DOCSIS 4.0



Liberty Global Tech - Robert-Jan van Minnen


Did you ever ask yourself, for how long will the coax keep delivering broadband?

DOCSIS 4.0

AGENDA

01 Why the next generation of cable internet

02 Solutions with DOCSIS 4.0

03 Implementation

04 The future

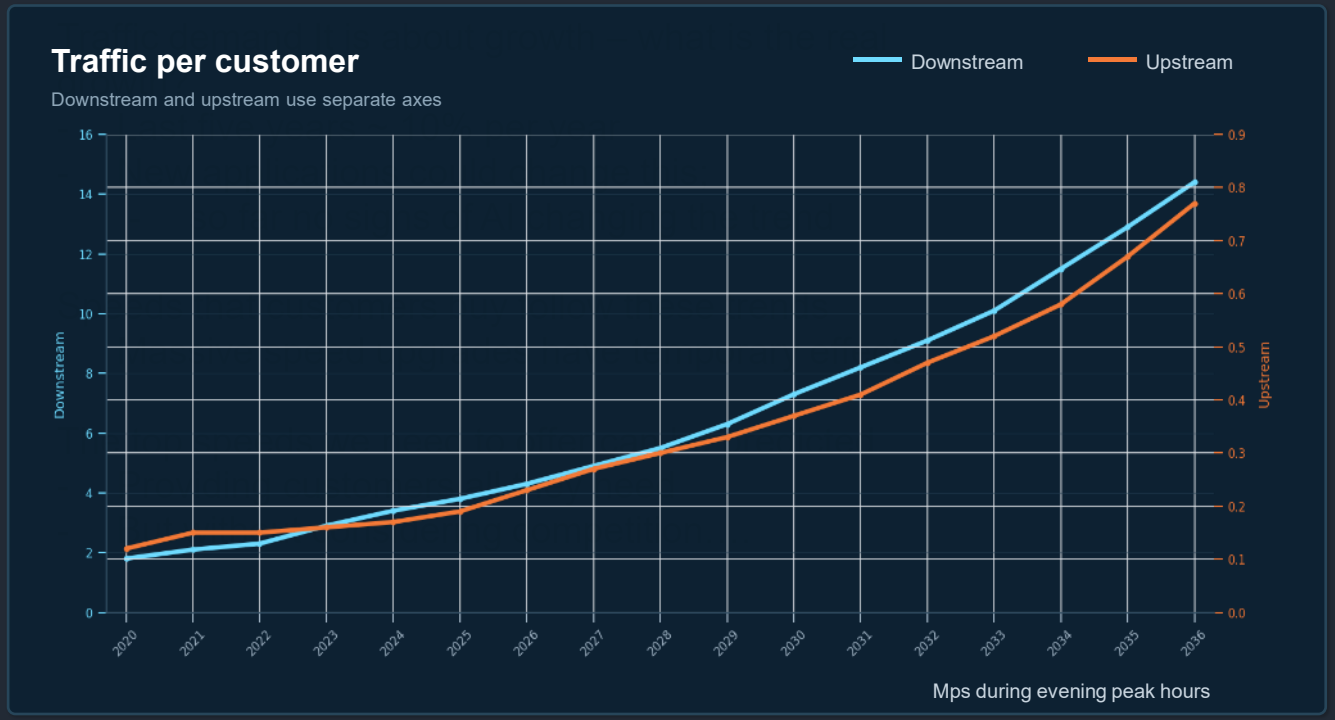


WHY THE NEXT GENERATION

What is driving the next generation of cable internet?

TRAFFIC KEEPS GROWING

A sustained demand curve makes capacity evolution unavoidable



THE SIGNAL

Growth does not flatten

Both directions continue rising through 2036, with upstream accelerating as well.

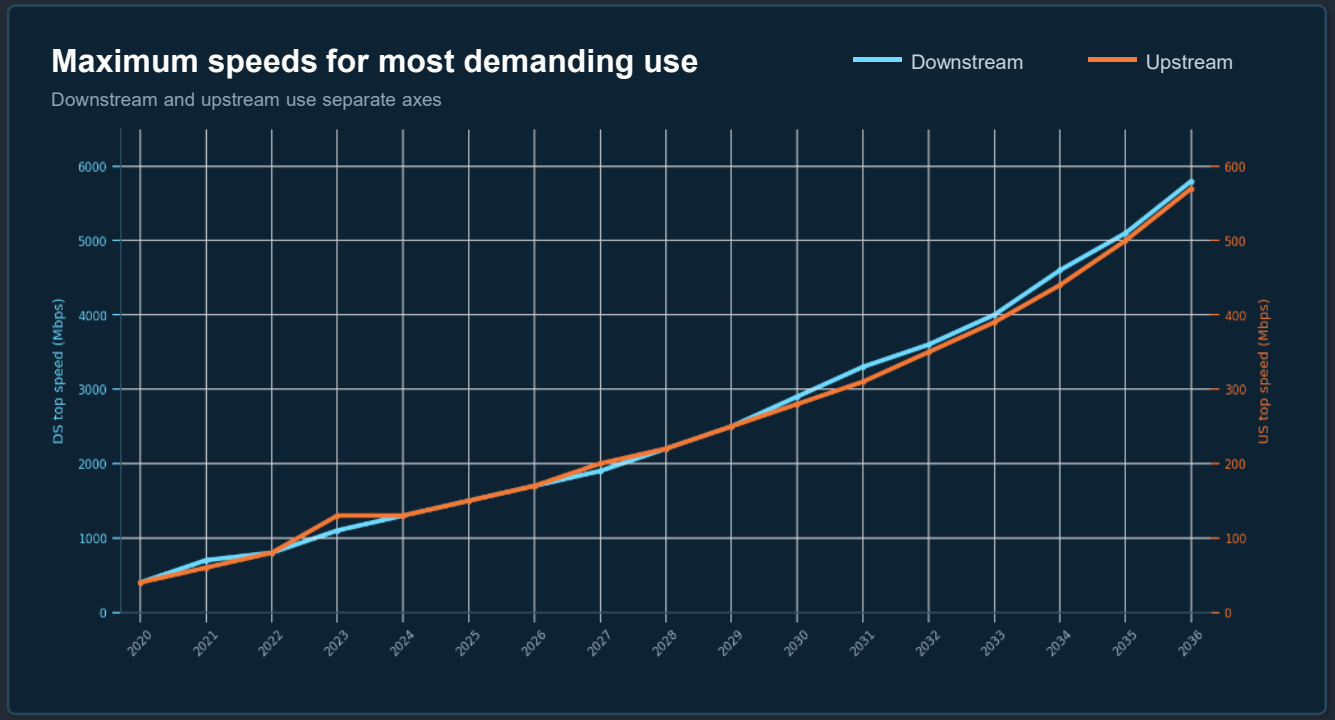
8× DOWNSTREAM
1.8 → 14.4

6.4× UPSTREAM
0.12 → 0.77

CAPACITY MUST SCALE AHEAD OF DEMAND

TOP MARKET SPEEDS KEEP RISING

The highest speed offering stays well ahead of what customers need



MOST CUSTOMERS NEED MUCH LESS

Top tiers move up

By 2036, the table reaches 5.8 Gbps downstream and 570 Mbps upstream.

14.5× DS TOP
400 → 5,800

14.3× US TOP
40 → 570

COMMERCIAL TIERS MUST BE SUPPORTED

CAPACITY TO STAY AHEAD

The shared network needs capacity for everyone

- Typically, 100-250 customers connect to the same node
- Every network, every node, every customer is different



- The capacity of the node must be more than the combined traffic + speed room
- Older DOCSIS still delivered while DOCSIS 4.0 is being deployed

DOCSIS 3,1 keeps delivering

DOCSIS 4.0 enables the future

By 2031, the first segments with DOCSIS 3.1 may exhaust. DOCSIS 4.0 will be there well ahead.

True Top Speed

Sustainable bill-board speeds

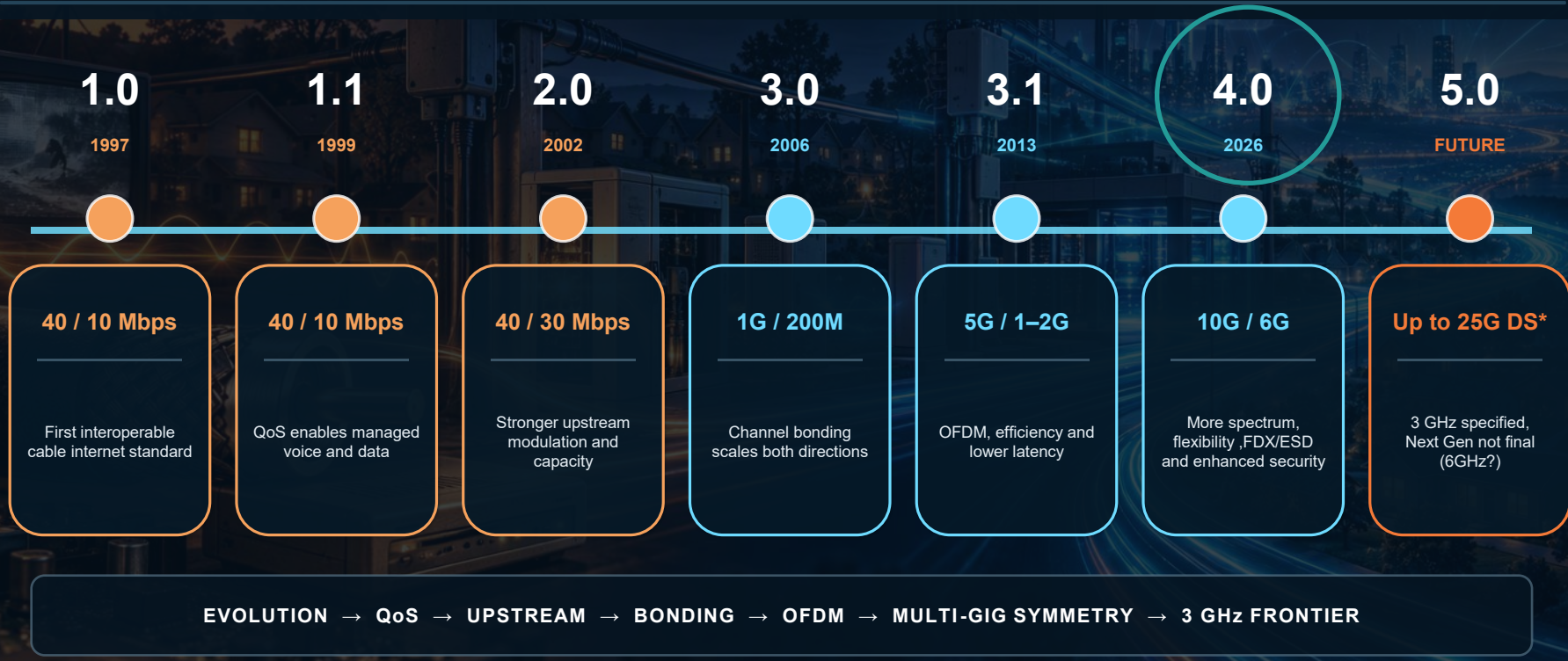
Economical

Healthy business model

VIABLE PROMISES

FROM DOCSIS 1.0 TO THE NEXT FRONTIER

Three decades of evolution: more capacity, flexibility and intelligence over HFC



**DOCSIS 5.0 is shown as a future direction, not a finalized specification.*

SOLUTIONS WITH DOCSIS 4.0

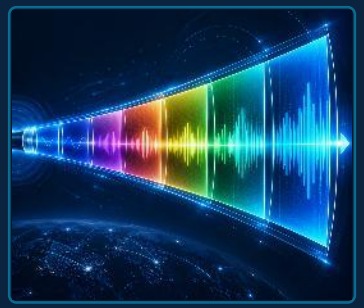
How does it work?

FOUR DIMENSIONS TO GROW CAPACITY

Four complementary levers from DOCSIS 3.1 - applied together to unlock more usable HFC capacity

01 SPECTRUM

MORE RF BANDWIDTH

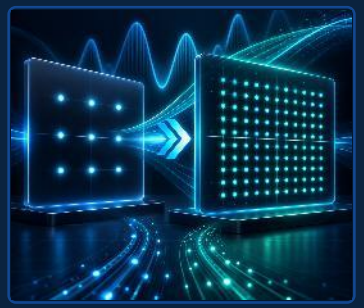


Widen the usable RF band to create more capacity-bearing spectrum.

MORE Hz

02 BITS / SYMBOL

DEEPER MODULATION



Use higher-order QAM to carry more bits per symbol when SNR allows.

MORE bits/Hz

03 LDPC

BETTER ERROR CORRECTION



Recover impaired data efficiently and operate closer to the channel limit.

MORE usable bits

04 DAA / R-PHY

DISTRIBUTED ACCESS



Move PHY closer to customers to improve RF quality and enable higher profiles.

MORE RF quality

CAPACITY = **SPECTRUM** x **SPECTRAL EFFICIENCY** x **CODING PERFORMANCE** - ENABLED BY **RF QUALITY / DAA**

More spectrum creates room; modulation and LDPC extract more from it; DAA improves the conditions to sustain both.

MORE RF BANDWIDTH

D4.0 offers two evolution paths



THE CHOICE **Extended Spectrum DOCSIS (ESD) with maximum flexibility** | Full Duplex in part of spectrum is possible but more complex

DEEPER MODULATION

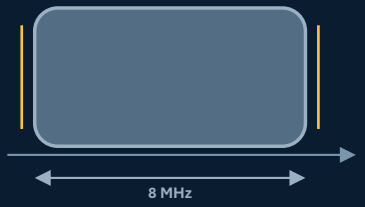
From a few 6-8MHz wide channels to many small 25/50kHz channels with individual modulation as of DOCSIS 3.1

DOWNSTREAM

SC-QAM

LEGACY

single carrier



COMPOSITION	Bonded fixed 8 MHz slots
ACCESS	One carrier / channel
MODULATION	Typically 256-QAM
EFFICIENCY	~5–7 bit/s/Hz

UPSTREAM

TDMA

LEGACY

time-slot sharing



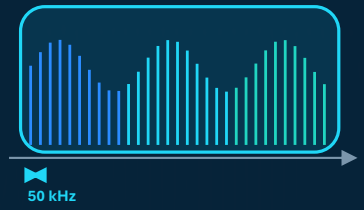
COMPOSITION	Bonded slots up to 6.4 MHz
ACCESS	Users share time slots
MODULATION	QPSK–64-QAM
EFFICIENCY	~2–5 bit/s/Hz

DOWNSTREAM

OFDM

DOCSIS 3.1+

adaptive profiles



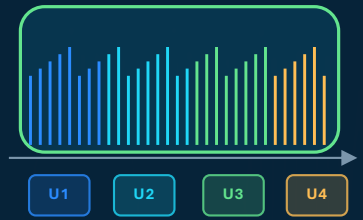
COMPOSITION	Wide block • 24–192 MHz
ACCESS	Many shared orthogonal carriers
MODULATION	Profiles up to 4096-QAM
EFFICIENCY	~6–12 bit/s/Hz

UPSTREAM

OFDMA

DOCSIS 3.1+

multi-user allocation



COMPOSITION	Wide block • 6.4–96 MHz
ACCESS	Many shared orthogonal carriers
MODULATION	Profiles up to 4096-QAM
EFFICIENCY	~4–10 bit/s/Hz

KEY DIFFERENCE

FIXED

Rigid channels • uniform modulation • edge overhead

FLEXIBLE

Orthogonal packing • adaptive profiles • granular allocation

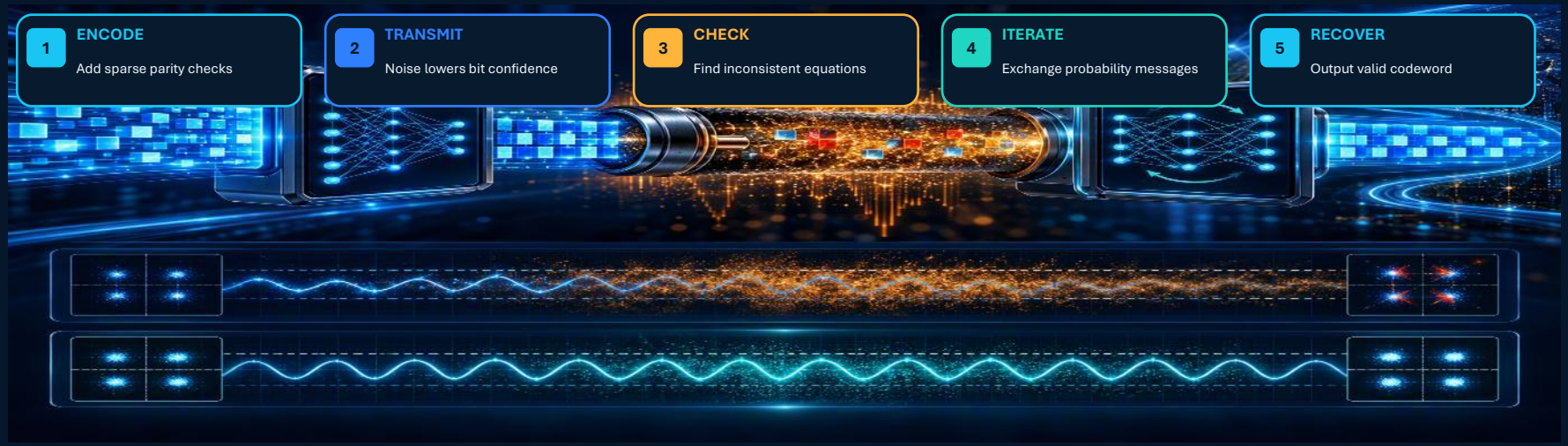
RESULT

More usable bits per Hz

Representative ranges indicate modulation potential; actual net efficiency depends on coding, pilots, cyclic prefix, profiles and plant quality.

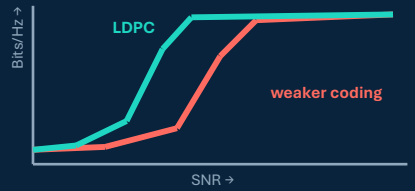
LDPC: TURNING NOISE INTO RECOVERABLE DATA

Structured parity and iterative decoding increase resilience at lower SNR



SNR RESILIENCE

LDPC coding pushes the error-rate waterfall toward lower SNR: the decoder combines soft QAM confidence with many overlapping parity checks.



OPERATIONAL EFFECT

- ✓ fewer uncorrectable codewords
- ✓ higher modulation sustained longer
- ✓ more usable capacity at the same RF quality

PARITY CHECK EXAMPLE: FINDING ONE BAD BIT

A simplified 8 × 8 even-parity grid illustrates the intuition behind LDPC check equations

	1	2	3	4	5	6	7	8	
1	1	0	1	1	0	0	1	0	✓
2	0	1	1	0	1	0	1	0	✓
3	1	1	0	1	0	1	0	0	✓
4	0	1	0	1	0	1	0	0	✗
5	1	0	1	0	1	1	1	1	✓
6	0	0	1	1	0	1	1	0	✓
7	1	1	1	0	0	0	1	0	✓
8	0	0	1	0	1	0	1	1	✓
	✓	✓	✓	✓	✗	✓	✓	✓	

RECEIVED CODE BLOCK

1 — ADD PARITY

Row 8 and column 8 make every total even.

2 — BIT FLIPS

Noise changes bit (4,5).

3 — LOCATE

Failed row 4 and column 5 intersect at the bad bit.

4 — CORRECT

Flip the bit and all checks pass.

Failed row 4 + failed column 5 → flip bit (4,5) → every parity check passes.

FROM PARITY TO LDPC

This 8 × 8 grid is a teaching example, not the actual DOCSIS LDPC matrix.

LDPC generalizes the idea:

- Sparse check equations connect selected code bits.
- The QAM demapper supplies soft confidence, not only hard 0/1 decisions.
- Overlapping checks exchange probability messages iteratively.
- Decoding stops when a valid codeword is found or iterations are exhausted.

Simplified even-parity example. Real DOCSIS LDPC uses larger sparse matrices and soft-decision iterative decoding.

DISTRIBUTED ACCESS ARCHITECTURE

DAA (Remote PHY) gives an SNR tailwind of 3-6 dB

TRADITIONAL HFC

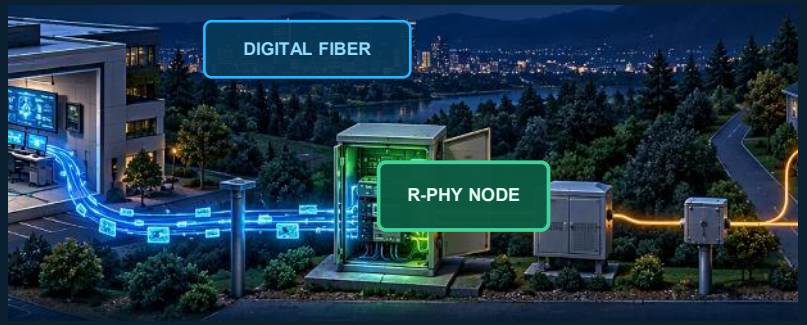
CENTRALIZED PHY



- **Integrated CCAP** — Core + PHY
- **Optical TX/RX** — Analog RF over fiber
- **Optical node** — O/E conversion
- **Coax plant** — Amplifiers + taps
- **Cable modem** — Customer premises

DAA — REMOTE PHY

DISTRIBUTED PHY



- **CCAP Core** — MAC / control
- **Ethernet transport** — Digital packets
- **R-PHY node** — PHY + RF conversion
- **Coax plant** — Amplifiers + taps
- **Cable modem** — Customer premises

THE SHIFT **Signal processing moves from the headend into the access node**

Analog optical transport → digital Ethernet transport **Coax distribution remains**

DOCSIS 4.0: CAPACITY COMPOUNDS

Four complementary dimensions multiply the usable capacity of the HFC network

01 SPECTRUM	×	02 BITS / SYMBOL	×	03 LDPC	×	04 DAA / R-PHY
MORE RF BANDWIDTH		DEEPER MODULATION		BETTER ERROR CORRECTION		DISTRIBUTED ACCESS
> 50% More Hz		> 2 More bits/Hz		> 2 More usable bits		Better RF quality

COMBINED MULTIPLICATIVE CAPACITY POTENTIAL

Optimization for every segment of the network possible

The total uplift is the product of the gains in each dimension. The weakest dimension limits how much of the theoretical gain becomes operational capacity.

EXECUTIVE TAKEAWAY

DOCSIS 4.0 capacity is unlocked by combining more spectrum, more bits per symbol, stronger coding and better RF conditions.

1 + 1 + 1 + 1 ≠ 4

The four levers compound into one larger capacity outcome

IMPLEMENTATION

An evolution, not a switch

DOCSIS 4.0: AN EVOLUTION, NOT A SWITCH

Moving to DOCSIS 4.0 requires progressive upgrades while managing real-world network constraints



01 STEP-BY-STEP EVOLUTION

The move to DOCSIS 4.0 does not happen overnight.

It is an evolution of many small steps: spectrum changes, node upgrades, amplifiers, taps, CPE and operational readiness synchronized with normal life-cycle



02 NEW SPECTRUM, NEW ISSUES

The existing network is not perfect.

Using new frequencies exposes impairments that were previously outside the operating band or less visible.
Less than 10% additional amplifiers.



03 UNCONTROLLED DOMAINS

Some conditions remain outside direct network control.

Radio interference, connectors, splitters and in-home coax wiring can limit achievable profiles and stability.



04 CLASSIC TECHNOLOGY PERCEPTION

Modernization must also address perception.

Reliability and power consumption need to be demonstrated with field evidence, telemetry and operational performance.

SUCCESS CONDITION — **Treat DOCSIS 4.0 as a controlled network evolution: upgrade, measure, learn and expand.**

THE FUTURE OF COAX

Lots of runway

DOCSIS EVOLUTION: A LONG-RUNWAY PLATFORM

Evolve capacity in stages: upgrade the platform, optimize with AI, split service groups and keep future paths open



NOW

DOCSIS 3.1

Established base

2026-2034

DOCSIS 4.0

Progressively replaces 3.1

NOW → NEXT FEW YEARS

AI-OPTIMIZED PHY

Tailor profiles and subcarriers per modem

AS DEMAND REQUIRES

SEGMENT SPLITTING

Add capacity without digging

10–15+ YEARS

FUTURE OPTIONS

Fiber deeper or next-generation DOCSIS

PLATFORM VIEW DOCSIS 4.0 creates a multi-year capacity runway, while AI and segmentation extend the useful life of HFC.

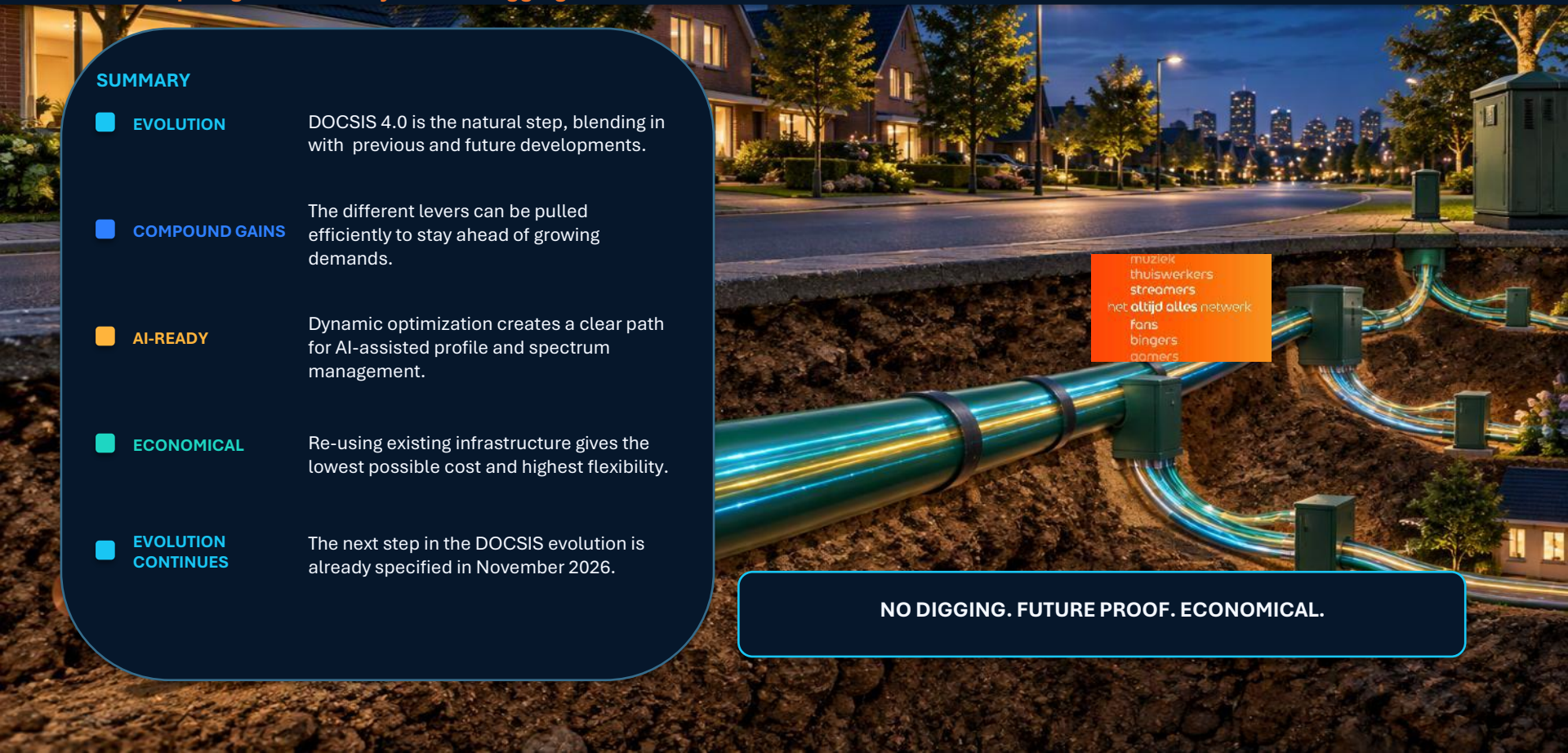
LONG-TERM Fiber deeper | DOCSIS 5.0 concepts

SO; FOR HOW LONG WILL THE COAX KEEP DELIVERING?

A decade-plus growth runway without digging

SUMMARY

EVOLUTION	DOCSIS 4.0 is the natural step, blending in with previous and future developments.
COMPOUND GAINS	The different levers can be pulled efficiently to stay ahead of growing demands.
AI-READY	Dynamic optimization creates a clear path for AI-assisted profile and spectrum management.
ECONOMICAL	Re-using existing infrastructure gives the lowest possible cost and highest flexibility.
EVOLUTION CONTINUES	The next step in the DOCSIS evolution is already specified in November 2026.



NO DIGGING. FUTURE PROOF. ECONOMICAL.

DOCSIS 4.0



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DOCSIS 4.0: MORE CAPACITY FROM THE EXISTING CABLE

A decade-plus growth runway without rebuilding the access network



SUMMARY

10+ YEARS	DOCSIS 4.0 expands the capacity runway of the existing cable network with at least a decade, probably more.
COMPOUND GAINS	More spectrum, enhanced modulation, stronger error correction and digitized distribution work together.
AI-READY	Dynamic optimization creates a clear path for AI-assisted profile and spectrum management.
SCALE BY SPLITTING	Further growth comes from multiplying service segments when local demand exhausts capacity.
EVOLUTION CONTINUES	The next step in the DOCSIS evolution is already specified in November 2026.

NO DIGGING. MORE SPECTRUM. SMARTER USE. MORE SEGMENTS.