Remote PHY is Coming

Test and the Evolving Hybrid Fibre Coaxial Network

By VIAVI Solutions

The burning plant maintenance question is not *if* testing is still needed as distributed access architectures are rolled out, but *how* that testing will take place. The same changes that will allow Gigabit services to millions of subscribers across hybrid fibre coaxial networks will necessitate changes in processes and the tools used to keep plants running at maximum efficiency.

The race is on for service providers to allow delivery of Gigabit speeds with unprecedented service reliability. Hybrid fibre coaxial (HFC) networks are rapidly evolving to meet these demands. New technologies, such as DOCSIS 3.1 and distributed access architectures (DAA), like Remote PHY, leverage much of the existing infrastructure to deliver Gigabit speeds and extend the life of the HFC plant. These changes are effectively pushing out or eliminating the need to pull fibre to each subscriber location. Even more advanced technologies, such as Full-Duplex DOCSIS, are on the horizon with the promise of enabling symmetrical Gigabit offerings. These exciting network evolutions will enable new service offerings, such as wide-scale 5G mobile backhaul, creating the possibility of new revenue streams for service providers.

Whilst exciting, these evolutions create HFC plant monitoring and maintenance challenges. The need for critical test capabilities, upon which operators have relied for years, is stronger than ever but the processes and tools used to provide those capabilities must evolve with the changing HFC. All these changes are being implemented in the face of important day-to-day challenges, such as customer churn resulting from poor service quality and holding the line on OPEX since the average revenue per user remains stagnant. All of this creates the perfect storm for HFC maintenance tools and processes.

How are hybrid fibre coaxial networks eolving?

Several changes are happening to keep up with subscriber demand. This article focuses on distributed access architectures (DAA). Cable operators are deploying node splits at a rapidly increasing rate, reducing the size of downstream service groups to enable delivery of Gigabit services - in some cases, doubling or tripling the number of nodes over just a two- or three-year

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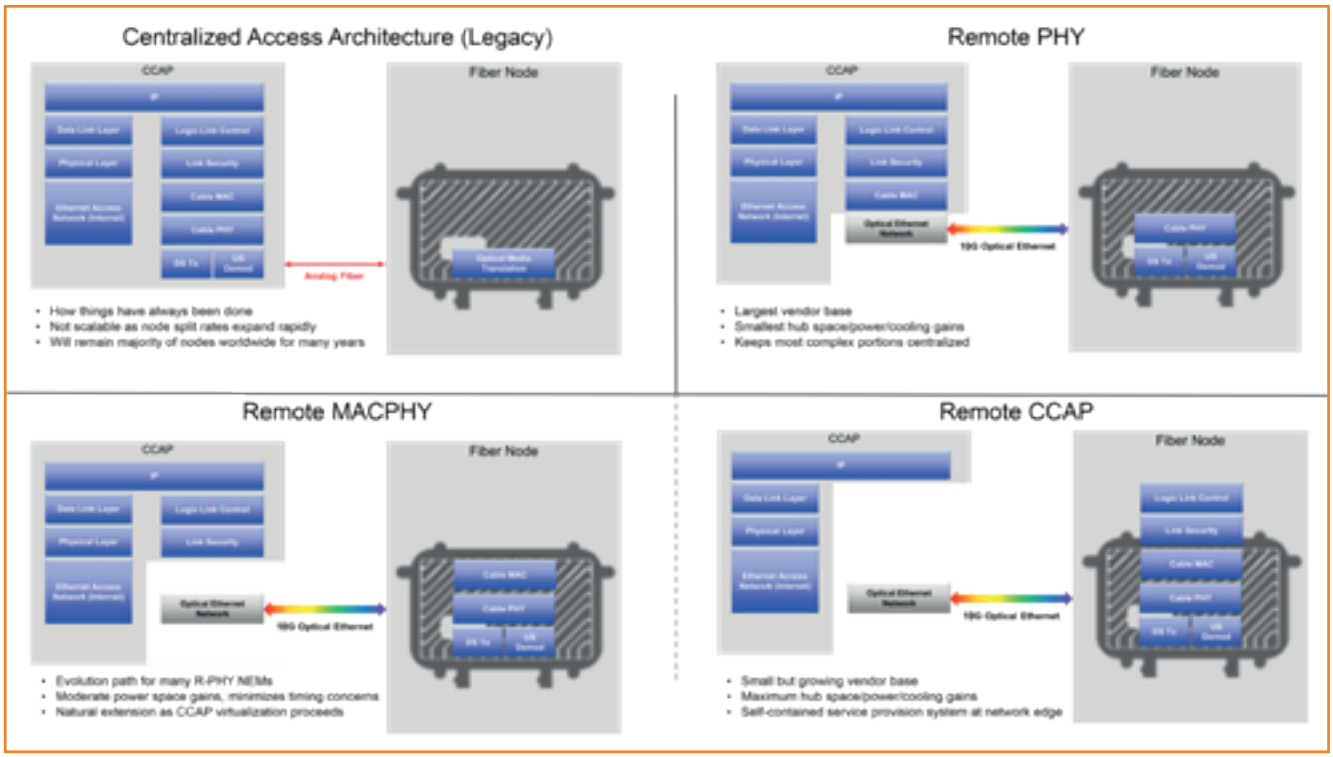

Figure 1: DAA options

period. While this can increase speeds, it also creates new problems in operator hubs. The rapid expansion of node splits means that more rack space, power and cooling capacity are required.

To combat this issue, DAA technologies are being deployed that virtualise and migrate certain aspects of the network, reducing the need for rack space, power and cooling in these facilities. Remote PHY is the DAA variant receiving the most attention to date and, as its name implies, it essentially moves the PHY layer from the hub out into the plant, eliminating racks of optical receivers and combining networks. Other variants migrate additional capabilities, up to and including the entire CCAP, out into the field.

The R-CCAP option took off early, largely in APAC, as one vendor was very early to market with a solution enabling simultaneous transition to DAA and DOCSIS 3.1. Maximum rack space/power/cooling benefits can be obtained with this option, but concerns over single-sourcing and decentralised management have limited adoption among major operators. The detailed pros and cons of each variant are covered well in many other technical papers, so will not be covered here. See Figure 1 above for an overview of the basic variants.

Other DAA benefits

In addition to resolving the hub overcrowding issues, there are many other benefits resulting from DAA implementation. DAA is a key enabler as operators strive to move CCAP functionality upstream, eventually virtualising them into the cloud and/or data centres. By enabling hubs to evolve from housing, with row after row of specialised equipment, and RF splitting/combining networks into potentially nothing more than a small collection of optical switches, DAA facilitates this upstream migration. Much like telcos are envisioning a CORD (Central Office Rearchitected as Data centre) architecture for the future, many MSOs have a similar HERD (Headend Rearchitected as Data centre) concept in mind. See below for an example of possible network migration enabled by DAA.

Beyond enabling MSO pursuits of desired future state architectures and the obvious hub space/power/cooling advantages, other benefits include:

- A higher SNR digital optical link enables higher modulation order attainment in DOCSIS 3.1 (more bits/Hz!).
- A more robust optical link – higher plant reliability and reduced maintenance costs with elimination of fidgety analogue optical link.

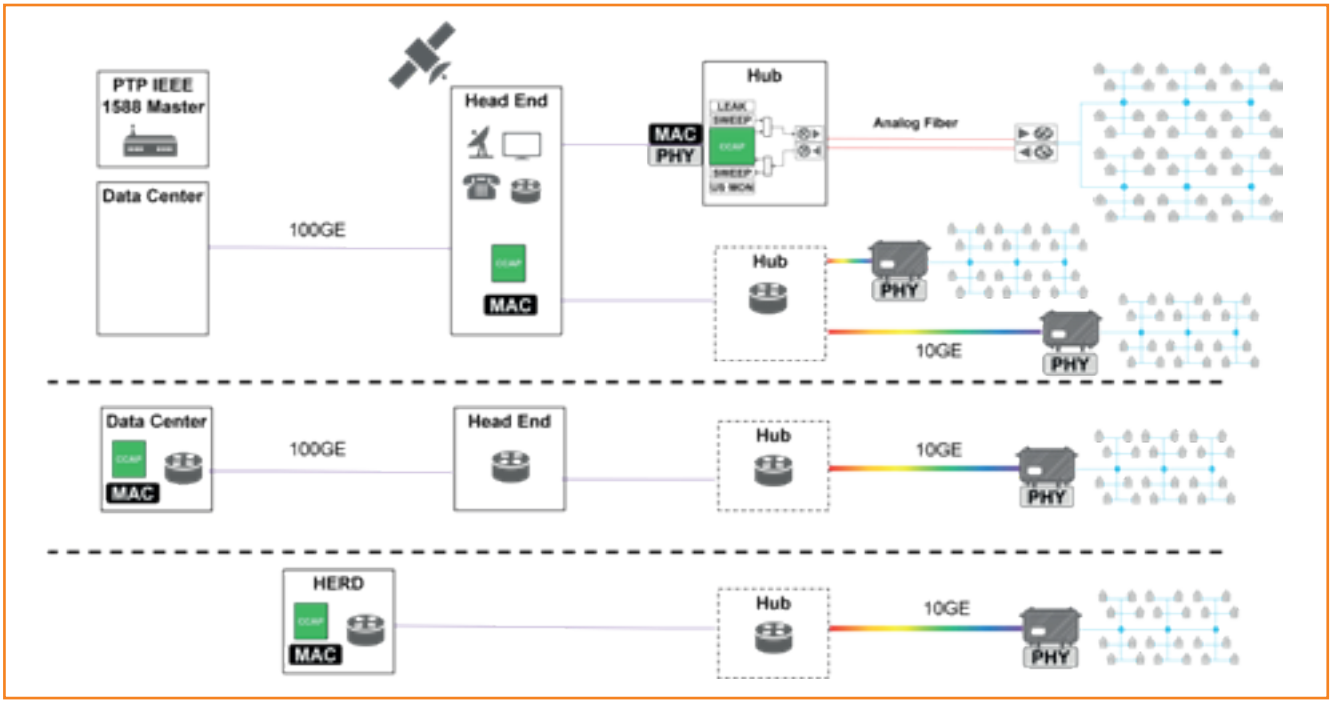

Figure 2: Possible evolution path of hybrid fibre coaxial networks

- It enables increased service offering flexibility as Ethernet pushes deeper into the plant. It can serve high-usage customers or FTTH clusters via EPON, provide Ethernet for business services or 5G backhaul from the mux deployed deep into the network instead of running dedicated fibre for each.

Is test still needed in the DAA environment?

Questions have emerged about the continued need for test as the fibre-deep programmes often associated with DAA shrink cascade to just a few amps. The short answer is yes! Customers will still leave if service is poor. Connectors still corrode, cars still hit poles and subscribers still mess with the in-home wiring.

Also, in the modern HFC network, every bit of capacity is important. Plants must be clean to pass more packets and reach the higher modulation orders available from DOCSIS 3.1. Testing is the only way to ensure a clean plant, maximise OPEX ROI and ensure customer satisfaction.

Test challenges in DAA networks and solution options

Just because the need for test doesn't go away, it doesn't mean that plant maintenance is 'business as usual' for the Tech Ops folks. DAA rollout and implementation creates numerous monitoring and maintenance challenges for the evolving hybrid fibre coaxial network. Listed opposite are a few of the most significant challenges:

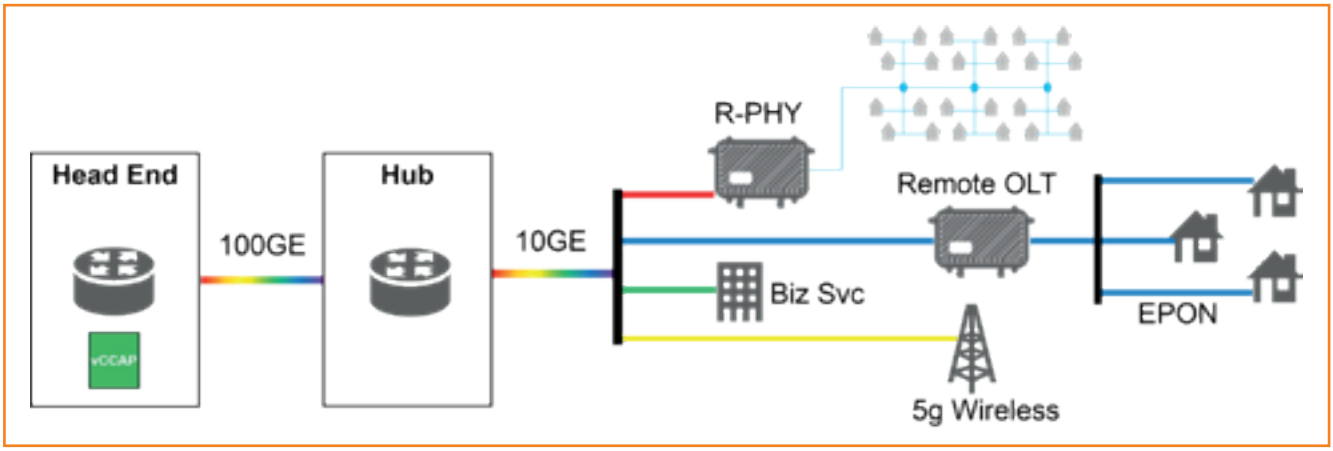

Figure 3: Deeper Ethernet simplifies new service roll-outs

- Removal of RF test points from hubs.
- Creation of a new interface clouding traditional maintenance responsibility demark points.
- Proliferation of architectural variants and network equipment vendors in use.
- Timing concerns resulting from MAC-PHY separation (R-PHY only).

Removal of RF test points: As mentioned previously, one major benefit of DAA is the redistribution of at least the PHY layer capabilities into the field and therefore the removal of the associated hub-based gear and combining networks. The downside of eliminating RF from the hubs is the disruption of existing maintenance processes, which rely on hub-based monitoring gear such as leakage, return path monitoring and sweep.

Fortunately, there are solutions that leverage the Remote PHY Device (RPD) such as virtual test hardware to handle spectrum analysis, sweep functionality including bi-directional telemetry signalling and leakage tagger capabilities. By combining the RPD with orchestration software running on standard x86 or virtual machine servers, ingress remediation and return sweep processes can be identical for technicians, including the use of their existing field meters whether testing in legacy nodes or any DAA variant nodes. This greatly simplifies the transition to DAA by minimising the complexity faced by technicians maintaining a plant that is a heterogeneous mix of architectures from a mix of vendors.

New interface blurs demark lines: Many operators are just now starting to fully realize the challenge created by splitting up previously co-located network functions and migrating some of them out into the field. This is disruptive to traditional demarcation points for existing MSO groups and processes. It is not always clear nor obvious where the split between headend or field groups lies with the new interface created by this messy separation. This creates an environment ripe with opportunities for responsibilities falling through the cracks and finger-pointing during troubleshooting. Figuring out and clearly defining ownership of aspects on either side of this new interface is critical to long-term DAA success

Proliferation of architectures/vendors: The path which operators take to evolve the HFC will be gradual and inconsistent throughout the plant. Advanced technologies will need to be deployed in certain parts of the plant sooner than others to keep up with demand. Lesser-used areas might keep legacy technology longer to keep costs down. The result is a plant that will be changing constantly over the next five years or more. Technicians may need to work on a R-PHY node from one vendor in the morning, a legacy node before lunch and an R-CCAP node from another vendor in the afternoon.

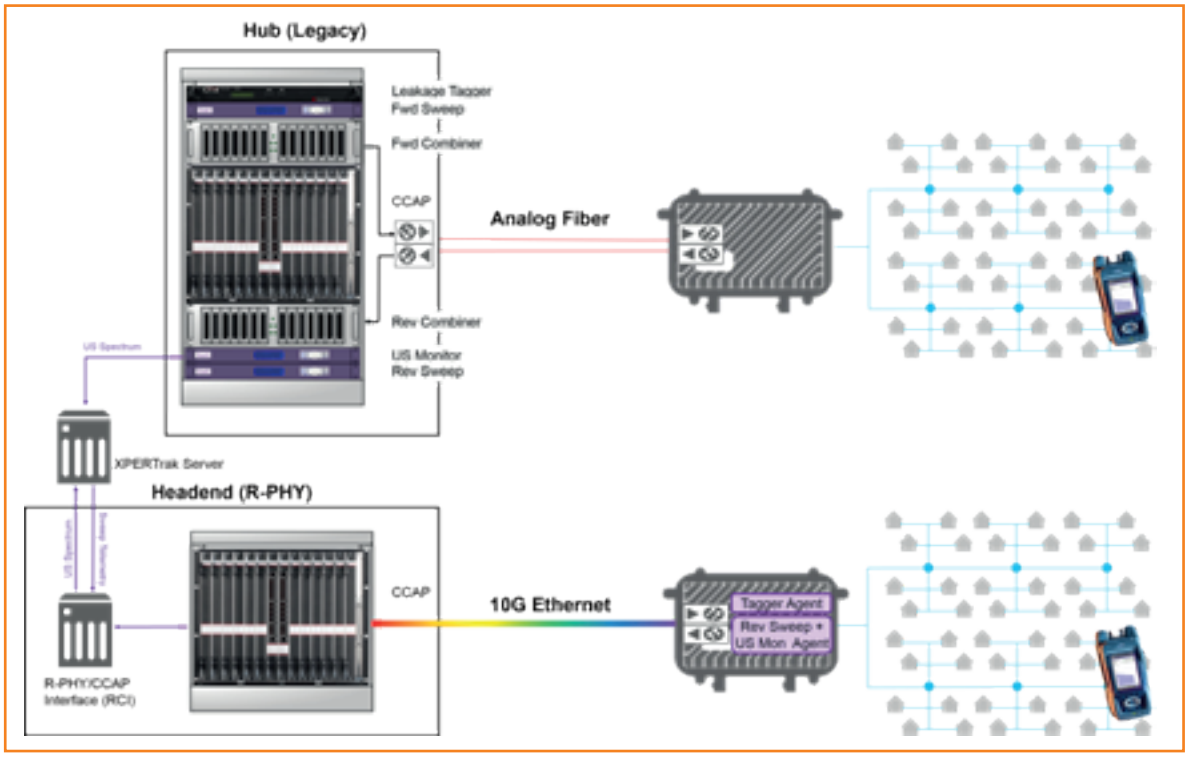

Figure 4: Virtualised test capabilities replace hub-based HW for DAA

> **The challenge emerges when the MAC and PHY layers are physically separated, often by long distances and several network hops.**

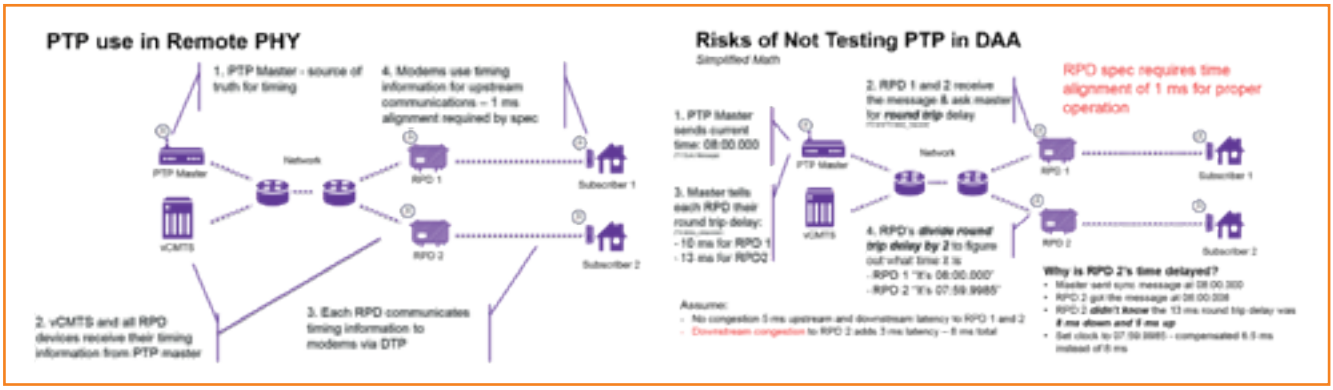

Figure 5: PTP use in R-PHY overview: example of problems that can arise

Unless standardised processes using common tools are made available across the many variants, this will become unmanageable for the field workforce.

Timing concerns from MAC-PHY separation: The clear majority of folks who monitor and maintain HFC plants have not given much thought to IEEE 1588 Precision Timing Protocol (PTP) during their daily activities. While most are aware of the criticality of proper timing in DOCSIS communications (especially A-TDMA and OFDM-A DOCSIS upstreams), it just never seems to be a problem in legacy systems where MAC and PHY layers are co-located often in a single chassis. The challenge emerges when the MAC and PHY layers are physically separated, often by long distances and several network hops. The diagrams above explain the basics of PTP and how the assumption of symmetrical delay characteristics between upstream and downstream can create problems that are difficult, if not impossible, for field techs to diagnose. Technicians must be aware of this new wrinkle and test processes defined for initial turn-up and future troubleshooting use cases.

Bigger picture – DAA prep, installation/ cutover and maintenance

We have just scratched the surface on the realm of test implications over the DAA lifecycle - there is a lot more to think about. There are several DAA-focused papers/sessions planned for SCTE Cable Tech Expo 2018; great resources for those wanting to learn more about this topic. In the interim, please consider the framework below, a more complete roll-out and testing process outline for the DAA journey that most

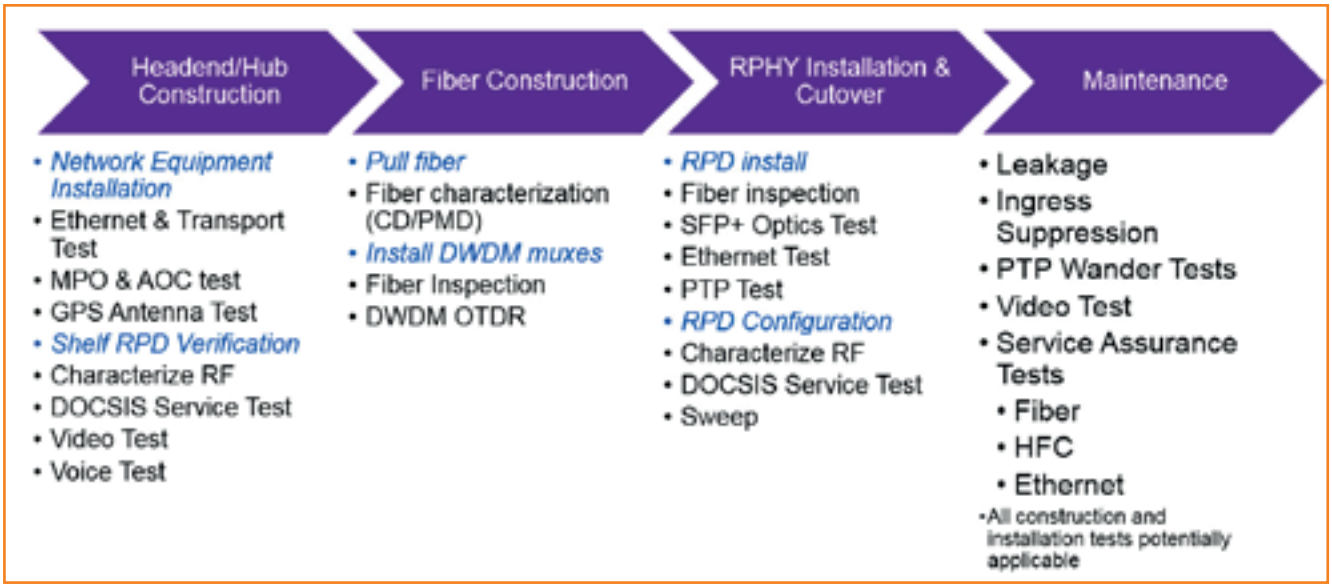

Figure 6: Framework for Remote PHY lifecycle test needs

> **Field instruments will evolve to be more adaptable and will interact with both physical and virtual test systems to further reduce mean-time-to-repair issues.**

MSOs will embark upon in the next few years. This framework will be fully explained in future webinars and other published works in the next few months.

Conclusion

The burning plant maintenance question is not *if* testing is still needed as distributed access architectures are rolled out, but *how* that testing will take place. The same changes that will allow delivery of Gigabit services to millions of subscribers across hybrid fibre coaxial networks will necessitate changes in processes and the tools used to keep plants running at maximum efficiency.

Virtualisation is certain to play a pivotal role, using deployed network elements as probes replace dedicated hardware, in some cases. Software solutions will process massive amounts of data into actionable results in this virtual environment. This will place the focus on specific plant issues causing subscriber churn and minimise the field time required to locate them.

Field instruments will evolve to be more adaptable and will interact with both physical and virtual test systems to further reduce mean-time-to-repair issues. Perhaps the key to it all is the ability of test systems to keep up with the changes while keeping maintenance and troubleshooting simple for technicians, shielding them from the underlying complexity. The only certainty regarding DAA rollouts is that failing to plan for test aspects is equivalent to planning to fail.