Whitepaper

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“Skate to Where the Puck is Going”

Lessons on creating autonomous networks

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Foreword

Autonomous network operations are not an incremental change, nor are they the next update of traditional automation. Rather, it is a very different approach to automation and breaks an enormous number of accepted "rules" in telecom. This makes the move to autonomous networks difficult – but if done properly, hugely beneficial and transformative to the business.

In this study we combine in-depth primary market research with Appledore's years of market coverage on the evolution of telecom networks and operations toward autonomy. While this document focusses on broadband access; the technology, process, and impacts are consistent across technologies, organizations and professions. In fact, broadband access is one part of the larger picture – and will be a contributing technology in 5G densification as well.

Our knowledge base includes our ongoing research into the closely related topics of NFV, Cloud Native, and SDN. While Nokia sponsored this study and paper, Appledore must emphasize the extensive editorial freedom were given to research, draw conclusions, and present our findings. We thank Nokia for making this possible and emphasize the independence of our conclusions. We believe that every fixed broadband operator ought to at least read this – even if, after reading, your conclusion is "we are on the right track and have this under control." In that case: congratulations. Yet the "level 4 autonomy chasm" appears real and widespread, so others may find there are at minimum morsels to be gleaned from these pages.

Our North Star for autonomy is a set of three volumes that Appledore is publishing as long-form market outlook reports. We encourage all to seek these out. Part #1 is our "blueprint" for autonomous software, featuring our best practices. Part #2 lays out an evolution framework for brownfield evolution, showing how this enormous, company-wide effort may be broken into achievable steps and accomplished gradually. Part #3 (underway) will be the actual market outlook, capturing where operators and suppliers are in the process. In this study our primary research touched on all three sub-topics.

We also refer interested readers to this research note capturing how difficult it is proving for many to "cross the Level 4 autonomy chasm."

Executive Summary

This paper summarizes the result of primary market research into fixed broadband operators' evolution toward autonomous networking. It is based on a series of very in-depth interviews with fixed broadband operators, across geographic and size segments. All are in the process of implementing Nokia Altiplano Access Controller with the goal of achieving autonomous operations.

Autonomous networking is not a simple upgrade of existing operations. It is rooted in fundamentally different concepts and depends on changing organizational expectations, assumptions, business processes, and metrics. We must truly think differently to maximize gains. Whereas today's automation captures and mechanizes manual processes, autonomous operations have vastly more flexibility and independent automation, based on defining and maintaining a desired end state (often called the "intent").

A critical learning was that every operator confirmed how closely inter-related the software technology of autonomy is with business process, and therefore, people. A few confirmed this by expanding on how autonomy was part of a transformative end-to-end vision that would leapfrog both their offerings and their cost structure. Others confirmed this by describing the challenge to implementation in a large and complex organization. Others acknowledged that they need to "think differently" – and not use shiny new technology to re-invent the past.

We grouped what we learned into key findings. These are:

1. Operators are **beginning their journeys** to autonomy – in some cases gradually, but in all cases consciously.
2. **Autonomy is strategic**. Even in a single technology organization such as fixed broadband, autonomous network operation must be thought of as part of a larger, end-to-end, strategic, business process. Think global, act local.
3. **Operators are determined to eliminate independent software silos for each vendor** and replace them with a single, unified, multi-vendor autonomous environment.

The next three findings all depend on open, abstracted APIs – which are hugely valued:

4. "NaaS' service provisioning APIs are being used by all to simplify communications with the OSS/IT stack, and to create for more flexible and less brittle provisioning code.
5. Open, richer and more real-time APIs are considered essential to expose performance, fault and other observability data to whatever systems and process (ML? AI?) an operator desires.
6. Open expandability -- enabled by rich APIs – is demanded, and are being cautiously exploited

And one unexpected finding from this group:

7. Autonomous broadband adds M&A-level value

Appledore recommends that all broadband operators learn from these pioneers. **If we could make only one recommendation**, it would be for C-suites, despite the technical nature of autonomy, to get directly involved, and (likely via a cross functional team) ensure that autonomous operations' business promise is understood and maximized. We are indeed at Geoffrey Moore's Chasm or Clayton Christiansen's Innovator's Dilemma. We cannot look backward and assume that tomorrow will look like yesterday or today, but rather plan for decades of tremendous productivity growth and service flexibility.

If we could add only a second recommendation it would be to borrow from the Silicon Valley ethos: "start early, learn, find gaps, close them, and iterate". Facebook famously called this "move fast and break things."

The practical actions being taken, and discussed, below illustrate many ways of dealing with this challenge. We hope everyone learns from them.

Importance of the "Last Mile"

The application of autonomous concepts to telecom networks began in the data center. First with NFV, but after a restart, more successfully with cloud-native, telcos began to adopt concepts of disaggregation and autonomous placement and repair to network workloads. Data centers are the logical place to start because they are both a new technology that requires new infrastructure, and also a technology to which autonomous control may be most easily applied.

This research project examines broadband access networks—in their most modern form almost entirely passive optical networks (PONs). They represent the largest investment ("the money is in the poles and the holes") and determine the ultimate throughput for all (fixed) communications. Moreover, servicing the broadband access network is expensive – requiring truck rolls. Optimizing this plant pays a large dividend, and diagnosing configuration errors can greatly improve CX (customer experience) at low cost. So, while not as straightforward as cloud-native in a datacenter, the return in total may be higher. Since the industry has begun another round of investment in broadband technology, it is the ideal time to apply modern automation methods to the costliest part of the network.

This study gathered information on how a wide range of broadband operators are applying autonomy to broadband access networks. We thank the many broadband operators that participated, and Nokia for making the project possible.

Autonomy is more than software. It demands re-thinking operations.

Autonomy demands that we think very differently. It is first and foremost a *business process change* and is only secondarily embedded in software. Moreover, autonomy impacts much more than cost – it also makes many new services practical and economically viable, thereby driving new revenues and opportunity.

Specifically, autonomy decouples (abstracts) business and service operations from resource specifics, and eliminates narrow silos. The result is that operators can easily define new services and commercialize new service packages, without explicitly working out all the provisioning details. In some cases, these new services are as simple as on-demand access — exposed as an API to a third party. Other service innovations will be more complex. In all cases they demand that an order is easy to place and understand by a non-telecom entity. ***This breaks tradition (forces deep change), but can enable new services and revenues, as well as a new and improved cost structure.*** Intent-based autonomous software exposes such services. In fact, we wrote a research note linking the relationship between APIs, NaaS, digital services, intent and autonomy, here.

Autonomous networks are **NOT** simply the next step in traditional automation. In the past, automation has been, in effect, mechanizing human actions. Sometimes this was batch files, automating what were previously manual actions, at a command line or EMS. In other cases, it was explicitly crafted logic to perform steps that humans performed before—often referred to as workflow. The important point is that none of these automation methods had *actual intelligence* or decision-making baked into the software; it was simply a wrapper around human engineering. *Consequently, it was brittle and unable to adapt to exogenous change.*

One definition of autonomy is "*The quality or state of being self-governing*." True autonomous operation depends on the concepts of **control theory**. An objective (or outcome) is defined by **intents**, which are abstracted characteristics of the end state. Rules and algorithms react to new orders or changes in the environment to maintain that state. As such, an autonomous system is self-governing and does not require intervention from an external authority. It is also highly flexible and can be easily programmed to support new services or configurations. Myriad definitions of autonomy exist from other industries, and Appledore encourage all to learn from those, but within telecom operations the TM Forum has its IG1251, IG1252, and IG1253, as well as its Autonomous Networks Manifesto.

In practical terms it means that orders and operations are greatly simplified, healing can occur automatically (if it is configurable by software), and any change in inventory or network configuration can be accommodated automatically. *The opportunity for productivity improvement, not just in repair but in the cost and speed of orders and in the ability to innovate, is large.*

> ***"The APIs give us the flexibility to build an ecosystem of automation across ordering, customer support and outside operations. When I ask new things of my IT lead, he says 'no problem.'"***
>
> ***Jason Schreiber, President Wire3***

There is a practical complication, as described in this research note. As we approach autonomy, the business norms, operational norms, and expectations, especially within large, structured operators, make it difficult to effect these changes. Everything from the metrics we use to manage the business to organizational structures are built around old ways of thinking. And as we all know, change is difficult.

What we found

Data and Methodology

We interviewed ~10 fixed access broadband operators – all in the process of moving from legacy (EMSes) to network domain controller software capable of autonomy and multi-vendor operation. This primary market research was augmented by our extensive discussions with CSPs and vendors across domains including the IP/optical core, Cloud datacenters, IP/optical enterprise edge, WAN operations 5G RAN and C-RAN operations, representing many dozens more data points.

The operators interviewed represented a diverse sample; small vs large, greenfield vs. brown; centralized vs federated organizations. Similarly, our contacts varied. In some cases, we spoke with the manager of the transformative project, in others, research or group standardization managers, and in a few, C-suite occupants (CEO, CTO). We have endeavored to reduce these to common themes. We believe all are useful for individual companies implementing autonomous networks but are also learnings for the industry in general.

Finding #1: Operators are beginning, locally, their journey toward autonomy.

Despite all the hype about modern, cloud-native, automated networks – operators globally are still in the early stages of deploying true autonomous network operations. This is supported by our own research, as well as TM Forum surveys, which show that most operators are struggling with the jump to

"Level 4" processes, which is where the fundamental concepts of autonomous operations begin to seriously challenge entrenched ways of working.

Most participants chose to walk before attempting to run (smart!), and expected to solve practical issues one by one over a period of many months — likely a year or more. Examples of this gradual approach include:

- an early focus on single vendor implementations
- focus on a single domain
- limited closed loop autonomy.

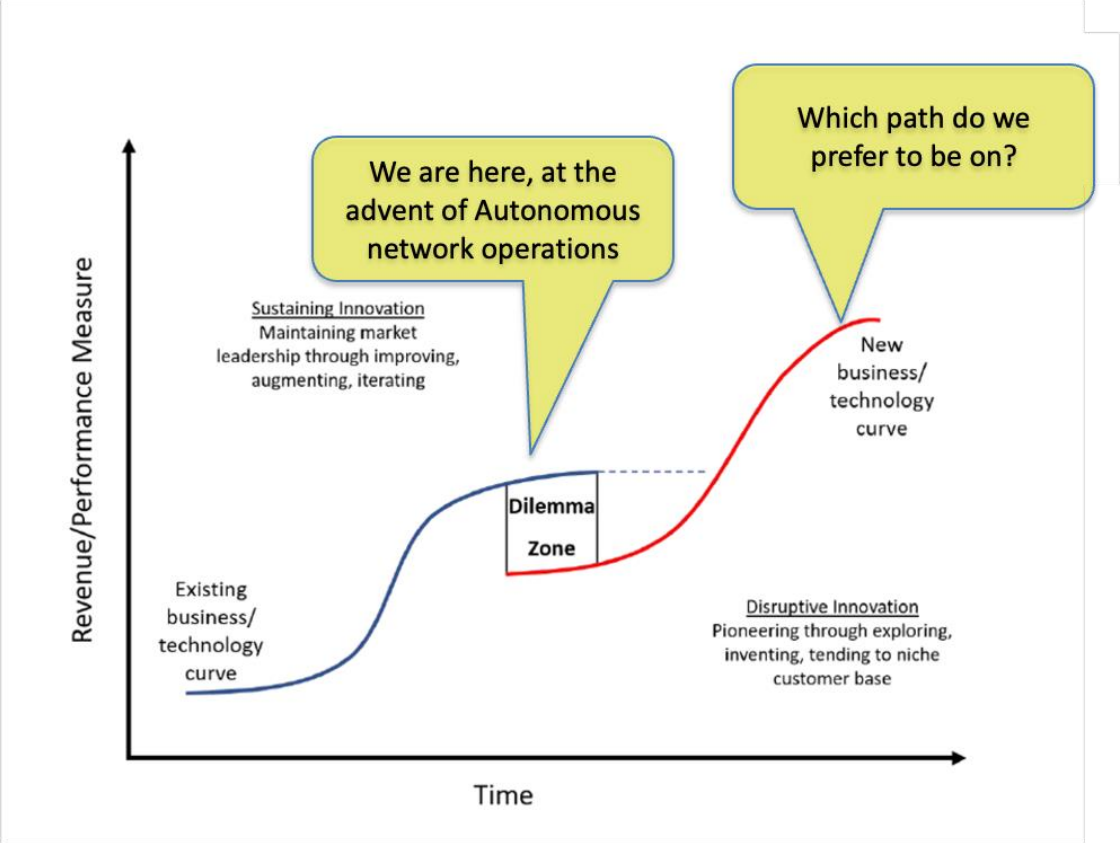
> ***"This is a chance to gain experience with various autonomous software products. Clearly, Orange have ambitions for end-to-end autonomy. All domains are being considered, and we are in the process of identifying the best options to accelerate and reach our targets faster. We need to consolidate in the coming months how we will operate, what tools we will use considering our multi-geography footprint…"***
>
> ***Charles Marais, Network Architect, Orange Group***
>
> ***"Our goal is to future-proof our network operations, in part by hiding complexity from the IT [OSS] stack. We will approach this incrementally; starting single-vendor and with cap-and-grow for new customers and new service. In maybe two years we can then complete a forced migration."***
>
> ***Mathieu Van der Grinten, Manager IP and FTTH, Delta Fiber***

Nothing here is surprising: it's a huge job. It is also a highly disruptive process; this means two things:

1. Early transformations to autonomous networking are pioneers; and ***pioneers need to challenge accepted wisdom in order to make great leaps forward***. This is difficult within any large organization.
2. Almost by definition, new, next-generation software products, standards, equipment models, and knowledge are incomplete. This is the story of new technologies always; Clayton Christiansen captured this conundrum well in his management and strategic classic '*The Innovators Dilemma*" (building on the equally towering work of Joesph Schumpeter on "creative destruction"). While this may sound arcane, there are many decades of proof that **any new technology, in its early days, cannot compete on classical cost and features with older tech. But within a few years the race is over.** Think transistors versus tubes, or integrated circuits versus discrete transistors. Game over.

Appledore believes **the industry is at that awkward point** where new technology (autonomous network software) is not quite mature enough to match legacy systems feature-by-feature, yet already has a more sophisticated approach. Moreover, it is on a trajectory that will soon fully obsolete legacy systems *and operators that retain legacy software or even a legacy mindset*.

Figure 1: Substitution of mature for emerging technology creates the "innovator's dilemma"



Graphic: Appledore Research

The implication is that we are on the cusp of an immature technology (autonomous networking) that will soon eclipse traditional methods – if and when we let it grow. This research records the fact that many diverse organizations see value in the end point and are tackling the messy job of deploying autonomous network automation software for their broadband access networks.

> ***"I worked in the Valley and have close knowledge of how technology can be transformative and enabling. At Starhub, our entire C-suite is committed to becoming a digital ecosystem enabler, and network autonomy is crucial to our success – in agility, flexibility and cost."***
>
> ***Ayush Sharma, CTO Starhub***

Finding #2: Autonomous operations have strategic value

. . . if you are willing to think beyond the technology and beyond the constraints of today's operations

> ***"Skate to where the puck is going, not to where it is now."***
>
> ***Wayne Gretzky***

One of our best practices from the autonomy "blueprint" series of reports linked above is that operators should have a "plan" -- an end-to-end, next generation, operating model and software architecture -- in place before they begin. Each domain and each software product deployed should conform to this plan. The goals of this plan are 1) to ensure adoption of best practices internally and in

any software built or acquired, 2) to ensure that everything works well together in the long run, and 3) provide a roadmap for pioneers to follow.

Two operators stood out for communicating an enterprise-wide strategic intent—an intent that went far beyond broadband access. In both cases the briefing party was a C-Suite occupant, and identified themselves as the architect of a future operations paradigm that autonomous broadband access fit into. Both explained the strategic importance of a greatly simplified operations environment in which service innovation was rapid and inexpensive; orders flowed automatically, without human intervention; and domains manage themselves—and when they could not heal themselves provided very clear data on impacted services customers and the root cause. In both cases they also espoused the value of a unified automations paradigm for a multi-vendor broadband access network. In their minds, how PONs were managed had a huge impact on (for example) customer experience (CX) operations and innovation agility.

The balance of the operators communicated important long-term goals even if they did not describe a complete end-to-end plan. The most common strategic points stated were:

1. Northbound Intent based ordering APIs are critical to simplified NAS[1] (OSS) integration and rapid service innovation and deployment
2. Northbound APIs delivering a menu of more real-time and richer observability data, are essential in order to drive accurate root cause analysis, AIOps, and reduce costly maintenance actions (e.g.: truck rolls, extensive customer support)
3. Southbound APIs capable of interfacing common automation methods to a variety of vendors and equipment permutations are essential to achieve consistent, unified multi-vendor operation. **Corollary**: common goal was multivendor support on a single autonomous system
4. Open systems that allow broadband operators to easily integrate and innovate without the software vendor "in the critical path"

Finding #3: Native multi-vendor is every operator's long-term objective

. . . Yet all agree that they are on a journey, not at the destination. Standards, equipment models and operator-vendor cooperation must all evolve.

> ***"Our goal is to achieve 100% automation. First, we need to get away from separate silos for assurance and fulfilment, and from having dedicated tools for each vendor. We aim to achieve this by migrating vendors and optical access technologies to a single platform."***
>
> ***Bruno Cornaglia (Fixed Access Senior Manager) Vodafone***

[1] Appledore has redefined the OSS landscape and taxonomy as "network automation software" (NAS) in which the new reality reflects how forward-looking software, including autonomous software, AIops, Cloud native infrastructure and others, and purchased and deployed. OSS on the other hand connotes a backward looking taxonomy.

Our third, major, consistent finding was the importance of **multi-vendor operation**, but often combined with challenges in implementation.

Multi-vendor is nothing new. CSPs have desired multi-vendor operation for many decades – for obvious reason – to maintain competition, ensure fair pricing, and ensure that upgrades feel competitive pressure. Yet multi-vendor is challenging both technically and practically. Therefore, the industry must develop a normalization model, while avoiding the dreaded "least common denominator" which de-values innovation and important features.

The historical result has been vendor islands which greatly limited end-to-end operational benefits. Specifically, it means acquiring, maintaining, operating, integrating, and updating (with new features and technology) multiple systems, increasing the work and cost by "n" times. Furthermore, it almost ensures incompatibilities – even slight differences in how systems work and what data they provide, and in what format. Writ large, this is one of the drivers of the huge "tax" (as famously called by Keith Willets, founder of the TM Forum) that the industry pays to maintain and enhance our base of OSS/EMS software.

One of Appledore's best practices is that there ought to be a single autonomous system managing each domain (whether a technology or administrative domain).

The good news here is that every broadband operator interviewed recognized this as a desirable outcome. And nearly everyone *also* noted the complexity of getting there – citing mostly small but real gaps in the standards, and work to normalize any vendor to the standard interface. They also noted that not every major vendor opens up its interfaces – but Nokia is amongst those to do so, evidenced in their support for Broadband Forum's Cloud CO models. Still, integration can be challenging, as there are significant variations across vendors' OLT hardware and software decisions taken. Clearly, being multi-vendor is not a decision that can be made unilaterally; it demands participation by multiple parties.

The plans forward of operators varied:

- Some believed that their testing indicated that multi-vendor support is practical now, but have started single vendor for the first implementation and will re-evaluate as they gain more experience in the field
- Others found that the standards today are lacking, and that significant work is required to onboard non-compliant suppliers. Hence, they run separated domain controllers, as they want to gain automation and abstraction benefits, seeing a single multivendor controller as a long-term goal.

> ***"We believe that we are among the largest, if not the largest, broadband operators in the world that is at the same time successfully operating a single, multi-vendor automation software system. Our goal is to incrementally grow its capabilities and value."***
>
> ***Guy Scott, NBN***

As shown in NBN's domain controller implementation, Nokia supports multi-vendor via models and southbound APIs on Altiplano – based on Broadband Forum data models and architecture

specifications. BBF's standard device models are flexible to support a variety of operator network designs, hardware capabilities and multiple hardware form factors. Abstracting all that away is not obvious, but standards are working on abstraction layers (BBF Network Resource Management) to improve the ease of use for network build/planning, service build/fulfillment, assurance and service operations.

We believe the takeaway ought to be clear: the industry must continue down this road, apply standard models, identify gaps, document them and drive those needed through standards (e.g.: the Broadband Forum's Cloud CO initiative) and, where vendors are recalcitrant, weigh the long-term cost of such resistance and decide accordingly. We believe this means effectively dictating open APIs and models for all vendor products – natively.

Finding #4: Operators value APIs, abstraction and the power of intent

Even when operators don't use the word "intent", they recognize the importance of simplifying and automating order flows, and generally recognize that intent is THE critical enabler. While some operators spoke more of the local benefits, and others, often C-suite occupants, spoke more broadly if its impact on end-to-end operations, **everyone** believes that abstracted, intent based, northbound APIs will have a far-reaching impact on operations, agility, cost, and accuracy.

Opinions varied as to whether the completeness and granularity of existing north-bound APIs was sufficient. Frankly, Appledore believes all such things will be works in progress that are expanded and refined for years maybe more than a decade—the point of the Innovator's Dilemma, above. We explicitly recommend starting simple and growing as technological maturity and comfort with the risks evolves. Appledore's opinion supports starting early with intent-based ordering APIs for two reasons. First, they are likely to be more elegant and effective than today's imperative ordering methods, even if certain parameters or use cases are not fully supported. Closely connected though, is the second reason: the earlier broadband operators begin their intent-based API journey, the sooner they gain experience, provide valuable feedback and input and improve the breed.

> ***"We operate in a tight wholesale environment, at huge scale to meet growing demand for broadband connectivity in the UK. We need to drive down costs for every line we provide – so we can roll out our next generation fibre network at speed, expand into harder to reach areas and maintain competitive prices. This demands a high degree of automation and efficiency, and low integration and upgrade costs to evolve the system. This is made possible by transforming our OSS with network domain controllers offering open APIs, both for intent based provisioning and for more real-time data collection."***
>
> ***Trevor Linney, Openreach***

Finding #5: Operators prioritize observability and rich data exposure via APIs

Continuing with findings related to open APIs, operators recognize the need for more granular and more real-time performance, fault and state information – and prioritize the resulting ability to have faster, more accurate root cause analysis. They specifically value open, real-time (or NRT) APIs that can feed this information to any system required. Such rich and near-real-time "observability" data, in an open format, allows a range of benefits. Most fundamentally, this can cut down on root cause analysis

time, and greatly improve accuracy, which impacts costly and time-consuming truck rolls. The benefits similarly are dual – faster resolution (happier customers) and cost reduction.

Here the operators were nearly unanimous that performance/observability APIs demand further investment. This is not surprising and Appledore believe this will be a journey – and that experience will be the best guide to prioritizing future roadmap investments such that the most beneficial data are added. In particular it is too early to fully anticipate the needs of AI/ML, but few doubt that this need will arise.

Finding #6: Operators demand open expandability – enabled by rich APIs. And are beginning to exploit them

Expandability uses all of the APIs discussed above, plus more. Not surprisingly, all operators value the ability to extend the functionality available today "out of the box". Clearly many operators will have unique operational needs that could not be fully anticipated (*warning! – we caution against re-inventing the past!*).

And almost every CSP expressed a concern that dependence on any supplier could create a practical bottleneck to progress and innovation. Many also noted that the ability to extend via DIY or third-party add-ons was a strategic imperative to ensure the freedom to innovate.

A perfect and comprehensive set of APIs may never exist. Rather than demand perfection immediately, we advise that operators think realistically about what they would be able to develop and maintain on their own (DIY solutions). History is littered with do-it-yourself OSS that never met its potential and have become non-standard relics driving integration costs up, and innovation down.

DIY software projects, especially for something as new and complex as autonomy, guarantee a lack of sufficient resources for success. Appledore has released research showing how, in the age of cloud native, successful products, with successfully supported roadmaps, demand scale. DIY – even for the largest operators in the world – does not deliver such scale. We believe the proper path is to pick from among the best commercial solutions, experiment early and provide feedback (change requests, etc.) to improve.

Finding #7: Autonomous broadband can deliver strategic M&A value

This one is a surprise finding and demands emphasis.

Two broadband operators – **Wire3 and Starhub** (not surprisingly represented by C-Suite occupants) noted the *strategic* importance that a proven, autonomous, and multi-vendor software infrastructure deliver. In an era of consolidation, even operators that have simplified their challenge by remaining single-vendor are likely to suddenly be thrust into a situation where they have two or more vendors, automation platforms, and operating models.

Both expressed the belief that proven and advanced operations, which could be extended into an acquired (or otherwise combined) property, could significantly raise either the transaction value at acquisition, or the operating performance of the combined entity, or both. **This elevates the "one system, multiple vendors" discussion—regardless of whether there are bumps in the road getting**

there—to a higher level. It also thrusts mundane software technology decisions into the role of shareholder return.

C suites – even at large decentralized players might learn from such singular focus on superior operation performance – and opportunities abound. In North America, for example, we can point to similar success at **Lumen** -- which had four different software stacks and operating models to unify (and is doing so). And should it go through, **Verizon** will need to consolidate the **Frontier** operational environment — in exactly this domain.

Table 1: Table of Key Findings and learnings

Topic	Finding and commentary on context
Early Stages of Autonomy Journey	• Autonomy is a journey. Broadband operators are at the early stage – far from completed. • The good: they are getting started • The challenge: it's a long road and some appear to be moving slowly and struggling against ingrained methods, measurements etc.
Autonomy is being introduced coincident with access technology Refresh	• In every case, autonomous software was being introduced coincident with a new access technology; implemented by a "cap and grow" strategy where old technology remained on old software and was sunset, while all new moved to the new autonomous (or "to be autonomous" software platform. Often this meant initially single vendor with various plans to introduce multi-vendor operations
Inconsistency on end-to-end operational vision and architecture ***(e.g. inconsistent linkage between technology refresh and dramatic business transformation)***	• Some operators had crystal clear corporate plans for tomorrow's end-to-end autonomous operations, extending far beyond technology and implying new organizational structures, service innovation and offerings, and cost structures – with far less labor and more targeted labor expenditures (well qualified dispatches, only when absolutely necessary for example). • Other operators were planning more locally, seeking to modernize and improve local (broadband access) operations, but with a less clear and less aggressive company-wide and disruptive vision. We believe this is a road to sub-optimal gains.
Strong Desire for Multi-vendor; combined with Slow progress	• Every interviewed CSP felt that multi-vendor was ultimately necessary and desirable (although many took a near term simplification of "one vendor first") • Some felt the jump to multi-vendor operation would be relatively smooth utilizing the provided southbound abstraction layer and as industry standards evolved. • Others noted limitations in today's abstraction layers and the difficulty suppliers faced working collaboratively (politics, not in their interest, etc.)
Abstraction and Intent are universally desired, but implications beyond local benefits are not always appreciated	• Every CSP wanted intent based APIs and order configuration automation. • Only a few could explain how service creation, order capture (&CPQ), cross-domain (service) orchestration, and domain orchestration fit together. • This implies silos and delayed opportunity / benefits on a corporate level

Topic	Finding and commentary on context
Open APIs desired for several goals	• Intent/abstraction • Observability/rich, open data • Expandability, independence • Summary: Openness and APIs are universally desired.
Surprise: Open, Multi-vendor autonomy can be a strategic driver of enterprise value!	• When C-suite is involved in the goal setting and execution, the level and magnitude of benefits rises. • "intent", "multi-vendor" and "abstraction" may appear deeply technical, yet when appreciated in the big picture proper implementations of these concepts with a network technology domain can generate large, strategic, financial value (see example below).

Source: Appledore Research primary market research, with commentary from related research

Why change is so hard

Technology and software -- while sometimes the focus of new modernization projects – are not the most disruptive challenges on the road to autonomous network operations. Rather, ***the most difficult challenges are those that impact thousands of people, many of whom don't have the luxury of becoming experts in autonomous networks, nor the ability to drive strategic performance for the enterprise.***

If we roll back the decades and think of the original name of this class of software, it was "operations **support** systems" (OSS) — software to support ongoing *manual* operations and to make them more efficient. And therein lies the crux of the challenge. Software ("OSS") merely implements major parts of this process, and organizational structures are then built around operational teams. This is in fact one major thesis of Alfred D. Chandler's management classic– "*strategy and structure*." The unavoidable conclusion is that for network autonomy to be successful, we **will** need to re-think basic operational processes and **may** need to even modify organizational structure – both of which are disruptive (yet valuable). Without changes to people and process there will be inevitable conflicts between what people are structured and paid to do, and what the software is intended to achieve.

> ***The most effective change depends on a visionary leadership team (C-suite) establishing a set of future objectives, high level operations processes, and the metrics needed to measure and manage them.***
>
> ***Appledore Research***

This study and past research affirm this. Until such strategic objectives are in place we can only measure with backward looking data and backward-looking business assumptions. As evidence, in recent primary market research that we performed on IP & Optical autonomy we discovered that many operators were reluctant to merge existing organizations for optical and IP. Despite evidence that showed clear savings in cost, accuracy, operators were resistant to this disruptive change. Succinctly, they initially favored status quo over business performance.

C-suite leadership is essential to success

If Appledore could make only one recommendation to network operators that wish to successfully achieve autonomy – and gain the maximum benefits – it would be "Have the C-suite understand the far-reaching possibilities of autonomy, sponsor an end-to-end plan that defines modern operations processes and methods, distill technology requirements into a small understandable set (we suggest ours, here) and communicate them widely".

Beyond the obvious leadership and authority, a C-suite led plan (written by select professionals) avoids the practical issue that many professionals don't fully understand the ins and outs of autonomous networks. The plan provides a clear guide, and leverages expertise, ultimately educating a broader cadre.

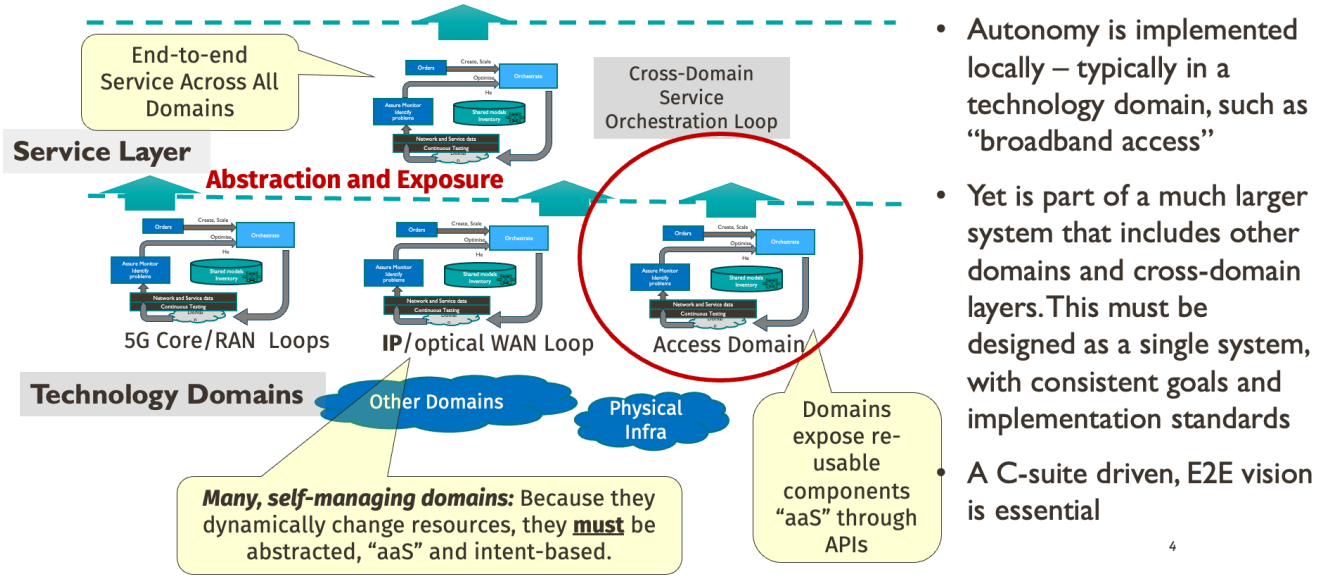
Autonomy is an end-to-end process that demands consistent goals

Autonomy is both local with domains such as broadband access or 5G RANs and also an end-to-end concept. Implemented consistently, it is a company-wide distributed set of software products interacting to create services, interact with customers, capture orders implement services per those orders, heal and scale as necessary, identify physical root causes and dispatch precisely, and manage your services end of life and or changes. This means the decisions made in domains such as broadband access ripple throughout the company—right up to BSS. In fact, we have shown that the parameters exposed to CPQ (configure-price-quote) to capture an order, and the options desired by a customer, are in fact the intents necessary for an autonomous software system to provision and configure that service. If the two systems have different visions, problems will arise.

The diagram below illustrates Appledore's view of modular, domain-led autonomy, and emphasizes how these systems must collaborate to create both end-to-end services and end-to-end operations.

One thought to keep in mind while looking at the picture below is how APIs and intent greatly simplify order flow and increase agility. In an intent-based world (as is the case with Altiplano), we can think of intent as beginning in a service definition (in the catalog), that is then transferred to CPQ to interact with customers, and to autonomous network operations in one or more technology domain to implement and for the basis for constant state/condition monitoring. Intent IS the content of those APIs, and this information becomes a ready, consistent set of data to be used throughout the service's lifecycle. Compared to traditional bespoke integration this is a multiple-order-of-magnitude improvement. Yet it crosses many operational and organizational boundaries.

Figure 2: Network and Service Autonomy is a rollup of many independent decisions



Source: Appledore Research

This combination of technical complexity yet broad business impact creates an unusual challenge. Because it "breaks rules and norms", C-suite understanding & involvement are necessary. And typically, C-Suite occupants are both spread thin, and several steps removed from such technology. Yet we believe that the evidence is overwhelming that a true strategic plan is an application of true leadership that will pay huge and ongoing dividends to the enterprise.

Altiplano in the context of these findings

The objective of this project was to find and document, independently, the learnings from broadband operators struggling with the transition to autonomous network operations. But we also feel the need to opine on the applicability of our sponsor's product entry– in the context of these findings.

Nokia Altiplano is built on control theory concepts. Dry, yes, but crucially important to long-term success. By implication, it abstracts implementation details into intents and has flexible algorithms to find implementations that meet those intents. It combines provisioning and assurance actions (essentially reconfiguration) on a single orchestration method and is intended to manage across vendors and equipment models/generations using a normalization approach (both are not only best practices, but specific operator priorities identified in this project). By reviewing Altiplano's architecture and goals, we found that its design objectives align with Appledore's best practices, and we also saw evidence that those who thought about operations with a forward-looking approach, were already making significant progress in terms of automation, simplification, multi-vendor support and open software integration.

> ***"Most software vendors sensationalize features; Altiplano under-sensationalizes."***
>
> ***Jason Schreiber, President Wire3***

Summary & Recommendations

This document summarizes our findings – that the industry is in the early days of autonomous network operations yet is already grasping the bigger picture and endeavoring to get there. It captured the trade-off that firms are making as they struggle with both the need to move quickly, in the complexity of the evolution – balancing strategy and practical tactics.

We found that how every operator recognized the importance of simplified operations and streamlined integration that are provided by intent-based operations, and open north and southbound APIs.

Growing on this research, combined with our large corpus of Research, Appledore makes the following recommendations:

1. **"Think global but act locally".** The practical reality is that individual technology domains and organizations will transform gradually over time. Monolithic transformation projects are costly and risky, and the details of network technologies are too arcane to be fully appreciated by any centralized planning organization. Our strong suggestion is to have a high-level master plan and objectives drawn up by a small cadre, led by the C- suite, and guiding local implementation choices, and decisions.

   Corollary: only with an end to end, master plan will all of the benefits and simplifications in the end-to-end flow of operations be realized.

2. **Overcome "The Innovator's Dilemma".** Begin your plan and transition soon. Business history shows the clinging to proven mature (legacy) technologies is a well-established road to ruin. On the other hand, gaining experience and expertise in the successor technology places you on a rapid learning curve and provides a first advantage and competitive advantage.

3. **Don't confuse autonomous network operations with an upgraded version of today's operations – they are radically different**. This truth has many consequences. First it means we cannot expect even well-educated expert staff to be universally familiar with the principles of autonomy. Second, we must understand that there will be far reaching changes to business process, organization, and management metrics. The changes run deep and must if you are to succeed.

4. **Address multi-vendor aggressively at an industry level and stand firm on the need**. Multi-vendor proved to be universally desired, and also the most complicated problem to solve, in the eyes of the many participants in this research.

   The good news is that every operator agreed that huge progress is already being made in industry standards, and the job now is to overcome the remaining gaps. Do it.

5. **Aim High**. The unspoken danger is aiming too low and achieving our target. Autonomy is not an incremental change that can provide a 20% or 40% improvement in existing operations. In those areas where autonomy may be applied, cost reductions can be 50% to 90% (meaning productivity improvements of *2x to 10x!*). Moreover, some of the biggest goals come when multiple domains have embraced autonomy and now orders, assurance, and proactive operations happen with minimum if any systems integration and automatically.

For those interested in digging deeper, Appledore has a rich corpus of research on autonomous network operations, control theory, control theory applied to Virtualization, and specific market outlook reports looking at the status of major software categories, such as domain service, orchestration, and autonomy in the IP/optical and Open RAN domains.

We again thank all the operators who gave generously of their time and experience, and we thank Nokia for making this possible, providing guidance and moreover providing Appledore autonomy ☺.

Insight and analysis for telecom transformation.

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