5G RuralDorset WP6 Neutral Host

Task 7: 5G Neutral Host Demonstration

Authors: Marilena Kalitsounaki,
Contributors: Digby Sowerby, Ross McPherson
Delivery date: 18th March 2022

Contents

UK 5G Testbed & Trials – Neutral Host Demonstration

This document sets out the implications and the interworking of the successful NH trials that took place in September 2021, using the 5G Standalone (5G SA) trial network along the Dorset coastline. 5G RuralDorset is a DCMS approved ground-breaking project to understand how next generation connectivity can help people live better, safer, and more prosperous in rural communities, even in environments as sensitive as Dorset's UNESCO-designated world heritage coastline. This trial deployment is now in place and extends until the end of March 2022.

This research and development project contributes to the understanding of how 5G deployments could potentially address some specific connectivity challenges impacting businesses and services in remote and rural areas. The project focuses mainly on use cases from the public safety, economic growth, food production and environmental monitoring domains.

What is Neutral Hosting?

Neutral hosting (NH) is a relatively simple concept but has a huge potential to address connectivity challenges. The term NH architecture is used to describe a network where resources are shared by multiple Mobile Network Operators (MNOs). Different methods exist to manage this multi-operator environment. Examples are:

- a single operator owns the resources and provides access to these resources to others;
- two or more operators own resources and mutually provide each other with access to their resources;
- an independent network provider owns the resources and provides a service to any operator customer.

For all the above models the MNOs pay rent or purchase a lease from the NH owner to have access to the NH network and use the shared resources.

The most primitive and common type of Neutral Hosting leads to the sharing of either physical resources such as radio equipment or sharing both radio equipment and spectrum. In the first case, the relevant architecture is referred as Multi Operator RAN (MORAN) and in the second case as Multi Operator Core Network (MOCN). As an example of this architecture, a NH base-station (gNB) can be connected to more than one core network belonging to different connectivity providers.

NH architecture allows MNOs to share a common Radio Access Network (RAN) infrastructure, reducing capital investment and releasing capital for deployment acceleration and service optimization. This is particularly important for rural areas, where the cost of deploying cellular connectivity outweighs the financial Return on Investment for the MNOs. By sharing the infrastructure supplied by the NH providers, network operators can now provide a seamless and robust service in previously unserved areas, bridging the digital divide.

Among the different types of NH architectures described above, MOCN is the most resource efficient solution since MNOs can pool their respective spectrum allocations. Also in the Portland 2 test site, where NH trials took place, spectrum allocation is dedicated for the project purposes. For these reasons we have chosen to implement and demonstrate MOCN type in WP5 and WP6. For the trial purposes the shared network includes a RAN, and the shared resources include radio spectrum. MOCN has been standardized by 3GPP with the relevant procedures mentioned in clause 5.18, 3GPP TS 23.501 (Release 15).

A high-level diagram of the MOCN model is as shown in Figure 1.

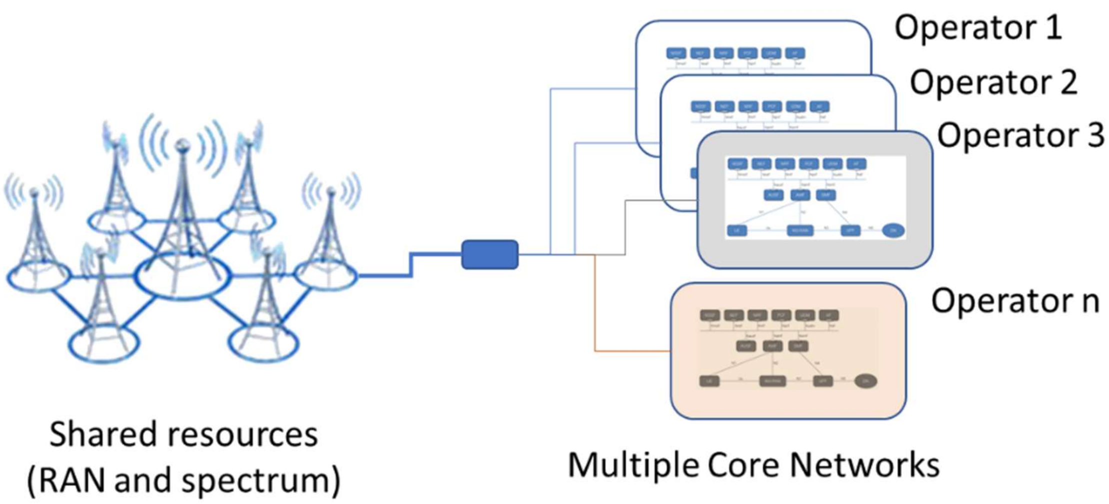


Figure 1 - MOCN Model - shared radio resources with multiple core networks

NH over 5G demonstration in 5G RuralDorset

In the 5G RuralDorset Network, 5G Connectivity is provided by Satellite Applications Catapult's (SAC) 5G Centre in Westcott and includes the UK's first integration of satellite backhaul within a 5G Stand Alone (5GSA) network, as well as the world's first 700MHz standalone network. Furthermore, Wessex Internet (WI) has deployed their on-premises 5G network.

To demonstrate the NH deployment, Neutral Networks (NN) have deployed a 5G RAN (gNB) in Dorset, Portland 2 site, acting as the NH provider. Engineers from SAC, WI and NN, have successfully managed to demonstrate the NH concept. This was achieved by managing to attach different 5G UEs, to the two different 5G networks using the same NH gNB. Each User Equipment (UE) was whitelisted in one of the two 5G networks. Through the single gNB, each UE was able to see and register to a 5G network and have access to network's resources and services (Figure 2).

This was the first demonstration of 5G network sharing in the UK 5G network sharing.

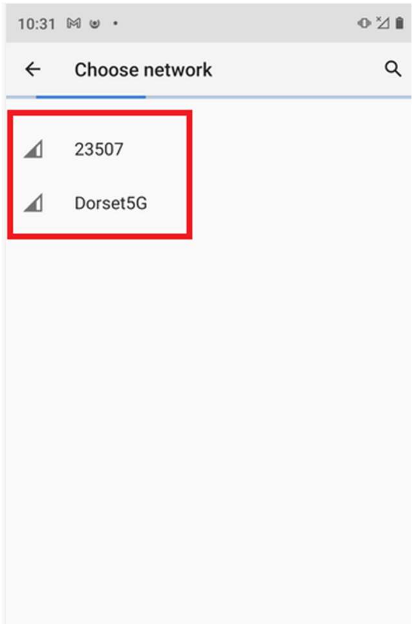


Figure 2 - A single 5G UE showing ability to identify and connect to both SAC 5G Core (Dorset5G) and WI 5G Core (23507) served by a single gNB

Lessons Learned, Next Steps and Challenges

From the feedback obtained following NH deployment and demonstration in 5G RuralDorset it is apparent that a network solution enabling NH can benefit both operators and end users. It was demonstrated that NH over 5G is relatively easy to deploy and maintain without the support of large MNOs and specialist cellular companies. What is more, in addition to terrestrial connectivity, it is possible to extend the NH functionality and integrate with satellite communications (5G over satellite was already deployed in 5G RuralDorset Network) for added redundancy and higher link availability.

The deployment and successful demonstration in Dorset rural environment is a good starting point towards the commercialisation of the NH capability in the region and beyond. Numerous opportunities arise from the successful demonstration of NH, which creates a framework for similar deployments around the UK. The ideal next steps would be a continuation of this project and the deployment of RAN enabled NH platforms as follows:

- Deploy and demonstrate various NH configuration over different RAN platforms as well as over an Open RAN platform at SAC's premises and test the platform with different core network available at SAC's premises
- Engage with a MNO (such as Vodafone), extend their network as part of the NH network in Dorset and explore further real use case opportunities as well as risks
- Deploy at Dorset and test NH over satellite backhaul
- Create a hybrid satellite-terrestrial backhaul network which supports NH over 5G and over satellite, for added redundancy and higher link availability with smart handover capabilities (satellite, fibre) to extend backhaul intelligence in the transport network
- Investigate the security aspects and challenges of NH through a study resulting in recommendations for MNOs and service providers
- Explore the capability of NH and network slicing, specifically on the NH concept that can be used to support radio slicing. Radio slicing is the use of different frequencies, radio access types, as well as network slicing, so that certain Network Functions of the 5G core can be shared among different core operators
- Investigate Dynamic Sharing Spectrum (DSS) technology and deploy in 5GRD. This technology investigates the capabilities of Neutral Hosting over both LTE and 5G while at the same time enables the parallel use the two technologies in the same frequency band.

The above will allow us to scope and commercialise the NH capability, both for the Dorset Coastal area and rest of the UK, where similar rural 5G systems will be deployed.

Implementing NH is not without challenges though. For instance, security is an important consideration when it comes to shared infrastructure. Previously isolated network segments, normally managed by a single operator, would be opened through the common infrastructure. Responsibilities such as SIM provisioning, performance and network management (certificate, change, configuration, fault management etc) will now need to be shared with the NH provider.

Annex: Test results

This annex presents the trial test results.

Figure 3 and Figure 4 are the NAS (Non-access stratum) files from gNB. They show a NAS request from the two different UEs with the different PLMNs, listed under Mobile Country Code (MCC) and Mobile Network Code (MNC) on the right-hand side.

Figure 3 shows the Registration Request from SAC UE towards the gNB, requesting PLMN 00101.

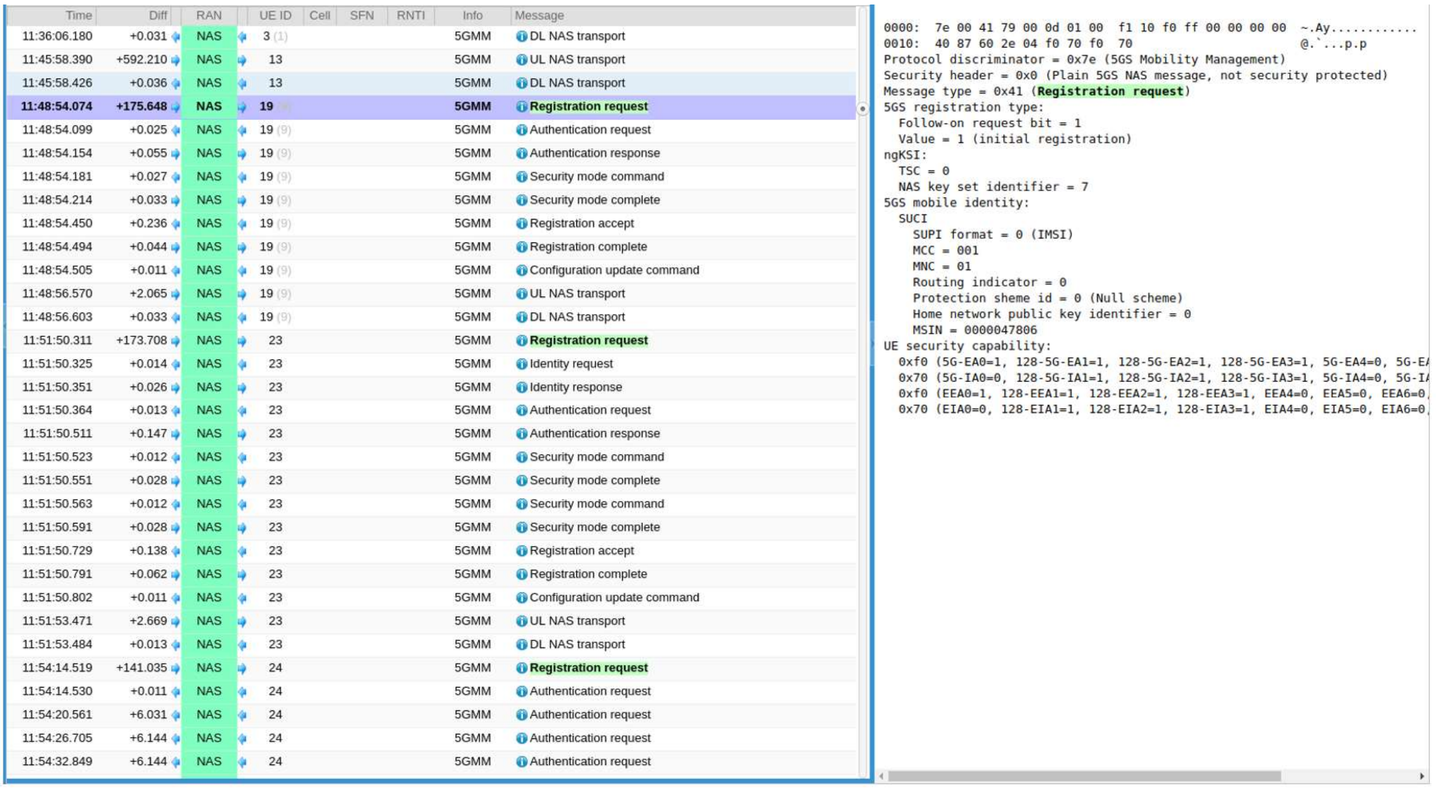


Figure 3 – NAS file from gNB for SAC UE

Figure 4 shows the Registration Request from WI UE towards the gNB, requesting PLMN 23507.

Time	Diff	RAN	UE ID	Cell	SFN	RNTI	Info	Message
11:36:06.180	+0.031	NAS	3 (1)				5GMM	DL NAS transport
11:45:58.390	+592.210	NAS	13				5GMM	UL NAS transport
11:45:58.426	+0.036	NAS	13				5GMM	DL NAS transport
11:48:54.074	+175.648	NAS	19 (9)				5GMM	**Registration request**
11:48:54.099	+0.025	NAS	19 (9)				5GMM	Authentication request
11:48:54.154	+0.055	NAS	19 (9)				5GMM	Authentication response
11:48:54.181	+0.027	NAS	19 (9)				5GMM	Security mode command
11:48:54.214	+0.033	NAS	19 (9)				5GMM	Security mode complete
11:48:54.450	+0.236	NAS	19 (9)				5GMM	Registration accept
11:48:54.494	+0.044	NAS	19 (9)				5GMM	Registration complete
11:48:54.505	+0.011	NAS	19 (9)				5GMM	Configuration update command
11:48:56.570	+2.065	NAS	19 (9)				5GMM	UL NAS transport
11:48:56.603	+0.033	NAS	19 (9)				5GMM	DL NAS transport
11:51:50.311	+173.708	NAS	23				5GMM	**Registration request**
11:51:50.325	+0.014	NAS	23				5GMM	Identity request
11:51:50.351	+0.026	NAS	23				5GMM	Identity response
11:51:50.364	+0.013	NAS	23				5GMM	Authentication request
11:51:50.511	+0.147	NAS	23				5GMM	Authentication response
11:51:50.523	+0.012	NAS	23				5GMM	Security mode command
11:51:50.551	+0.028	NAS	23				5GMM	Security mode complete
11:51:50.563	+0.012	NAS	23				5GMM	Security mode command
11:51:50.591	+0.028	NAS	23				5GMM	Security mode complete
11:51:50.729	+0.138	NAS	23				5GMM	Registration accept
11:51:50.791	+0.062	NAS	23				5GMM	Registration complete
11:51:50.802	+0.011	NAS	23				5GMM	Configuration update command
11:51:53.471	+2.669	NAS	23				5GMM	UL NAS transport
11:51:53.484	+0.013	NAS	23				5GMM	DL NAS transport
11:54:14.519	**+141.035**	**NAS**	**24**				**5GMM**	**Registration request**
11:54:14.530	+0.011	NAS	24				5GMM	Authentication request
11:54:20.561	+6.031	NAS	24				5GMM	Authentication request
11:54:26.705	+6.144	NAS	24				5GMM	Authentication request
11:54:32.849	+6.144	NAS	24				5GMM	Authentication request

```
0000:  7e 00 41 79 00 0d 01 32  f5 70 f0 ff 00 00 37 46  ~.Ay...2.p....7F
0010:  51 00 31 2e 04 f0 70 f0  70                       Q.1...p.p
Protocol discriminator = 0x7e (5GS Mobility Management)
Security header = 0x0 (Plain 5GS NAS message, not security protected)
Message type = 0x41 (Registration request)
5GS registration type:
  Follow-on request bit = 1
  Value = 1 (initial registration)
ngKSI:
  TSC = 0
  NAS key set identifier = 7
5GS mobile identity:
  SUCI
    SUPI format = 0 (IMSI)
    MCC = 235
    MNC = 07
    Routing indicator = 0
    Protection sheme id = 0 (Null scheme)
    Home network public key identifier = 0
    MSIN = 7364150013
UE security capability:
  0xf0 (5G-EA0=1, 128-5G-EA1=1, 128-5G-EA2=1, 128-5G-EA3=1, 5G-EA4=0, 5G-E
  0x70 (5G-IA0=0, 128-5G-IA1=1, 128-5G-IA2=1, 128-5G-IA3=1, 5G-IA4=0, 5G-I
  0xf0 (EEA0=1, 128-EEA1=1, 128-EEA2=1, 128-EEA3=1, EEA4=0, EEA5=0, EEA6=0
  0x70 (EIA0=0, 128-EIA1=1, 128-EIA2=1, 128-EIA3=1, EIA4=0, EIA5=0, EIA6=0
```

Figure 4 – NAS file from gNB for WI UE

In Figures 5 and 6 PDU_Session files contain details for the two different cores: WI has the IP 138.124.161.2 while SAC has the IP 10.10.1.95 both allocating a PDU session to a UE. These files prove that same gNB establishes PDU sessions with 2 different 5G Core Networks.

In Figure 5 we see that gnB establishes a PDU session with SAC AMF (IP 10.10.1.95)

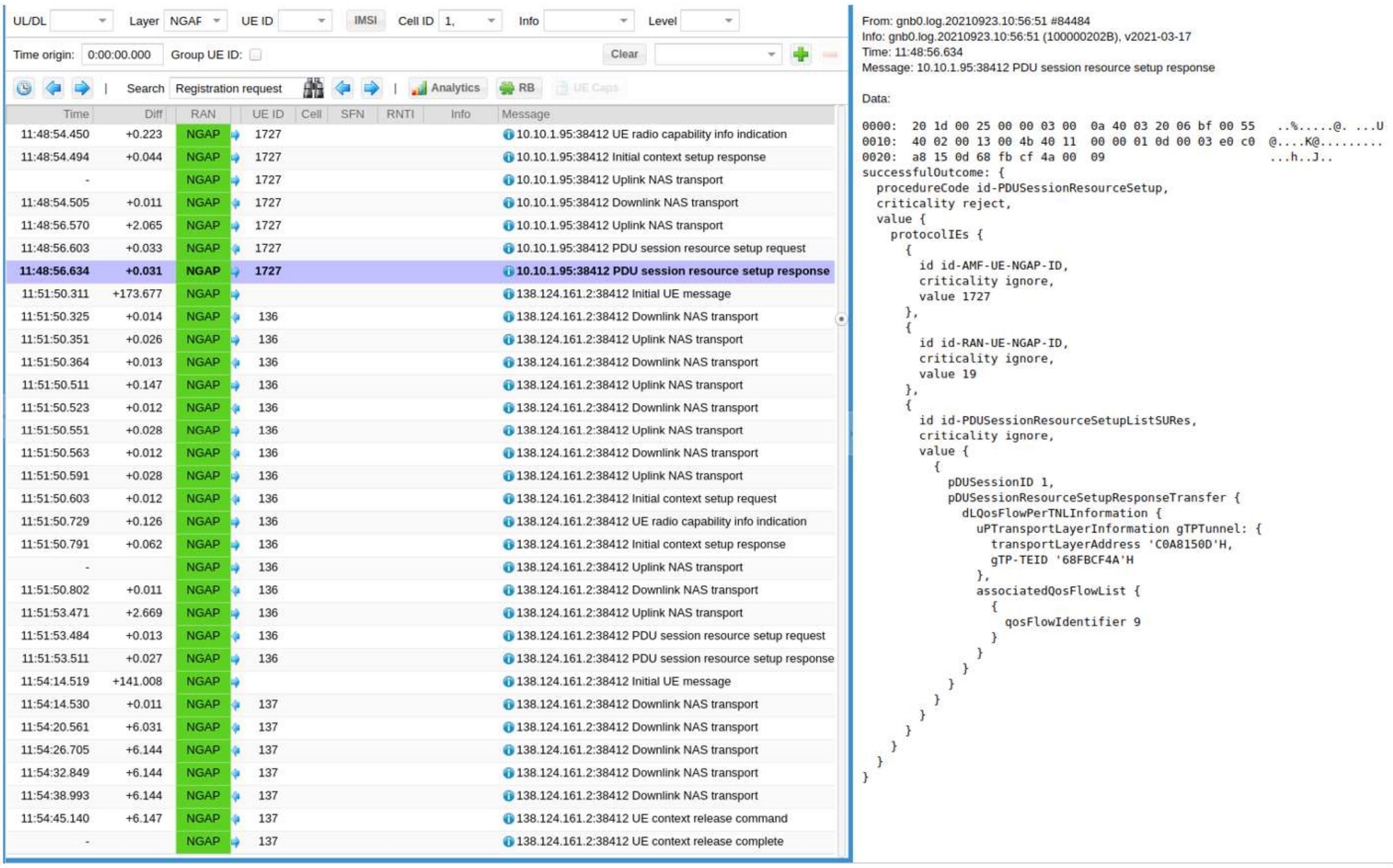
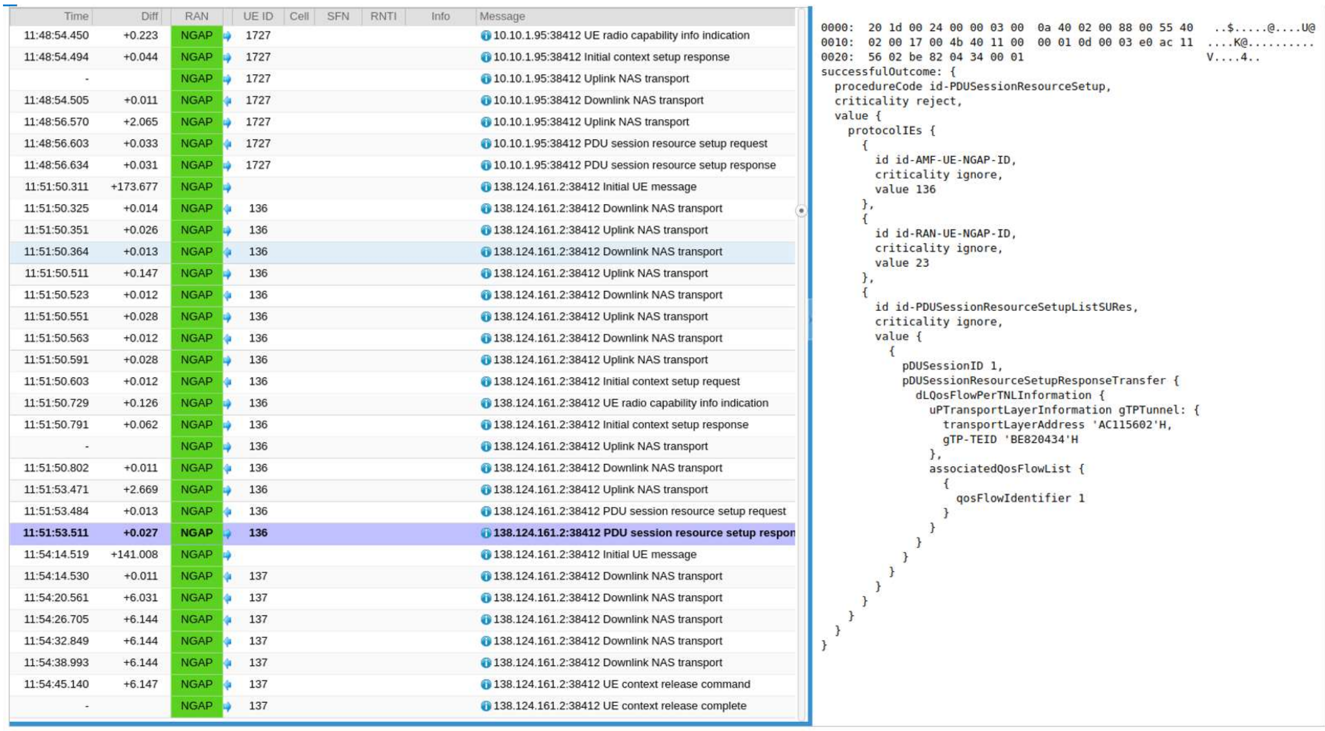


Figure 5 – PDU_Session file from gNB for SAC

In Figure 6 we see that gnB establishes a PDU session with WI AMF (IP 138.124.161.2)



Time	Diff	RAN	UE ID	Cell	SFN	RNTI	Info	Message
11:48:54.450	+0.223	NGAP	1727					10.10.1.95:38412 UE radio capability info indication
11:48:54.494	+0.044	NGAP	1727					10.10.1.95:38412 Initial context setup response
-		NGAP	1727					10.10.1.95:38412 Uplink NAS transport
11:48:54.505	+0.011	NGAP	1727					10.10.1.95:38412 Downlink NAS transport
11:48:56.570	+2.065	NGAP	1727					10.10.1.95:38412 Uplink NAS transport
11:48:56.603	+0.033	NGAP	1727					10.10.1.95:38412 PDU session resource setup request
11:48:56.634	+0.031	NGAP	1727					10.10.1.95:38412 PDU session resource setup response
11:51:50.311	+173.677	NGAP						138.124.161.2:38412 Initial UE message
11:51:50.325	+0.014	NGAP	136					138.124.161.2:38412 Downlink NAS transport
11:51:50.351	+0.026	NGAP	136					138.124.161.2:38412 Uplink NAS transport
11:51:50.364	+0.013	NGAP	136					138.124.161.2:38412 Downlink NAS transport
11:51:50.511	+0.147	NGAP	136					138.124.161.2:38412 Uplink NAS transport
11:51:50.523	+0.012	NGAP	136					138.124.161.2:38412 Downlink NAS transport
11:51:50.551	+0.028	NGAP	136					138.124.161.2:38412 Uplink NAS transport
11:51:50.563	+0.012	NGAP	136					138.124.161.2:38412 Downlink NAS transport
11:51:50.591	+0.028	NGAP	136					138.124.161.2:38412 Uplink NAS transport
11:51:50.603	+0.012	NGAP	136					138.124.161.2:38412 Initial context setup request
11:51:50.729	+0.126	NGAP	136					138.124.161.2:38412 UE radio capability info indication
11:51:50.791	+0.062	NGAP	136					138.124.161.2:38412 Initial context setup response
-		NGAP	136					138.124.161.2:38412 Uplink NAS transport
11:51:50.802	+0.011	NGAP	136					138.124.161.2:38412 Downlink NAS transport
11:51:53.471	+2.669	NGAP	136					138.124.161.2:38412 Uplink NAS transport
11:51:53.484	+0.013	NGAP	136					138.124.161.2:38412 PDU session resource setup request
11:51:53.511	**+0.027**	**NGAP**	**136**					**138.124.161.2:38412 PDU session resource setup respon**
11:54:14.519	+141.008	NGAP						138.124.161.2:38412 Initial UE message
11:54:14.530	+0.011	NGAP	137					138.124.161.2:38412 Downlink NAS transport
11:54:20.561	+6.031	NGAP	137					138.124.161.2:38412 Downlink NAS transport
11:54:26.705	+6.144	NGAP	137					138.124.161.2:38412 Downlink NAS transport
11:54:32.849	+6.144	NGAP	137					138.124.161.2:38412 Downlink NAS transport
11:54:38.993	+6.144	NGAP	137					138.124.161.2:38412 Downlink NAS transport
11:54:45.140	+6.147	NGAP	137					138.124.161.2:38412 UE context release command
-		NGAP	137					138.124.161.2:38412 UE context release complete

```
0000:  20 1d 00 24 00 00 03 00  0a 40 02 00 88 00 55 40   ..$.....@....U@
0010:  02 00 17 00 4b 40 11 00  00 01 0d 00 03 e0 ac 11  ....K@..........
0020:  56 02 be 82 04 34 00 01                            V....4..
successfulOutcome: {
  procedureCode id-PDUSessionResourceSetup,
  criticality reject,
  value {
    protocolIEs {
      {
        id id-AMF-UE-NGAP-ID,
        criticality ignore,
        value 136
      },
      {
        id id-RAN-UE-NGAP-ID,
        criticality ignore,
        value 23
      },
      {
        id id-PDUSessionResourceSetupListSURes,
        criticality ignore,
        value {
          {
            pDUSessionID 1,
            pDUSessionResourceSetupResponseTransfer {
              dLQosFlowPerTNLInformation {
                uPTransportLayerInformation gTPTunnel: {
                  transportLayerAddress 'AC115602'H,
                  gTP-TEID 'BE820434'H
                },
                associatedQosFlowList {
                  {
                    qosFlowIdentifier 1
                  }
                }
              }
            }
          }
        }
      }
    }
  }
}
```

Figure 6 – PDU_Session file from gNB for WI

5G RuralDorset

www.5gruraldorset.org
@5gruraldorset
LinkedIn
Rural 5G Group