Auditing partner approach to security policy
- Review of use of SecDevOps by each partner
- Setting up a password protected and limited access repository for project files
- Identification of possible attack vectors leading to
    - Identification of partner supply chain use of subcontractors etc
    - New project source material or suppliers
- Resolving sensitive use of contractors within the project
- Reporting approaches from suspicious suppliers to DSIT

Security within the DU Platform:

- Multi-layer approach proposed for security in the DU platform
- In a Neutral host platform there are two types of user who may rely on security features within the DU

- Neutral Host operator / Mobile Operator - owning the infrastructure, and having a need to ensure the DU platform is trusted, that authentication is required to join a network, and that the transport paths cannot be manipulated without authorization. The Transport layer likely needs Layer 2, MACSec and further still this could require IPSec
- Mobile operator / Private 5G user (renting compute facilities from the neutral host infrastructure provider), is likely to have their own encryption feature which typically sits in software i.e. a virtual security gateway or virtual cell site router. Our assumption is that MNO/tenants will deploy encryption on each compute blade before traffic is sent to the transport layer

The R&D nature of DU-Volution required that the component developments undertaken within the project were prioritized. Had Adtran been building a commercial platform, then the security requirements would have been much more aligned to commercialization plans, including the need for penetration testing etc.

High level summary of project costs

Maximum word count: 500 words

The DU-Volution project commenced in calendar Q1 2022 and ran till the end of calendar Q1 2025. The project was originally planned to close at the end of Q1 2024 but successfully applied for a 12-month extension. A summary of the total project expenditure, DSIT funding and non-DSIT funding for the project can be found in the table below:

	Total Expenditure	DSIT Funding	Non DSIT Funding
Labour	£6,899,940.04	£3,924,993.78	£2,974,946.26
Overheads	£1,465,359.70	£867,764.57	£597,595.13
Materials	£1,443,585.17	£729,223.07	£714,362.10
Capital Usage	£279,500.09	£106,172.74	£173,327.35
Sub Contract Costs	£607,130.46	£409,213.47	£197,916.99
Travel and Subsistence	£47,475.00	£28,416.60	£19,058.40
Other Costs	£17,652.10	£11,721.76	£5,930.34
Total	£10,760,642.56	£6,077,506.00	£4,683,136.56

High level summary of project costs (to DSIT and project participants). (Equipment and deployment costs of any networks are also of interest)

For a deployment project where a costed project is likely informative and suitable content for public consumption, in contrast with DU-Volution being an R&D project, project cost is not suitable for sharing with public. This effectively would imply that we are sharing development costs with the market. We are happy to continue sharing project costs with DSIT as we approach project closure.

Project Highlights

Maximum word count: 500

This could include project awards, events.

The DU-Volution project has been instrumental in helping Adtran to determine its plans relating O-RAN and open disaggregated mobile markets. The project brought together an ecosystem of vendors (Adtran, AccelerComm and Parallel Wireless) covering all aspects of a DU platform, in addition to BT, University of York and Scotland 5G Centre (Part of University of Strathclyde).

Project highlights:

- Facilitated a strong dialogue between ecosystem partners which, without the project, would have been challenging to facilitate
- Brought BT into the ecosystem as lead customer representative - who represented both the views of a mobile operator and that of a neutral host infrastructure provider
- AccelerComm launching and commercialising their FEC Look-Aside function in conjunction with AMD – providing alternative FEC Acceleration options to the industry
- Parallel Wireless managed to prove their software was able to stimulate use of a range of CPU types, opening up the supply chain options even further
- Adtran used the project to identify a strategy for its O-RAN DU platforms and after reviewing the market evolution, have taken steps towards building a neutral host DU platform – with demonstrable output currently at Proof of concept phase. This has moved TRL levels from TRL 4 to 6 /7 for Adtran.
- University of York for academic conference dissemination, presenting on topics beyond 5G, bringing a vision of the future to the ecosystem, to help us plan evolution of outputs beyond the project
- BT used the project to explore in more detail than would usually be possible, the methods, and the trade-offs which need to be considered in building a DU platform. The project has helped inform their future strategy
- The project benefitted massively from the project management support provided by Scotland 5G Centre.
- DU-Volution included a theoretical work package delivering insights into the partners regarding future evolution of the network. The scope and topics addressed were diverse and very enlightening – this really helps vendors to plan their next steps.

- Introduction to new partners and new projects has been a particular benefit, especially for Adtran. This fostered a strong relationship with AccelerComm and Parallel Wireless, but also lead to the collaboration via YO-RAN/University of York, and subsequently connecting Adtran with Slipstream Electronic Design and Radio Design. Eventually, this has led to a cluster of partners in the North of the UK and Yorkshire region with common interests in future RAN and open networking. This could support the cross fertilization of ideas and sharing of market opportunities moving forward.

Project Conclusions

DU-Volution lead to multiple vendors progressing their ideas into improved technology readiness levels, such as:

- AccelerComm commercially launched their FEC Look-aside solution with a high profile adoption by AMD. Subsequently they have developed solutions that could apply to the Non-Terrestrial Network sector, and continue to innovate on the challenging but extremely important boundary between Physical layer Software and hardware, finding ways to increase efficiency and offload compute resources into flexible reprogrammable hardware or similar alternatives. TRL Level from 5 to 9 estimated.
- Parallel Wireless progressed their software solutions into a more diverse supply chain for the delivery of O-RAN solutions than was originally planned. They have also accelerated other developments in relation to Service Management and Orchestration to help ease (facilitate) the deployment of their software at scale through operators networks. TRL improvement from 4 to 8 estimated.
- Adtran managed to build a proof of concept to demonstrate their use case aspirations in the Multi-operator, neutral host market. Although market forces acted against the original ambition, Adtran are now in a position to demonstrate their proposed solution into their customer base. Progressed from slide/presentation material into a demonstrable solution. TRL improvement from 3-to 6 estimated.
- The project allowed Adtran and other partners to build relationships with BT and the University of York, solidifying relationships and improving the likelihood/efficiency of future collaboration..

Other conclusions from the project:

- DSIT commented that our project goals and aspirations were seen as extremely complicated and challenging. Regardless they saw this project as a wise investment.
- The project from Adtran's (lead partner) perspective was as predicted - an extremely challenging project. Being able to deliver even half of what Adtran aimed for has been rewarding for us. We have proven the essential interfaces and believe the next step relates to exploring customer feedback to our plans and repackaging the technology developed during DU-Volution into a commercial product.

- It cannot be emphasised strongly enough, that this project could not have progressed in the way it did without the involvement of Scotland 5G Centre. They brought impartial and thorough oversite to the project that helped all partners thrive within the project and this helped us to communicate project delivery with DSIT team. This leads to a proposal for DSIT that when handling complex projects like DU-Volution, a split between Project Management Office and Lead Partner responsibility should be considered in future.
- Overall, the project demonstrated multiple improvements in relation to the diversity of UK supply for Open 5G networks. It has helped to stimulate future investment by a number of the partners involved.
- In order to support future success of the ecosystem involved in this project, further investment is needed by partners / UK ecosystem in the following areas :
    - Compute/server supply chain options
    - AI platforms to facilitate improvements within the RAN, and for use cases involving the open RAN network.
    - Cultivation of the benefits anticipated from and the potential routes to achieve a functioning neutral Host market in the UK to support improved ubiquitous mobile connectivity

Next Steps

DU-Volution's sustainability plan is likely to see further development by partners in their respective areas but is likely to include the following:

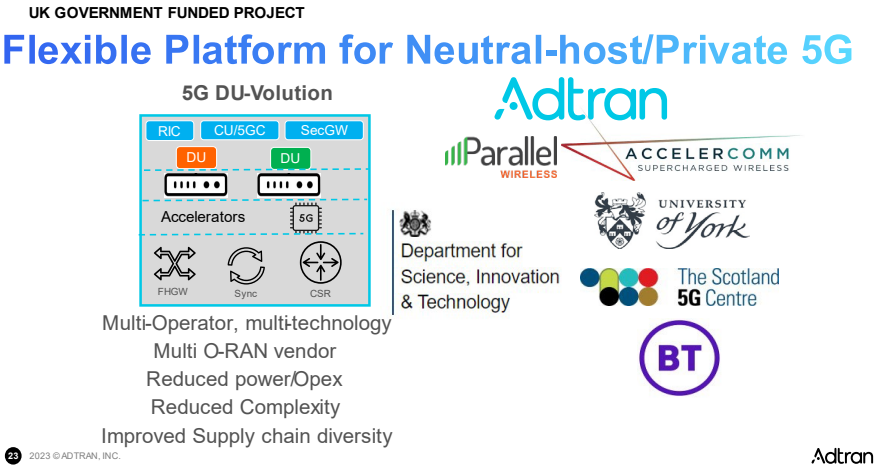
- Expansion of AccelerComm's market space towards Non-Terrestrial networking, taking the learning and technology developed prior to, and in association with DU-Volution into new market sectors.
- Parallel Wireless continue to develop their 4G/5G solution for multiple processor types and are aiming to expand their market presence.
- Adtran are taking the Proof of Concept for a neutral Host out to the customer base and will gather feedback regarding the preferred size and scale of such a product. The demo shows the compute/transport interface proposals we think will help to build an improved approach to Neutral Host solutions. The project has allowed us to re-imagine the way that Transport and Compute interact in a Neutral host, multi-tenant scenario. Developments already undertaken could potentially lead to commercialization shortly beyond the project completion. Development candidates are already under investigation for products to go to market based on this technology.
- Adtran also believe that the project has allowed us to balance technology development with that of portfolio planning, by using the change request and change of scope mechanisms offered by DSIT. To have pressed on with a product development without having learned from all of the valuable lessons we observed during the project could have been a reckless use of investment within Adtran. Instead, the project allows us to view potential outcomes both internally within the project and with one eye on external market conditions. The decision we took was to slow the development cycle down, understand requirements

more clearly and then beyond the project to broaden the portfolio proposal beyond that of only O-RAN platforms. To this end, Adtran provides a short synopsis of our direction of travel beyond the project

- We hope to continue working collaboratively with all partners beyond the end of the project, especially to take commercial directions forwards with AccelerComm and Parallel Wireless with details to be firmed up beyond the project
- Adtran believes that market access will be easier and that innovation supporting adoption of O-RAN is likely to be a stronger requirement in the Private 5G market, and that this could then drive adoption of Neutral Host technology beyond a user's Private 5G requirements
- Adtran also observes that building a Private 5G RAN solution in isolation is likely to fall short of market requirements. We have observed and begun testing the market for interest in AI related features within the same environment that a Private 5G network is likely to be used. We have observed a growing interest in AI to enable both RAN efficiency and operations within industrial/manufacturing facilities, and therefore turning our attention to a broadening of the business case and platform for this requirement.

Media Library

Example Presentation material capturing essence of DU-Volution Project. Presented variant of this slide at multiple events including Small Cell World Summit, NGON Conference, and multiple Adtran customer facing events:

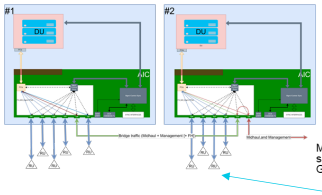


Adtran Neutral Host Space Model in COTS Servers at Connected Britain 2024:

PRIVATE 5G AND NEUTRAL HOST

What's in the street cabinet– Neutral Host sharing Midhaul

- Two Servers used to deploy two tenants.
- Shared transport domain from a single midhaul (CSR)
- Connectivity on demand for tenants via Neutral Host Portal



Shared Transport: Cell Site Router model

(Midhaul reaches two tenants)

Midhaul received on first server, sent onto second DU by Disaggregated X-haul Gateway.

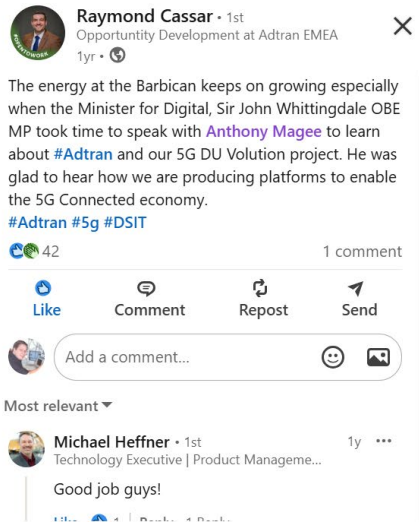
23 2024 © ADTRAN

Adtran

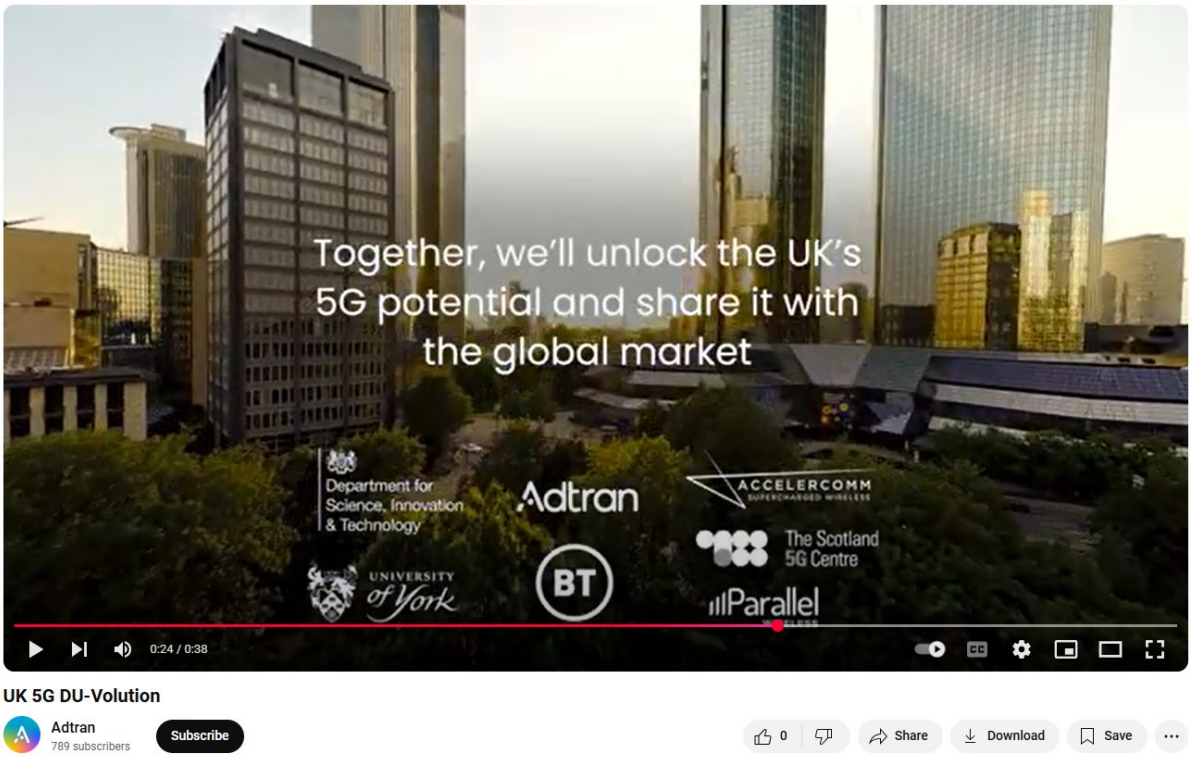
Adtran Technology Demonstration day, Adastral Park 2024.
Showing Prototype technology hosting Parallel Wireless on Intel x86/ARM platforms with Adtran synchronization and transport capability. Demo showing Public and Private support from a neutral host, neutral technology platform perspective.

Social Media Post – LinkedIn associated with Ministerial announcement of ONE projects

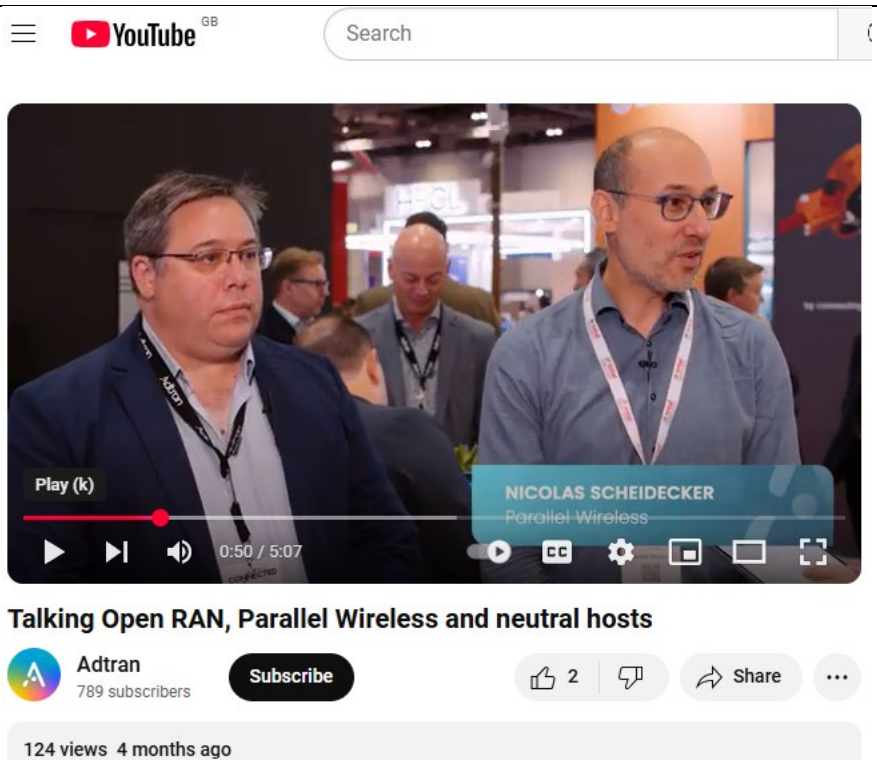
https://www.digicatapult.org.uk/apply/events/meet-us-at-the-ministerial-announcement-of-the-open-network-ecosystem-projects-and-open-networks-programme-collaboration-event/



Adtran Youtube video released at project launch/Modified to reflect new collaboration with Parallel Wireless and rebranding from ADVA to Adtran:
https://www.youtube.com/watch?v=adLFB_oSE-A



Video captured by Adtran at Connected Britain 2024:
https://www.youtube.com/watch?v=a69EDn9l6eI



https://www.linkedin.com/in/dyerkeith/ - reporting on Parallel Wireless recent news item re hardware agnostic support for O-RAN.