# Step By Step Methodology For Optimal Access Transformation Planning

Republished from July 2022 SCTE Journal

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## What is the problem?

Broadband access networks are constantly evolving to keep pace with subscriber demand, competitive pressure, and the requirement of launching new services. Building an optimal access transformation plan is a key factor in an operator's business success. This plan is closely moniroted by the leaders from strategy, product, engineering, finance and operations. How to build such a critical plan collaboratively?

## Key Takeaways

With a plethora of technology options available to cable operators, the operators should invest in long term planning to find an optimal access transformation solution. The take aways from this paper includes:

- a six-step process for achieving optimal plans
- motivations to get the 360° views of SOFT
- steps to determine which upgrades path is optimal

Although, this paper is focused on the financial risk, it is important to consider risks and constraints from all domains in the SOFT framework where all stakeholders in the organization can be onboard.

Key words: Access planning, optimization, strategy, speed tier, finance, operations

## Executive Summary

Broadband access networks are constantly evolving to keep pace with ever-growing subscriber demand, competitive pressure, and the requirement of launching new revenue-generating services. The access transformation plan for implementing this evolution drives most of the future investments and future operational complexity and can be a gating factor for revenue opportunities. Building an optimal access transformation plan is a key factor in an operator's business success.

Building such a plan is a complex collaborative process. This paper introduces a multi-step methodology to break down the complexity and accommodate the uncertainty of future assumptions. It showcases simple examples and highlights the decision-making process from a financial point of view. We show how different business requirements such as product roadmaps and budgetary constraints will influence the optimal solution to turn into a realistic executable solution. However, even though the financial implications of the access plan have been considered, a similar comprehensive analysis needs to be conducted from the operational, service, and technological risks points of view.

## Introduction

Cable operators are going through major access network transformations. These are driven by one of the following: competitive pressures [1]; targeted response, fixed wireless confusions [2]; 10G evolution goals [3]; or recent wins of Rural Digital Opportunity Fund (RDOF) funding [4] from the government. To address these needs operators are considering many access technology transformation options [5], [6], [7]. All these transformation options come at an expense from the financial, operational, and capabilities points of view. We have presented many papers on how to analyze different access transformation options; see, for instance, [8], [9], and [10]. The burning question to all operators is which is the right transformation strategy? This simple question that industry leaders are trying to answer is very complex and involved. One key takeaway from all the access transformation papers is that building an access network transformation strategy is a data-driven interactive process that cannot be mimicked with a single algorithm. The process starts with creating in-depth insights on all transformation options through evaluating multiple transformation strategies, optimization algorithms, and what-if scenarios. Using these insights, an informed decision can be made on the transformation strategy that best fits the corporate goals. Our goal in this paper is to provide a comprehensive mechanism on how to arrive at such a plan from a *financial requirements* point of view.

The fundamental questions one needs to ask include:

- What are the clearly defined transformation goals?
- How do we evaluate and compare the transformational plans uniformly?
- How can we be sure that this is the best transformation strategy amongst available options?

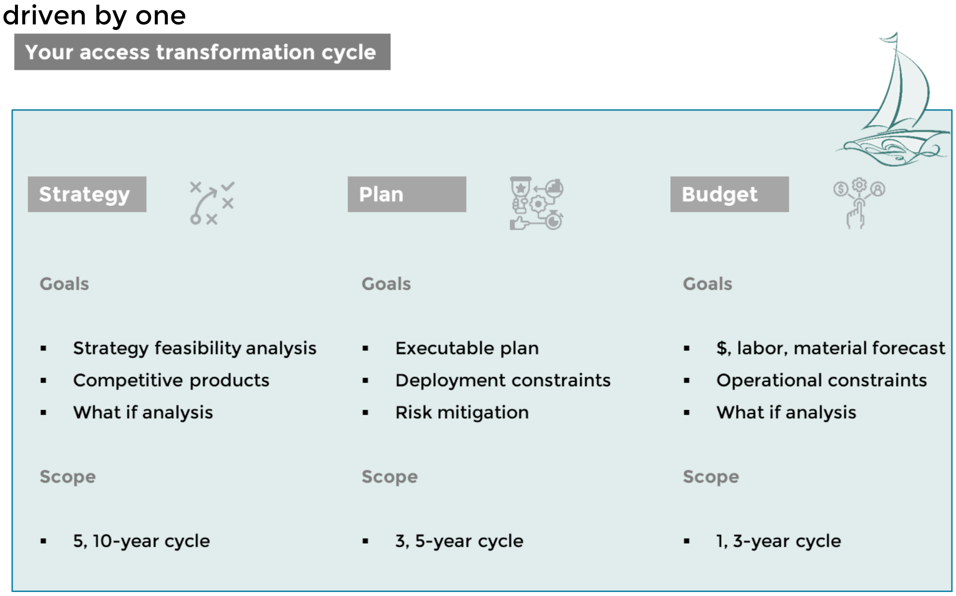



Figure 1  A typical access transformation goals and scope

- How do we align the company strategy into an optimal solution?

To understand the financial implications of the transformation choices, one needs to understand the access transformation cycle. This is elaborated in [8], [11]. As shown in Figure 1, when performing access transformation, one needs to consider the strategic, planning, and budgeting needs. Typically, **strategic planning** is done with a long-term vision in mind over a five- to 10-year horizon. While doing such long-range planning there will be many risks/unknowns (financial, operational, and technical) that the team needs to consider. Hence, they need to evaluate these through different *what-if* scenarios. The strategic plan should result in an **executable plan** that mitigates risks such as financial budget limitations, resource availability, etc., by establishing limits. Typically, these are done over three- to five-year cycles. Such an executable plan drives the yearly **budgetary planning** cycles more focused on the operational challenges such as market-level spending, labor, and material challenges.

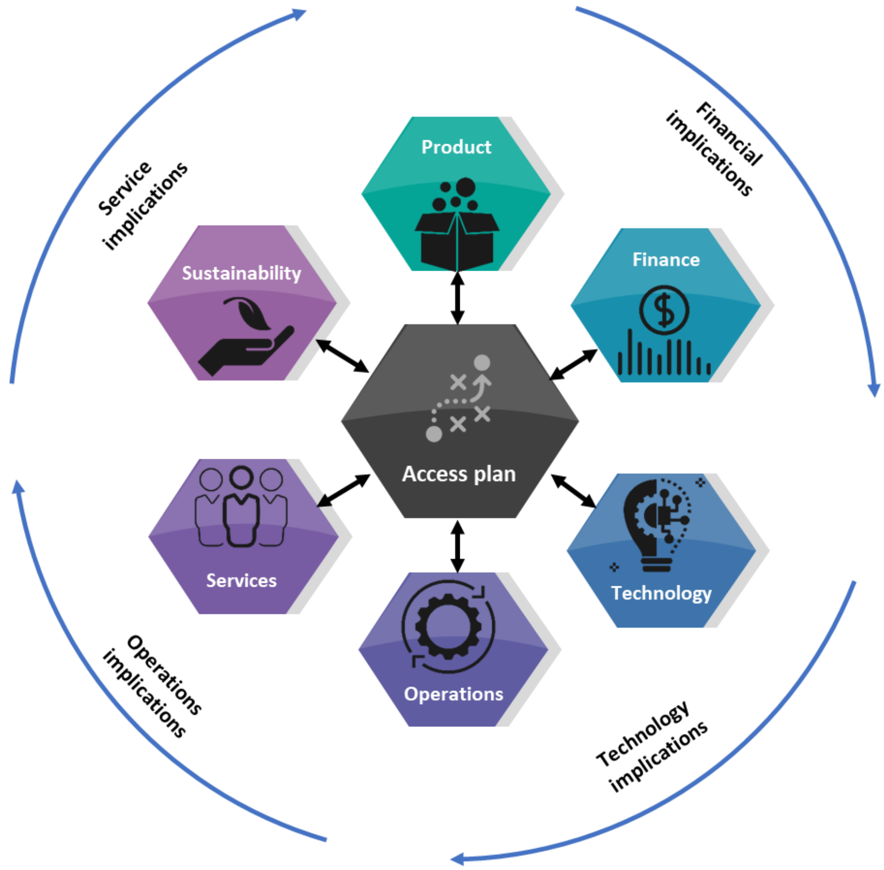


Figure 2 Access transformation analysis dimensions

As we have emphasized, access transformation planning is a multi-dimensional analysis that should consider realistic scenarios. In this paper, we focus on the financial aspects of such strategic planning and show how one can derive an optimal transformation strategy.

## High-Level Process

### SOFT Framework

Before diving into the financial transformation optimization, we want to present the other aspects of the access transformation plan that have implications (as explained in Figure 2) for the organization. We call this the services, operations, finance, and technology (SOFT) framework.

Creating an access transformation plan that is **executable** and **meets the goals** is essential for success in this hyper-competitive environment. To define what meets the goals, the planning team should consider:

- The financial implications include revenue through product offerings and deployment costs.
- The technological choice implications include the risks and capabilities of newer technologies and the deployment challenges.
- The operational implications include operating the networks and managing customers; and
- Finally, the service implications include keeping the customers happy and retaining them while offering next-generation services.

For a proper 360° planning, analysis in all four dimensions of SOFT is essential. But in this paper, we focus on the financial optimality aspects of transformation planning.

**Understanding Total Investment**

For any access transformation planning, knowing where your access network is now and what your target state is at the end of the planning period, as shown in Figure 3, is essential. To reach the target access network state, cable operators have many transformation upgrade options as explained in [12] and summarized in Figure 3. All these upgrade options cost different amounts and will have different investment timings (that is, different net present value or NPV of the investment). In some cases, the target state can be reached with a fundamentally different end-state technology option (such as FDX or FTTH). The financial decision between these upgrade options can be made based on the total NPV or total cost required for these upgrade options. There may be many viable upgrade paths to reach a target state. From the financial point of view, the operator needs to consider minimizing **the total investment** in making the right choice.

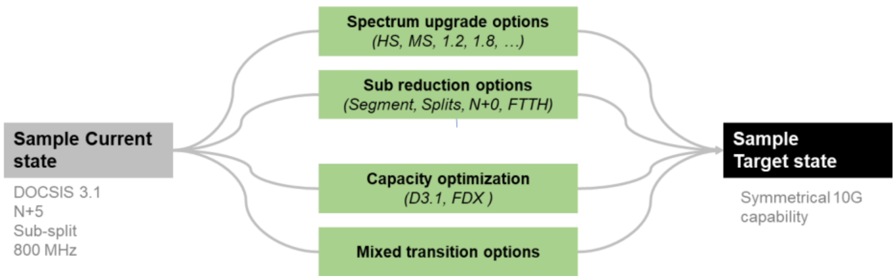



Figure 3 Access transformation upgrade options to reach a target state

An **investment difference** between two upgrade options – option$_1$, and option$_2$ – is the NPV cost difference of the upgrade cost overlay – that is, NPV (option$_1$) or NPV (option$_2$) – for the operator reaching from the current state to the target future state.

For example, as shown in Figure 3, an operator who has deployed D3.1 with Node + 5 status on an 800 MHz plant and a sub-split configuration wants to reach a symmetrical 10 Gbps capable solution in 10 years. The question here is what is the least expensive investment option the operator needs to take? Let's say the operator is considering the following two upgrade options:

- Option$_1$: *Reach N+0 FDX*: Upgrade to 1.2 GHz plant, N+0, and eventually to FDX
- Option$_2$: *Reach XGS-PON*: Upgrade to XGS-PON-based FTTH

The investment difference in selecting option$_1$ versus option$_2$ will be NPV (*Reach N+0 FDX*) – NPV (*Reach XGS-PON*) for the whole operator network over the 10 years.

Our goal in this paper is to determine an optimal plan that an operator should use to reach their target state. This goes beyond comparing a few scenarios. It involves finding the right order of upgrades to reach the target state with the optimal NPV cost. Note: Keep in mind that a financially optimal plan may not be an optimally executable or operational plan. In this paper, we focus only on financial optimality.

**Transformation Methodologies**

The key part of building any access transformation plan is prioritizing the upgrade options one wants to consider. To create an optimal solution, we needed to include all possible upgrade options for each state of a node. In this paper, we included the possibility of different types of upgrades a cable operator might consider. These options include:

Spectrum upgrades:

- Increase the upstream capacity through mid-split, high-split, and full-duplex options
- Increase the downstream capacity by adding additional OFDM blocks or adding full-duplex blocks (can include the increase of the overall plant capacity by upgrading to 1.2 GHz or 1.8 GHz)
- Increase the capability of fiber-to-the-home from XGSPON to NGPON2 or 100G PON

Sub reduction upgrades:

- Reduce the number of subscribers per node through node splits

- Reduce the number of subscribers per node through fiber deep options with N+0 FDX nodes
- Convert the HFC nodes to fiber-to-the-home nodes

One of the low-cost options available for cable operators is managing the spectrum allocation on the plant (between the node and the home). As shown in Figure 4, the operator can use the shared spectrum amongst homes on a node that can be effectively used as an upgrade lever[1]. The first spectrum lever is the total available spectrum per node. Typically, cable networks have a downstream upper-frequency limit of 750 MHz, ~ 800 MHz, or 1 GHz now. There is a lot of work in progress to support 1.2 GHz and 1.8 GHz plants. The other option is to carve out the spectrum for upstream and downstream usage judiciously. Most of the operators are using sub-split (5 MHz to 42 MHz) for upstream usage. The future upstream spectrum options available for the operators now are mid-split (5 MHz to 85 MHz) or high split (5 MHz to 204 MHz). These upstream and downstream bandwidths are used for carrying different DOCSIS technologies, as shown in the figure. Note that it is not the intention of this paper to go into the details of the spectrum allocation logistics, but to demonstrate the available options to operators. Note also that concurrent usage of the same spectrum in the upstream and downstream direction using FDX is not shown in the figure.

Figure 5 shows a graphical representation of all the upgrade options considered in the transformation plan used for this paper, including the above-mentioned spectrum options. The analyses used in this paper consider a six-year quarterly plan[2]. The ellipses in the graph represent the technology state of a node at a given time. The arcs in the graph represent the valid options between the technology states. Note that in the figure we did not provide the priority of choosing

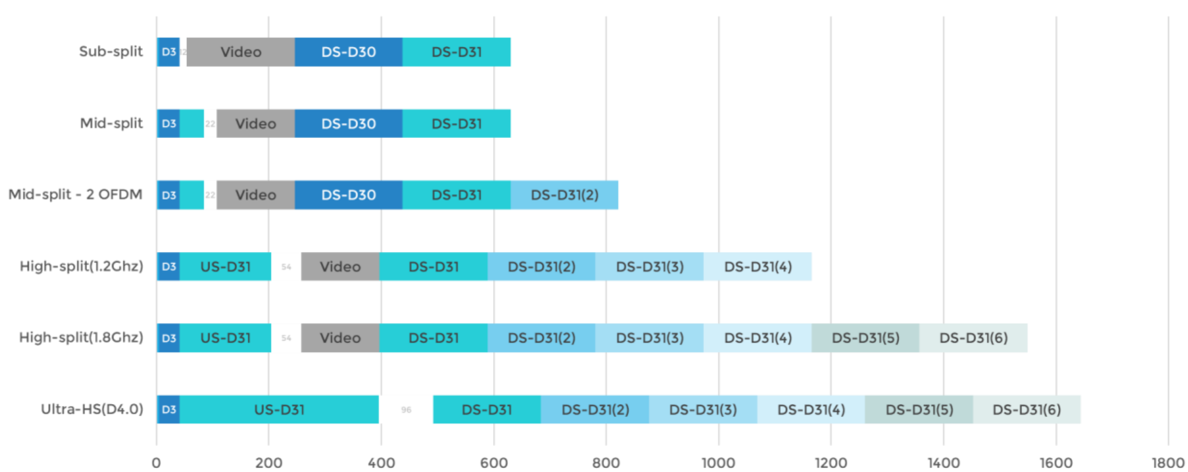



Figure 4 Different spectrum allocation options that are available to operators

[1] The costs of moving from current to future state spectrum options are considered in our analysis.

[2] The costs used for all upgrade actions in this example are based on the default cost included in the AP-Jibe tool. These costs are averages based on extensive industry research by our team.

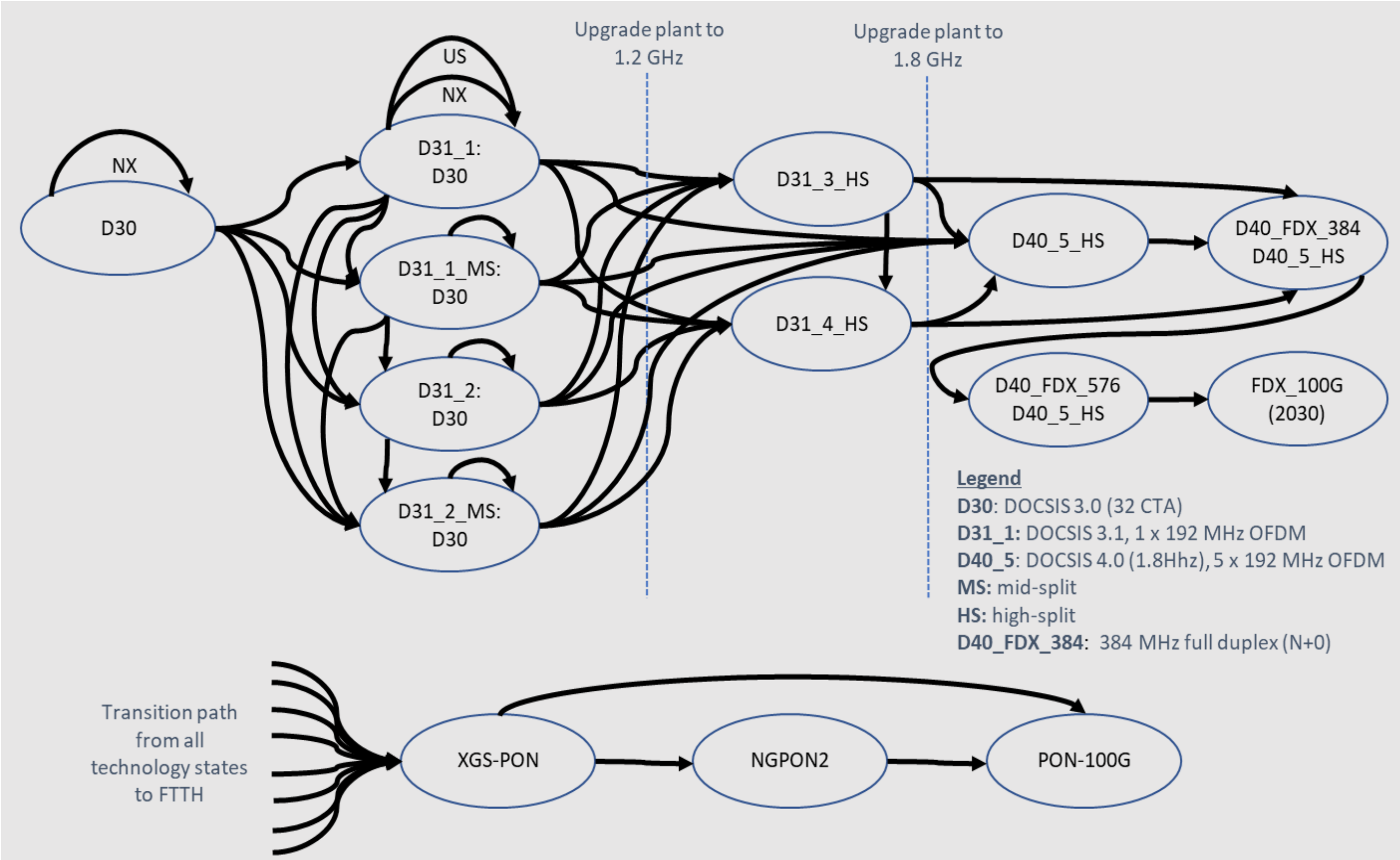



Figure 5 Different HFC and FTTH access upgrade options considered in this paper

an option, which is also essential to pick the right transitional option when more than one future technology state can solve the current upgrade needs.

**Different Upgrade Strategies**

The upgrades shown in Figure 5 represent the cardinality of the possible. An operator can manually specify the priorities of the upgrades, for example in a tool such as AP-Jibe[13]. This provides the best control of the upgrade strategy but can be very cumbersome and requires an in-depth understanding of the option priority impact.

**Exhaustive optimization**

The most apparent optimization criteria for a network transformation are the total investment cost or the NPV of the total investment cost. With all the possible upgrade paths available in the model, it is possible for each node to **exhaustively** calculate all the viable upgrade paths and pick the path that offers the least investment (cost or NPV).

For this paper, we defined two different exhaustive criteria to determine what the *best solution* means:

- **The lowest NPV**: In this exhaustive optimization criteria, for every node in the network, pick the upgrade path that keeps the node compliant with the needs and has the lowest total NPV for all the upgrade costs incurred during the analysis period.

**Greedy versus exhaustive algorithms**

Greedy algorithms: These are the algorithms used to select the optimal upgrade option based on the selected criteria. The option is selected without any knowledge of the future needs.

Exhaustive algorithms: These algorithms evaluate all viable upgrade paths for the full duration of the analysis and pick the optimal path based on optimization criteria such as minimize total cost.

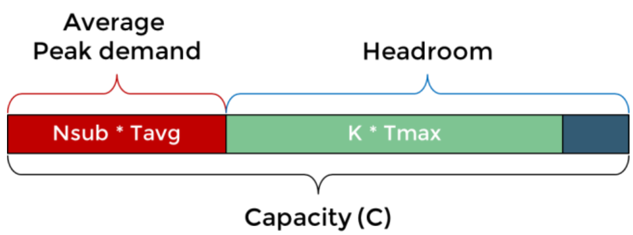
- **The lowest cost**: In this exhaustive optimization criteria, for every node in the network, pick the upgrade path that keeps the node compliant with the needs and has the lowest total cost for all the upgrades incurred during the analysis period.

The advantage of such brute force optimization or exhaustive optimization is that we will find the least cost upgrade path at the node level. On the other hand, the optimal is for the exact set of inputs and evaluation period. As explained in [14], calculation of the optimal upgrade path for 10 years versus looking at the first 10 years of an optimal path calculated for 15 years may present drastically different results. In addition, the solution may provide a different upgrade path at a node level and may not be an optimal solution from the technology, operations, and service point of view.

<u>**Business criteria-based optimization**</u>

As an alternative to the manual upgrade strategy or an expensive exhaustive optimization, the operator can use different corporate strategies as guiding principles to pick the best upgrade paths. The following are the three common classes of corporate strategies (Refer to ***Greedy versus Exhaustive algorithms*** sidebar):

**Kick the can down the road:** In this strategy, when a node needs to be upgraded, the preference is to pick the lowest cost option that satisfies the upgrade requirements. This is the *lowest cost* greedy optimization algorithm.




| | |
|---|---|
| C | The service group capacity |
| $N_{sub}$ | Number of subscribers in a service group |
| $T_{avg}$ | Average peak time consumption per sub |
| K | Access network QoE factor |
| $T_{max}$ | Maximum speed tier offering |

Figure 6 Quality of Experience based capacity allocation

**Minimize network upgrade actions (capacity-based):** In this strategy, when a node needs to be upgraded, the preference is to pick the viable option that provides the most added capacity to the node. That is because, intuitively, upgrade options that add the highest capacity will survive upgrades the longest. Using this option mitigates the risk of unforeseen demand growth increases (e.g., the COVID-19 pandemic impact). This is the *highest capacity* greedy optimization algorithm.

**Least cost per capacity:** A middle ground strategy tries to lower the network upgrade frequency and provide some growth risk mitigation without always using the biggest upgrade step. This upgrade strategy picks the viable upgrade option with the least cost per added bit of capacity. This is the *least cost per bit* greedy optimization algorithm.

Recently operators have been focusing more on network evolution strategies that combine demand growth with Quality of Experience (QoE) triggers [15], also referred to as K-factor triggers, based on the formula illustrated in Figure 6: C >= Nsub * Tavg + K * Tmax

K-factor triggers are also commonly used to incorporate future speed tier roadmap requirements into the access transformation plan.

Upgrades based on K-factor triggers are driven by the available headroom (see Figure 6) on an interface or service group rather than the capacity available per subscriber on the network. It, therefore, makes sense to include alternative upgrade strategies that focus on headroom rather than capacity:

**Minimize network upgrade actions (headroom-based):** In this strategy, the preference is to pick the option that adds the most headroom to a node's interface. The maximum speed tier an operator can deploy on an access link is bounded by the available headroom. A higher headroom strategy is the best hedge against competitive threats. This is the *highest headroom* greedy optimization algorithm.

**Least cost per headroom:** In this strategy, the preference is to pick the option with the least cost per added bit of headroom. This is the *least cost per headroom* greedy optimization algorithm.

If the operator can compare results for these strategies side by side, it creates valuable insights and allows them to quickly refine your transformation plan and pick a strategy that is closest to your vision.

A greedy algorithm by nature considers local optimization without considering the future implications of the decisions. For this reason, the operator may not get the lowest cost solution, but it provides alignment with the company strategy and more importantly, the upgrade decisions will be uniform across the organization.

**Six Steps to Reach an Optimal Plan**

Finally, let's create a process for reaching an optimal access network transformation plan

(Step 1) *Define the current and target status of the transformation plan*: As explained before in the paper, a transformation plan must be defined with a clear target state. Also, it is equally important to get the current state of the network as accurate as possible, preferably at the node level. The status of the node should include the deployed technology, homes passed composition information, distribution mileage information, and possibly the location of the node. It is also essential to forecast the bandwidth demand growth as accurately as possible.

(Step 2) *Create all the transformation requirements*: A transformation is driven by the transformation requirements or the drivers such as the product roadmaps, budgetary constraints, technology availability assumptions, etc.

(Step 3) *Find the transformation options, their costs, and the resource requirements*: Before running the planning exercise, gather details on the upgrade options that are available to you in terms of their capabilities, costs that will be incurred to make the transitions, and the resource requirements to make the transitions.

(Step 4) *Apply transformation business rules*: Apply different transformation business rules to your upgrade strategies such as market-level strategies to address competition, and preferred K-factor values while committing to the product offering, etc.

(Step 5) *Run different scenarios with different upgrade strategies and optimization methodologies*: Use the above rules across multiple optimization criteria and get node-level details. Aggregate them and use them to compare with the other scenarios.

(Step 6) *Compare the results against the evaluation criteria*: Compare different optimization strategies, discuss amongst the leaders, and decide what makes sense for your company goals.

We elaborate on this process with the help of the examples in the following sections.

## Developing Optimal Solution

Before performing the optimal transformation planning, the operator needs to collect the following high-level strategic information:

- The current network status at least at a node level;
- The competition such as their network status, upgrade options, etc.; and
- The target state goals.

In the following subsection, we provide a couple of examples that we use in this paper to demonstrate optimal transformation planning. Even though we could consider enterprise-level planning, we considered a single market in each case to go deeper into the analysis. In a real operator's analysis, multiple such markets with potentially differing strategies may be applied.

**Example 1: Meet the Rural Competition**

A cable operator that is serving a rural market with some fiber overbuilder competition is assessing its transformation strategy. Here is some information that we would consider in this example. Note that this section covers Steps 1 – 4 of the optimal transformation planning process. Also note that we do not go into the details of the cost and resources needs as highlighted in Step 3, as it is out of the scope of the paper.

- The market statistics:
    - Homes: ~150K (SFU 65%, MDU 22%, businesses 13%)
    - Subscribers: ~120K (~50K DOCSIS 3.1, ~70K DOCSIS 3.0)
    - Network status: 800 MHz plant
    - Node spectrum configuration:
        - Downstream DOCSIS 3.0 – 32 QAM, DOCSIS 3.1 - 1x192 MHz OFDM, video - 40 QAM channels
        - Upstream – Sub-split (up to 42 MHz)
- The competition for this operator is mostly the local fiber overbuilders who are deploying FTTH
- The operator's goals include:
    - Compete with FTTH by offering 1/1 Gbps by 2026 and meet the new broadband definition
    - Accomplish these offerings with the least cost to reach the target state
- The customer demand growth assumed for this market is
    - SFU and MDU heavy nodes upstream 30%, downstream 35%
    - Business heavy nodes upstream 32%, downstream 42%
- The planned top-tier product roadmap is shown in the table

| Year | Downstream BW | Upstream BW |
|---|---|---|
| **2022** | 1 Gbps | 35 Mbps |
| **2023** | 1 Gbps | 100 Mbps |
| **2024** | 1 Gbps | 500 Mbps |
| **2026** | 1 Gbps | 1 Gbps |


Figure 7 Example 1 organic demand growth based access upgrade analysis

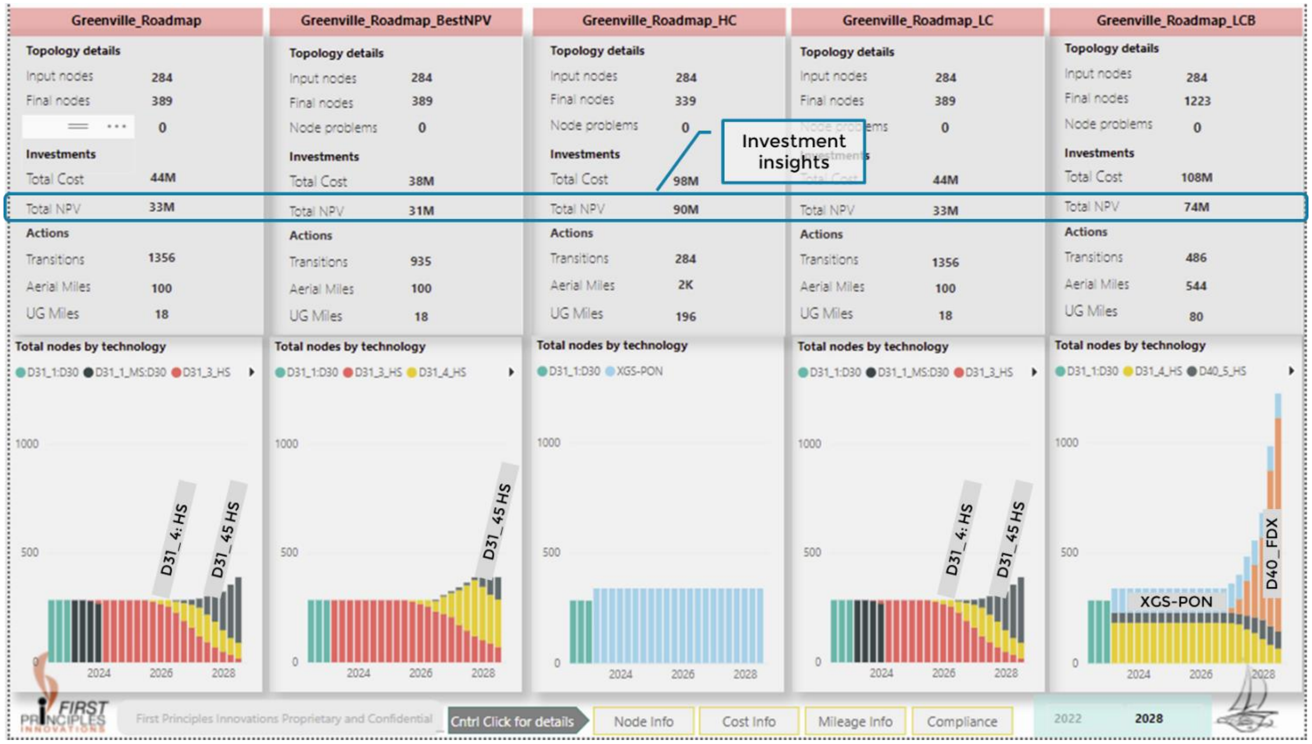



Figure 8 Comparison of exhaustive and business criteria based optimal solutions for example 1

- The operator budgetary constraints are not considered in this example
- Upgrade options
  - In an 800 MHz plant, any upgrade to more than one block of 192 MHz OFDM is not possible
  - When an upgrade of the plant is needed the operator chooses to jump to 1.2 GHz with high-split

***Scenario Optimization Analysis***

After completing Steps 1– 4, the operator needs to use a planning tool, such as AP-Jibe [13] as a next step (Step 5) to get a sense of the organic network evolution needs. Typically, the organic network evolution is driven by the customer demand growth profiles. For this example, the operator may identify the market technology transitions as shown in Figure 5.

As part of Step 5, we also recommend for the operator to include business requirements such as

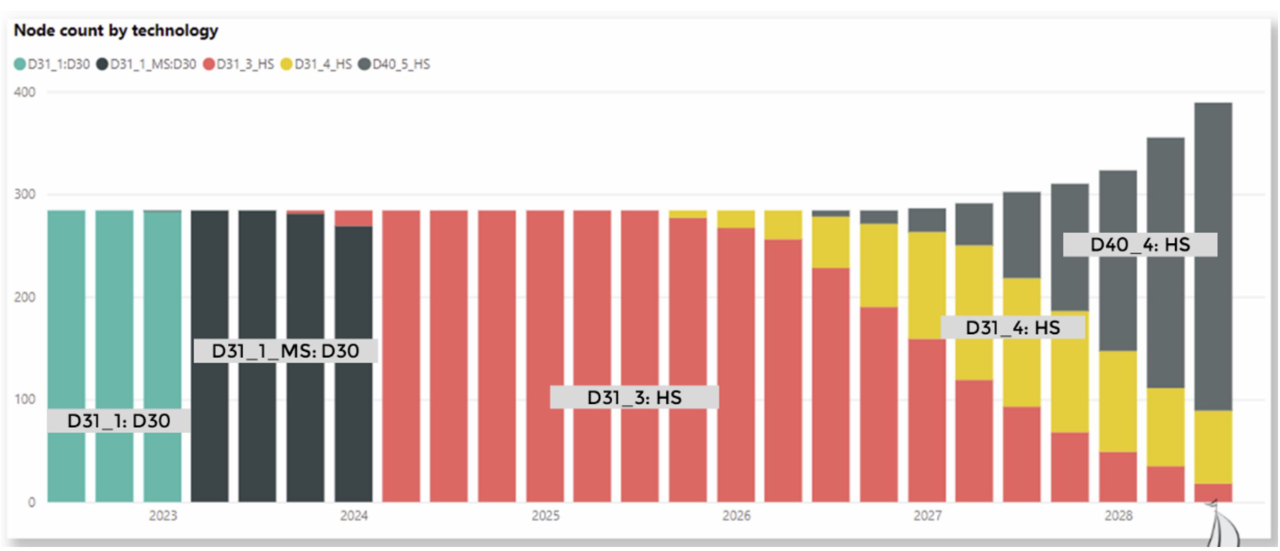



Figure 9 Example 1 business constraints with the organic growth based access upgrade analysis

Figure 10 Demonstration of a bias created by the exhaustive analysis with bounded endpoint

the product needs, budgetary constraints (not included in this example), etc. This gives the operator a real picture of the node upgrades, as shown in Figure 7. Note that the product needs in the upstream direction are triggering mid-split and high-split faster (as shown in Figure 7) than the organic growth as shown in Figure 8. This is the time an operator should reconsider any changes to the business requirements.

Once the baseline upgrade plan is created, it is time to find an optimal solution *that meets the business goals*. Refer to [14] for a detailed discussion on the optimization options. As shown in Figure 9 an operator can compare these options side by side to understand the implications. The basic roadmap gives the non-optimal solution. The best NPV provides the exhaustive optimization of the upgrade strategy without looking into the business strategies, whereas the

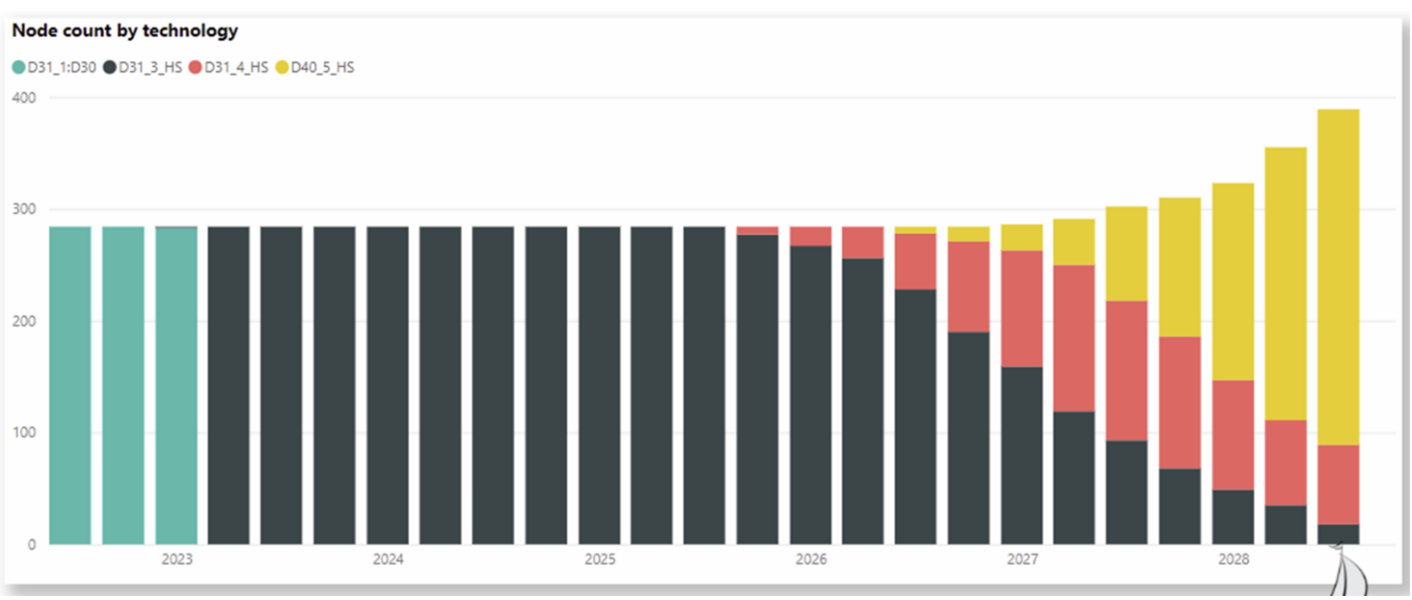


Figure 11 Example 1 optimized access transformation plan that meets the roadmap constraints

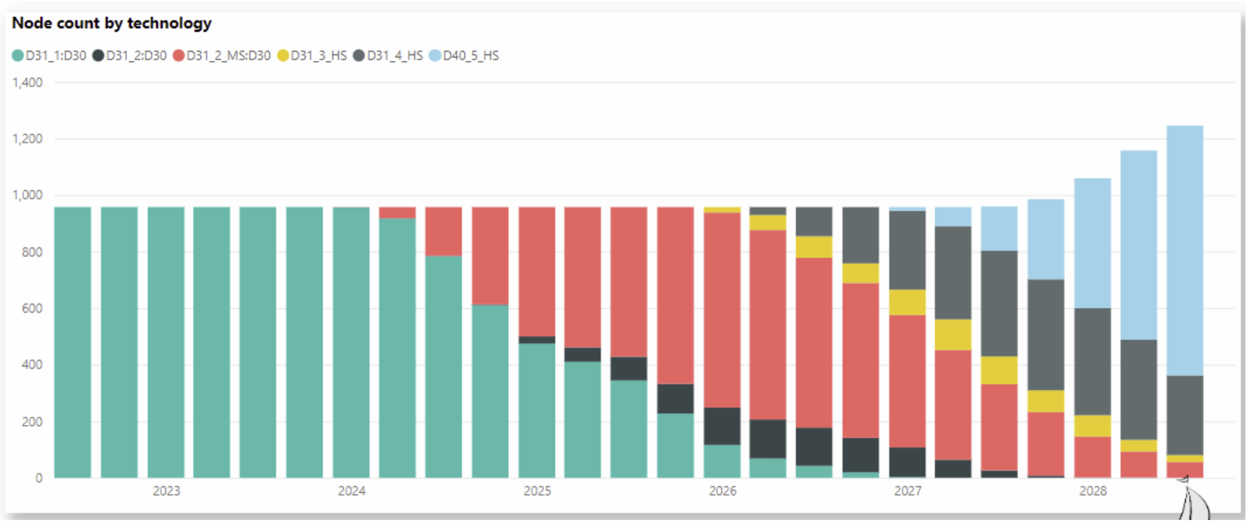



Figure 12 Example 2 organic demand growth based access upgrade analysis

next three provide different business strategies based on optimization. In Figure 9 the business strategies included in the comparison are: *Minimize network upgrade actions* (Greenville_Roadmap_HC); *Kick the can down the road* (Greenville_Roadmap_HC); and *Least cost per capacity* (Greenville_Roadmap_LCB). A quick comparison shows that not doing the optimality analysis will have an investment difference of $2 M ($33 M - $31 M). The highest capacity option (HC) will have a $59 M ($90 M - $31 M) investment difference. The lowest cost option (LC) will on the other hand still have an investment difference of $2 M ($33 M - $31 M) but will have a significant overall cost of $44 M. Making such side by side comparison gives the leaders the financial impact of their choices or not making such an analysis.

Note that the network upgrades do not stop after the six years of the analysis that we are performing in this example. Hence, conducting a six-year optimal analysis is going to create a bias towards low-cost options at the end of the analysis period. To avoid such bias, we recommend analyzing longer periods, such as 10 years for six years, and picking the first six years, as shown in Figure 10. Also, note that a low-cost example does not always mean an executable plan. In this paper, we

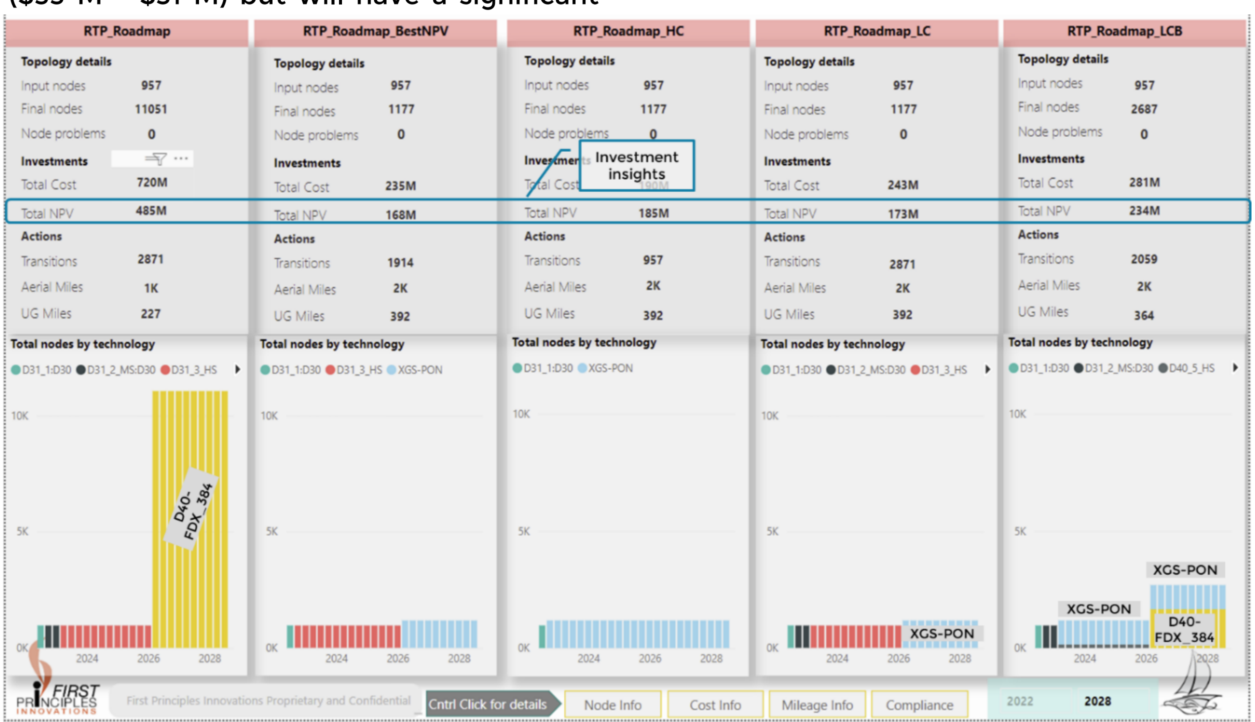



Figure 13 Comparison of exhaustive and business criteria based optimal solutions for example 2

focused only on the financial dimension, but not the other dimensions such as operations to analyze the 360° optimal solutions.

All these insights can be used to recommend an upgrade strategy to the leadership team, as shown in Figure 11. The recommendation includes the insight from the best NPV solution to forgo the upgrade to mid-split in the early years to realize the cost and NPV benefit. In the later years, the recommendation is to diverge from the best NPV solution to favor future safeness by selecting upgrades to D4.0 over node split actions to fulfill the upgrade requirements.

**Example 2: Targeted Deployment to Meet Aggressive Competition**

A cable operator that is serving an extremely competitive urban market is assessing its transformation strategy. Here is some information that we would consider in this example. Note that this section covers Steps 1 – 4 of the optimal transformation planning process. Also note that we do not go into the details of the cost and resources needs as highlighted in Step 3, as it is out of the scope of the paper.

- The market statistics:
    - Homes: ~502K (SFU 65%, MDU 18%, businesses 17%)
    - Subscribers: ~251K (~201K DOCSIS 3.1, ~50K DOCSIS 3.0)
    - Network status: Recently upgraded to 1 GHz plant
    - Node spectrum configuration:
        - Downstream DOCSIS 3.0 – 32 QAM, DOCSIS 3.1 1 x 192Mhz OFDM with 40 QAM channels for video
        - Upstream – Sub-split (up to 42 MHz)
- The competitors for this operator are the telcos and the fiber overbuilders who are aggressively deploying FTTH and pushing symmetrical speeds. Their opportunities include gaining new customers with targeted better products and retaining their existing customer base.

| Year | Downstream BW | Upstream BW |
|---|---|---|
| **2022** | 1 Gbps | 100 Mbps |
| **2023** | 1 Gbps | 500 Mbps |
| **2024** | 1 Gbps | 1 Gbps |
| **2026** | 5 Gbps | 2 Gbps |

- The operator's goals include:
    - Compete with FTTH by offering 5/2 Gbps by 2026 and meet the new broadband definition

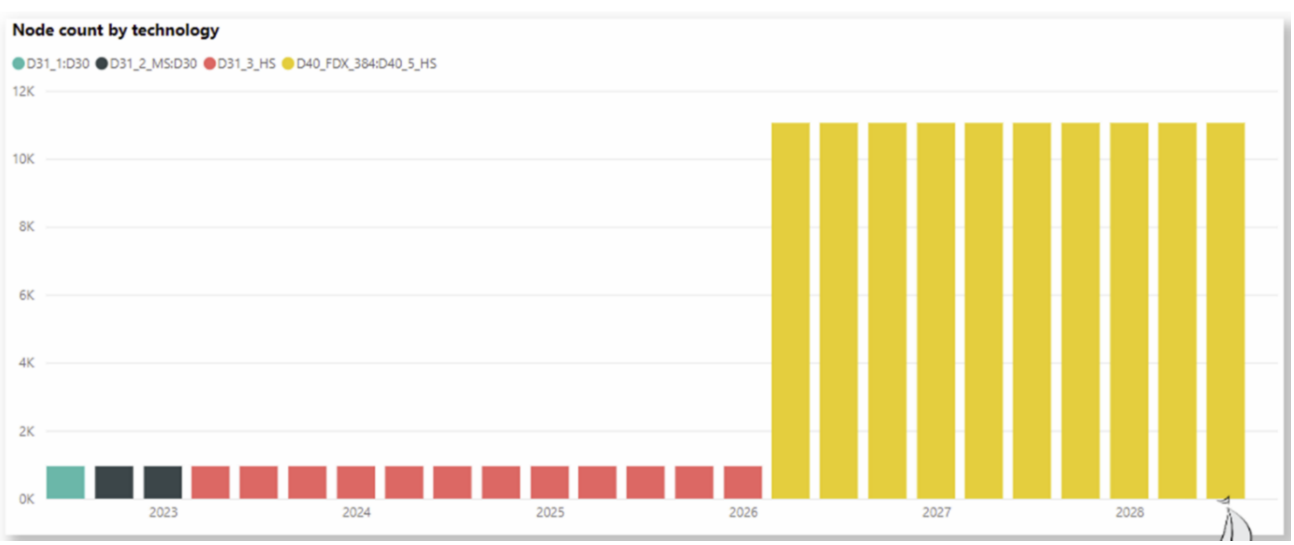


Figure 14 Example 2 roadmap constraints with the organic growth based access upgrade analysis

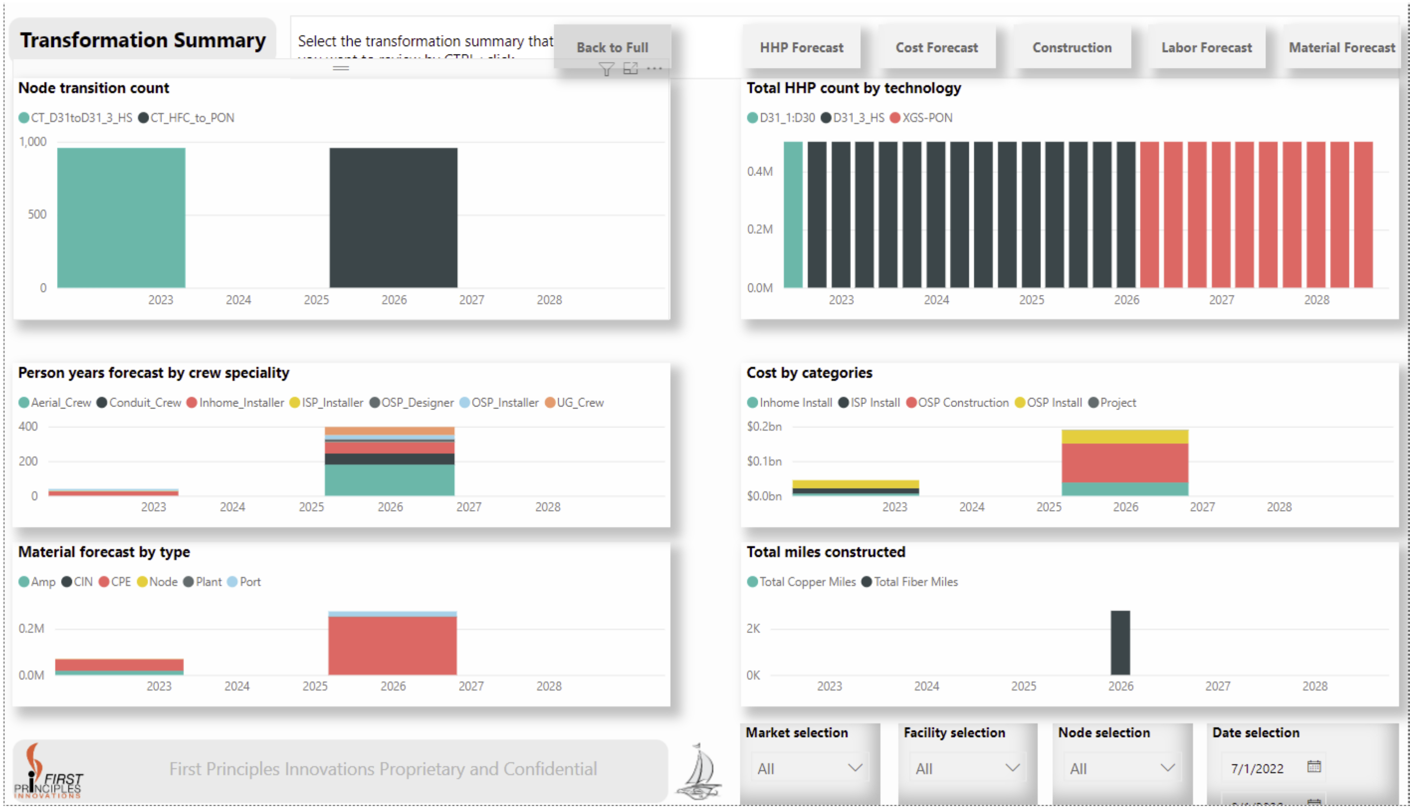



Figure 15 Comparing SOFT parameters before committing to the final plan is essential

  - Accomplish this with the least cost to reach the target state but also be able to offer the best future-safe products

- The customer demand growth assumed for this market is
  - SFU and MDU heavy nodes upstream 30%, downstream 40%
  - Business heavy nodes upstream 32%, downstream 42%
- The planned top tier product roadmap is shown in the table
- The operator's budgetary constraints include: 75M in 2022 with a 5% incremental budget per year
- Upgrade options – all options in Figure 5 are being considered

### *Scenario Optimization Analysis*

Note: We have repeated some of the explanations that we used in Example 1 in this example also for the sake of clarity. We suggest the readers pay attention to the subtle differences.

After completing Steps 1– 4, the operator needs to use a planning tool, such as AP-Jibe [13], as a next step (Step 5) to get a sense of the organic network evolution needs. Typically, the organic network evolution is driven by the customer demand growth profiles. For this example, the operator may identify the market technology transitions as shown in Figure 12.

As part of Step 5, we also recommend for the operator include business requirements such as product needs, budgetary constraints, etc. This gives the operator a real picture of the node upgrades, as shown in Figure 12. Note that the product needs in the upstream direction are triggering the mid-split, high-spit, and major transition to FDX when 5G symmetrical (as shown in Figure 13) is introduced rather than the organic growth as shown in Figure 12. This is the time an operator should reconsider any changes to the business requirements.

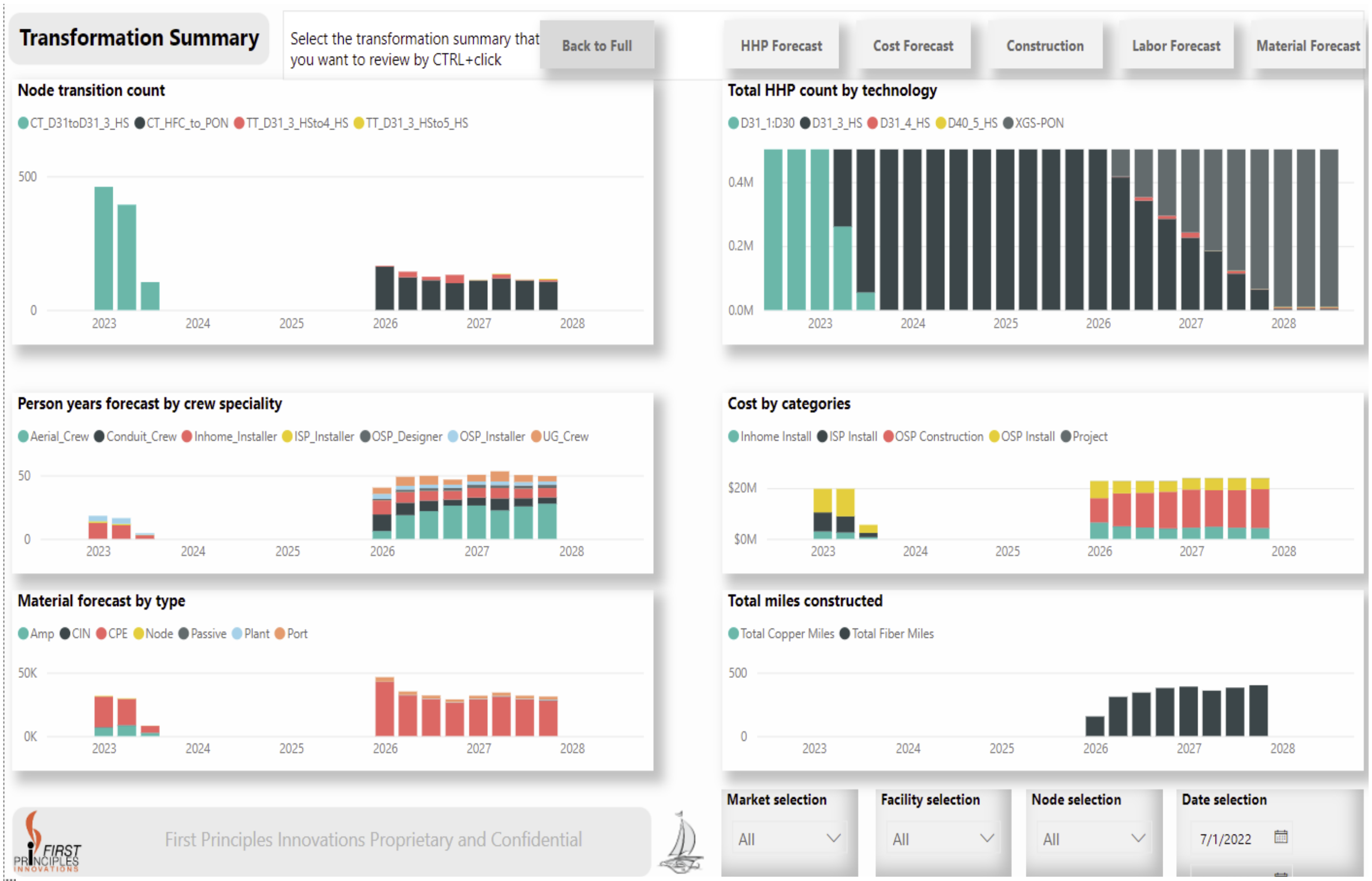



Figure 16 Impact of budgetary constraints on activities, resources, construction and cost

Once the baseline upgrade plan is created, it is time to find an optimal solution *that meets the business goals*. Refer to [14] for a detailed discussion on the optimization options. As shown in Figure 14 the operator can compare these options side by side to understand the implications. The basic roadmap gives the non-optimal solution. The best NPV provides the exhaustive optimization of the upgrade strategy without looking into the business strategies, whereas the next three provide different business strategies based on optimization. In Figure 14 the business strategies included in the comparison are: *Minimize network upgrade actions* (RTP_Roadmap_HC); *Kick the can down the road* (RTP_Roadmap_HC); and *Least cost per capacity* (RTP_Roadmap_LCB). A quick comparison shows that not doing the optimality analysis will have a significant investment difference of $317 M ($485 M - $168 M). The highest capacity option (HC) will have a $17 M ($185 M - $168 M) investment difference but will have a lower overall cost of $190 M. The lowest cost option (LC) will on the other hand still have an investment difference of $5 M ($173 M - $ 168 M) but will have a significant overall cost of $243 M. Making such side by side comparison gives the leaders the financial impact of their choices or of not making such an analysis.

Before committing to a plan, we recommend the operator performs a 360° view on the drivers of all the SOFT parameters such as costs, resources, etc. For example, as shown in Figure 15, it is clear that upgrading the full market to FTTH in one period will run into budget and resource issues. To mitigate the financial risk, realistic yearly budget caps for the market can be overlayed on the solution. Such budgetary restrictions to spread the activities, as shown in Figure 16, even though more realistic to implement, will delay node

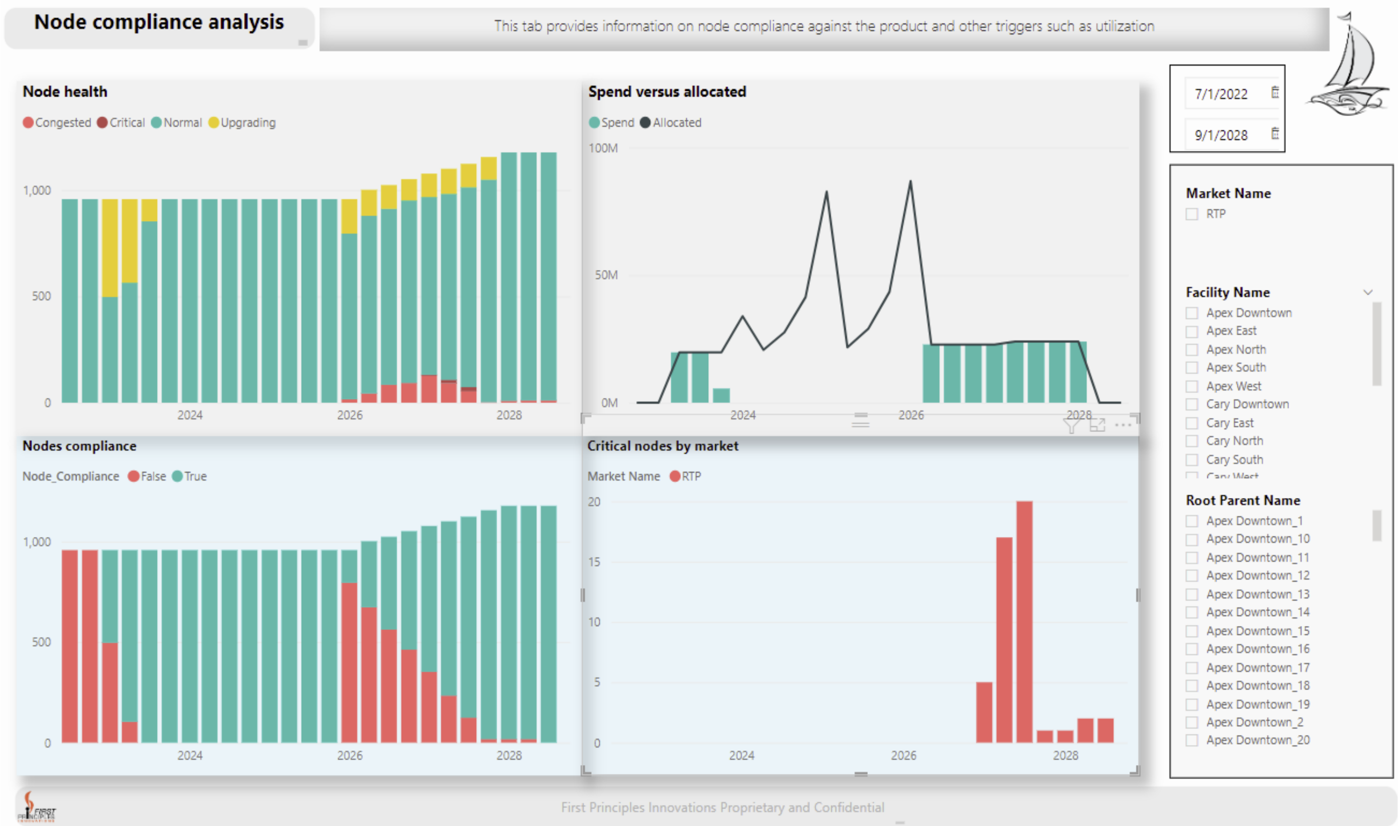



Figure 17 Node compliance and node health when budgetary constraints are applied

upgrades that can cause issues with compliance (due to roadmap requirements) or even with the health of the node (due to congestion). This forces the operator to debate the priorities of the nodes to determine which nodes can be delayed in the upgrades, as shown in Figure 17. At the end of this optimal prioritization exercise, the operator needs to determine a more realistic executable transformation option.

## Conclusions and recommendations

With a plethora of technology options available to cable operators, it is no surprise that many upgrade paths can be found that fulfill their future service (target state) requirements. However, as seen from the simple examples in this paper, the cost of the solutions can be vastly different. Therefore putting in the effort to find an optimal solution is an absolute must.

Building the optimal access transformation solution is a six-step process but is not a simple calculation, as demonstrated in this paper. The key to the process of creating an optimal solution is generating detailed insights to get the 360° views of SOFT implications (only financial implications are considered in this paper) due to the upgrades. Finding the details of the upgrade options is only part of the problem. The next step is to determine which of these upgrades is optimal.

From a financial perspective, the most important insight comes from the calculation of the mathematically optimal path. However, it does not provide the complete picture and should always be complemented by an in-depth analysis of business criteria upgrade strategy, as shown in this paper.

The optimal solution created from a financial perspective is not the end of the road. As shown in the second example, overlaying the plan with realistic financial constraints is a necessary first step toward an implementable solution.

Lastly, it is important to consider risks and constraints from all domains in the SOFT framework to refine the plan to a point where all stakeholders in the organization can be onboard.

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