

THE 6G TECHNOLOGY SERIES

Eight questions about 6G

6G has a calendar with meeting numbers on it: specifications frozen in December 2028, the first American auction in April 2027 and the conference that settles the spectrum in late 2027. It does not yet have anything a carrier can sell, and the last cycle cost the three national carriers $333 billion before the C-band bill. Read the eight parts to find out:

1. which dates are already fixed and how far to trust them
2. where the spectrum comes from and what each range costs to use
3. what 6G adds beyond 5G-Advanced
4. what a cycle costs and how much cash is left for the next one
5. what the vendors' open and AI-native bets amount to on paper
6. which capabilities pay before the freeze (five, all of them 5G)
7. the twenty dated events that would move the calendar and the four that matter
8. what 6G will do and who is asking to pay for it

First edition · October 2026

About this ebook

This ebook collects the eight parts of *The 6G Technology Series*, published by Blue Prysm at www.blueprysm.com/analysis/.

The website carries the current edition. Where a figure here differs from the website, the website is the later version.

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First edition, October 2026

DATA AS OF

PART 1 3GPP and ITU-R pages as read 2 Oct 2026

PART 2 statute, FCC and ITU documents as read 2 Oct 2026

PART 3 ITU-R and 3GPP documents as read 2 Oct 2026

PART 4 SEC filings retrieved 2 Oct 2026 · auction results as published

PART 5 alliance and company documents as read 2 Oct 2026

PART 6 the dates in parts 1 to 5, as read and checked 2 Oct 2026

PART 7 the dates in parts 1 to 4 and 8, as read and checked 2 Oct 2026

PART 8 3GPP, operator and vendor documents as read 2 Oct 2026; SpaceX's 800 MHz agreement as announced 8 Oct 2026, read 12 Oct 2026

Method version 1.1

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Errors can be reported at www.blueprysm.com/contact/.

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AT&T, Verizon and T-Mobile's combined capex ran from **$44.0B** in 2019 to a peak of **$56.7B** in 2022 and back to $47.8B in 2025. The C-band auction cost the three of them $78.2B in 2021, before clearing. After capex and dividends, FY2025 left $33.8B across the three. At the 2021 price, the next 160 MHz of upper C-band would cost $46.4B, which is more than a year of that.

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The O-RAN Alliance, founded by five operators in February 2018, counted over 220 participants and over 150 specifications in July 2026, down from over 300 participants in March 2025. The AI-RAN Alliance, founded by eleven companies on 26 February 2024, reached 132 members two years later. Ericsson spent **SEK 48.9 billion** on R&D in 2025 on sales of SEK 236.7 billion, and expects a flat RAN market in 2026. Nokia spent EUR 4.9 billion on EUR 19.9 billion, with Mobile Networks flat at EUR 7.8 billion. Huawei spent CNY 192.3 billion on CNY 881 billion.

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Of ten capabilities on the 6G roadmaps, **five** have a frozen release, a licensed band and a device on sale today, and all five are 5G features earning on existing networks. Two more arrive with the upper C-band, which may not carry service until **31 December 2030**. The last three wait for Release 21 and for the spectrum WRC-27 decides, which puts their first revenue in **2030** at the earliest, and the last cycle says later rather than earlier.

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Which dated signals would move the timeline and in which direction?

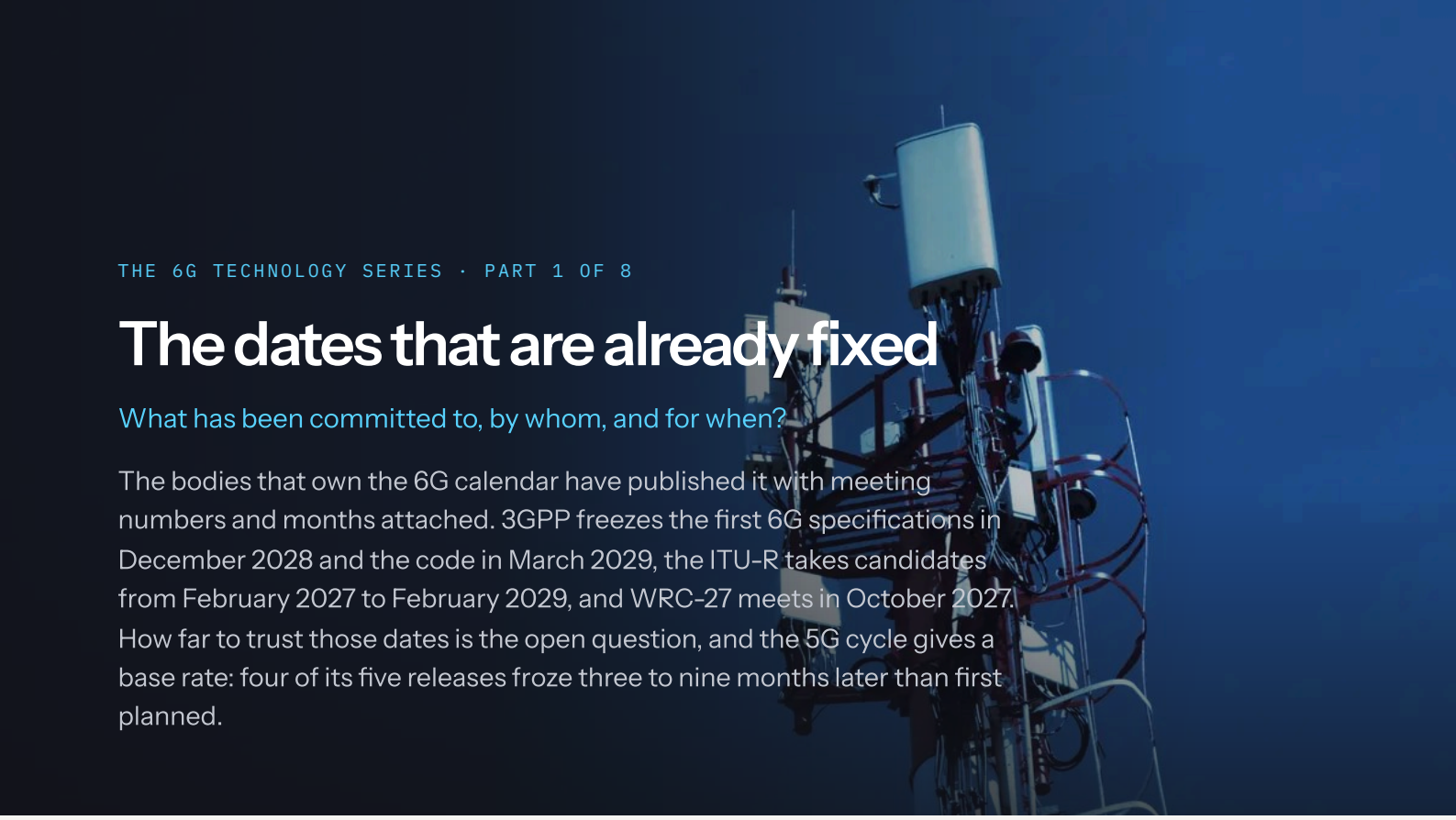
Twenty dated events between November 2026 and September 2034 decide whether the 6G timeline holds, and four of them carry most of the risk. Two are 3GPP plenaries, the migration decisions of **7 to 11 December 2026** and the Release 20 freeze in **March 2027**. The other two are WRC-27 in **October 2027** and the Release 21 freeze in **December 2028**. Each announces its own slip in a document a third party can read, whether a plenary report, a Final Acts footnote or a public notice. The NTIA's 7 GHz report is due in the same month as the first.

PART 08 **What 6G will do** 75

What does each capability do, what is decided, who wants it, and where is the value?

Of the eight capabilities called 6G, one has a retail price, satellite messaging at **$10 a month**, carrying 0.0002% of one carrier's traffic. One has a paying customer, a government: sensing, with more than 500 Chinese base stations under a ministry order. The other six have trials at most. 3GPP has decided that 6G stands alone, shares spectrum with 5G and must work without AI; how a 5G phone becomes a 6G one, and what the core looks like, are due in **December 2026**.

Work with Blue Prysm 90



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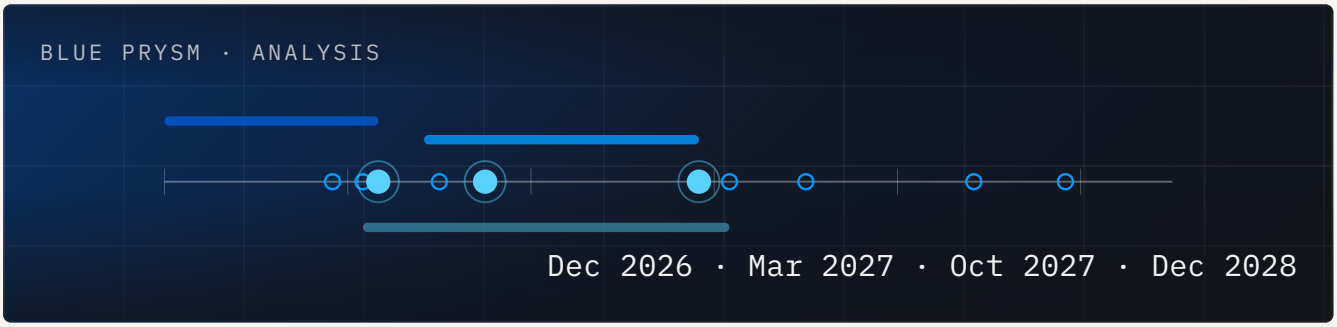
The dates that are already fixed

What has been committed to, by whom, and for when?

The bodies that own the 6G calendar have published it with meeting numbers and months attached. 3GPP freezes the first 6G specifications in December 2028 and the code in March 2029, the ITU-R takes candidates from February 2027 to February 2029, and WRC-27 meets in October 2027. How far to trust those dates is the open question, and the 5G cycle gives a base rate: four of its five releases froze three to nine months later than first planned.



IN BRIEF

- 3GPP agreed the Release 21 timeline at its June 2026 plenaries. Stage 1 freezes in March 2027, Stage 2 in June 2028 and Stage 3 in **December 2028**; the ASN.1 and OpenAPI code freeze follows in March 2029. Release 20, which holds the 6G study, is projected to freeze in March 2027.
- The ITU-R takes IMT-2030 candidates from WP 5D #54 in February 2027 until twelve days before WP 5D #59 in February 2029, with the specifications due by mid-2030 at the latest. WRC-27 meets in Shanghai from **18 October to 12 November 2027**, and its agenda item 1.7 decides the 6G spectrum.
- Of the five 5G releases whose first plan is on the record, four froze later than planned, by **3, 6, 9 and 3 months**. Release 19 held. None froze early.
- Qualcomm expects commercial 6G systems from 2029, Nokia late 2029 for early adopters and Ericsson 2030. The first US 5G service went live on 3 April 2019, twenty-two months before the ITU specification existed, so the date to plan on is the Release 21 freeze.

Three bodies each own one part of the calendar

3GPP writes the specification, the ITU-R certifies it as IMT-2030, and the World Radiocommunication Conference decides what spectrum it may use internationally. Each has published its dates, and they run in that order (Exhibit 1).

EXHIBIT 1

Three bodies own three kinds of date, and only the conference dates are fixed by treaty

BODY	WHAT IT DECIDES	ITS 6G DATES	HOW THE DATE CAN MOVE
3GPP	The specification: the Release 20 study and the Release 21 normative work	Release 20 freeze March 2027 (projected); Release 21 Stage 3 freeze **December 2028**; code freeze March 2029	By consensus at a plenary, announced in a news item; moved four times in the 5G cycle
ITU-R WP 5D and SG 5	Recognition as IMT-2030: requirements, evaluation guidelines and the submission window	Requirements and guidelines to SG 5 on 30 November to 1 December 2026; candidates from February 2027 to February 2029; specifications by mid-2030	By the Study Group's own schedule; the IMT-2020 equivalent ran five years and five months
ITU WRC-27	International spectrum identification under agenda item 1.7	**18 October to 12 November 2027**, Shanghai, after RA-27 on 11 to 15 October	Fixed by treaty; conference dates have not moved
Vendors	The commercial date, inferred from the freeze	Qualcomm from 2029; Nokia late 2029 for early adopters; Ericsson 2030	Fixed by nobody; a vendor's statement

The ITU-R recognises a 3GPP release as IMT-2030 after the fact; the WRC identifies bands for IMT without allocating them to any carrier.

Source: 3GPP release pages and the Release 21 timeline news of 10 June 2026; ITU-R WP 5D IMT-2030 page and Document IMT-2030/2; ITU WRC-27 page; Qualcomm statement of 2 March 2026 as reported, Nokia 6G page, Ericsson note of 12 June 2026 (Published).

3GPP's part comes in two releases. Release 20 holds the 6G study: fourteen study items by 3GPP's June 2026 count, opened in stages. The use-case study opened in September 2024, the radio scenarios study in December 2024, and the core radio and architecture studies at the Prague plenaries of June 2025. The use-case report, TR 22.870, was approved at SA#111 in March 2026. The radio report, TR 38.914, stood at 90% after the same plenaries and was approved in June 2026. Release 20's own functional freeze is projected for March 2027 at SA#115.

Release 21 carries the normative 6G work, and 3GPP agreed its timeline at the June 2026 plenaries in Singapore. Package approval and the Stage 1 freeze fall in March 2027. The Stage 2 freeze comes in June 2028, after an 80% checkpoint in March 2028, and the Stage 3 freeze in December 2028 at TSGs#122. The ASN.1 and OpenAPI code freeze follows in March 2029, which Ericsson reads as the first 6G specifications

being available in early 2029. One thing differs from the 5G cycle: 3GPP's webinars with ATIS have said Release 21 is expected as a single drop, one code freeze rather than the staged drops of Release 15.

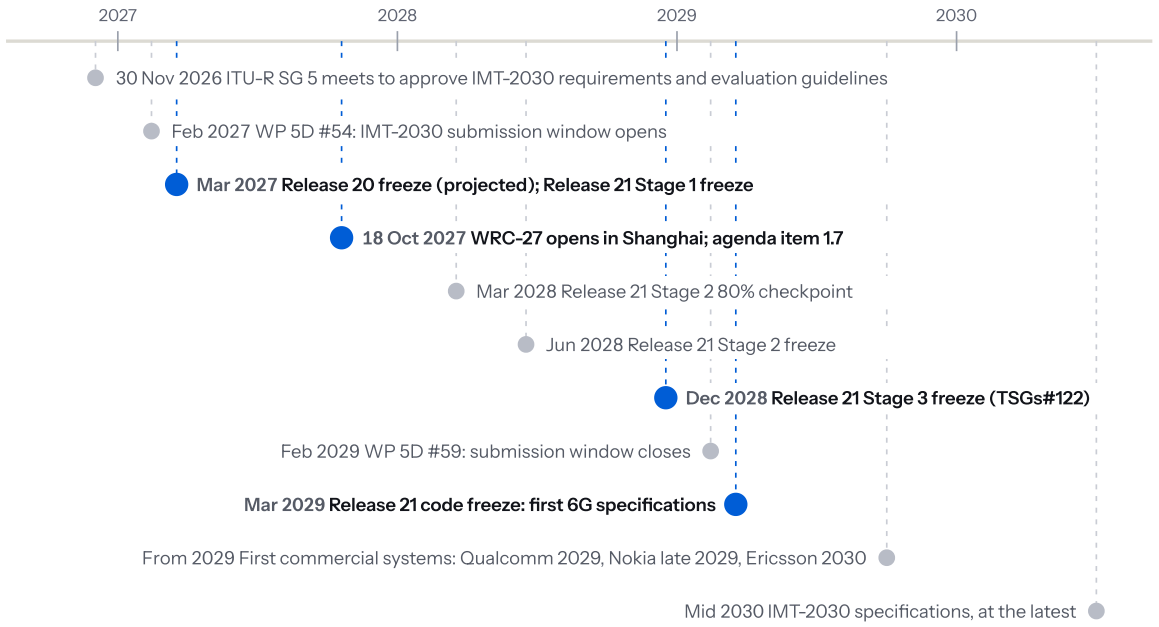
The published calendar runs from a March 2027 freeze to a mid-2030 target

The ITU-R's part is a process with a window. The Radiocommunication Assembly approved the IMT-2030 framework in Dubai in November 2023 as Recommendation M.2160. Working Party 5D then completed the draft minimum technical performance requirements at its 51st meeting in February 2026, and the evaluation guidelines at its 52nd in June 2026. Both go to the Study Group 5 meeting of 30 November to 1 December 2026 for approval. The window itself opens at the 54th WP 5D meeting in February 2027 and closes twelve days before the 59th in February 2029. 3GPP's own page puts the target for technology proposals at early 2029 and the resulting specifications at mid-2030 at the latest.

The conference's part is a single event with a fixed agenda. WRC-27 meets in Shanghai from 18 October to 12 November 2027, after the Radiocommunication Assembly of 11 to 15 October. Its agenda item 1.7 decides whether 4.4 to 4.8 GHz, 7.125 to 8.4 GHz and 14.8 to 15.35 GHz are identified for IMT, and part 2 takes that up. Exhibit 2 places the dated events on one axis, and Exhibit 3 lists every entry with the status its source gives it.

EXHIBIT 2

Eleven dated steps run from the Study Group 5 meeting of November 2026 to the ITU's mid-2030 target



Source: 3GPP Release 21 timeline news (10 June 2026) and release pages; ITU-R WP 5D IMT-2030 page and Document IMT-2030/2; ITU WRC-27 page; vendor statements as listed in the sources (Published). Note: 3GPP dates are its current plan; a date marked projected on the source is projected here.

EXHIBIT 3

Of sixteen entries on the published calendar, five are done, four are scheduled meetings and five are 3GPP plans

DATE	MILESTONE	BODY	STATUS
Nov 2023	IMT-2030 framework approved by RA-23 (Rec. ITU-R M.2160)	ITU-R	Done
Sep 2024 to Jun 2025	6G study items opened; the core radio and architecture studies at TSGs#108, Prague	3GPP	Done
Feb and Jun 2026	IMT-2030 technical performance requirements and evaluation guidelines completed in draft (WP 5D #51, #52)	ITU-R WP 5D	Done
Mar 2026	TR 22.870, 6G use cases and service requirements, approved at SA#111	3GPP	Done
Jun 2026	TR 38.914 approved at RAN#112; Release 21 timeline agreed at TSGs#112	3GPP	Done
30 Nov to 1 Dec 2026	The two IMT-2030 reports to Study Group 5 for approval	ITU-R SG 5	Scheduled

Feb 2027	WP 5D #54: IMT-2030 submission window opens	ITU-R WP 5D	Scheduled
Mar 2027	Release 20 functional freeze (SA#115); Release 21 package approval and Stage 1 freeze	3GPP	Projected
Mid 2027	Early Release 21 architecture to WP 5D #55 as information	ATIS for 3GPP	Planned
18 Oct to 12 Nov 2027	WRC-27, Shanghai; agenda item 1.7 decided	ITU WRC	Scheduled
Jun 2028	Release 21 Stage 2 freeze (80% checkpoint March 2028)	3GPP	Planned
Dec 2028	Release 21 Stage 3 freeze (TSGs#122)	3GPP	Planned
Mar 2029	Release 21 ASN.1 and OpenAPI freeze; first 6G specifications	3GPP	Planned
Feb 2029	WP 5D #59: submission window closes	ITU-R WP 5D	Scheduled
From 2029	First commercial 6G systems: Qualcomm from 2029, Nokia late 2029 for early adopters, Ericsson 2030	Vendors	Expectation
Mid 2030	IMT-2030 specifications, at the latest	ITU-R, per 3GPP	Target

Status is the word the source uses or the nearest to it. A date marked projected or planned is 3GPP's own current plan; a date marked scheduled is a meeting in the calendar. February 2029 follows March 2029 in the table because the ITU window closes before the 3GPP code freeze; the IMT-2030 submission is built from the frozen Stage 3.

Source: 3GPP release pages and the Release 21 timeline news of 10 June 2026; ITU-R WP 5D IMT-2030 page; ITU WRC-27 page; ATIS and 3GPP webinar of April 2026; vendor statements as listed in the sources (Published).

The only dates owned by a body that cannot move them are the conference dates. Everything else is a plan, and the organisation that made it can revise it at its next plenary. The last cycle shows how often that happens.

Every 5G release but one froze later than first planned

5G's releases are the base rate for 6G's, and they are unusually well documented. 3GPP announces each shift in a news item, and the trade press of the day records the plan it replaced.

Release 15, the first 5G release, was delivered in pieces. The non-standalone specifications were approved at RAN#78 in December 2017 and the standalone ones at TSG#80 in June 2018. A third piece, the late drop, was planned to have its functional freeze in December 2018 and its ASN.1 freeze in March 2019. At RAN#82 in Sorrento that December, 3GPP pushed both back by three months, to March and June 2019. At the same meeting it pushed the whole of Release 16 back by three months, to open a gap between the physical-layer and the protocol specifications.

Release 16 then moved again. At the electronic plenaries of March 2020, 3GPP shifted its Stage 3 freeze from March to June 2020 and Release 17's from June to September 2021, citing the move to electronic meetings. In December 2020 it moved Release 17 once more, to a Stage 3 freeze in March 2022 and a protocol coding freeze in June 2022. Release 18 went the same way: at SA#98-e in December 2022 its

Stage 3 freeze moved from December 2023 to March 2024, for the same reason. In the end Release 16 froze on 3 July 2020, Release 17 on 18 March 2022, nine months after the date it was scoped to, and Release 18 in March 2024 (Exhibit 4).

EXHIBIT 4

Four of the five 5G releases froze later than first planned, and Release 19 held

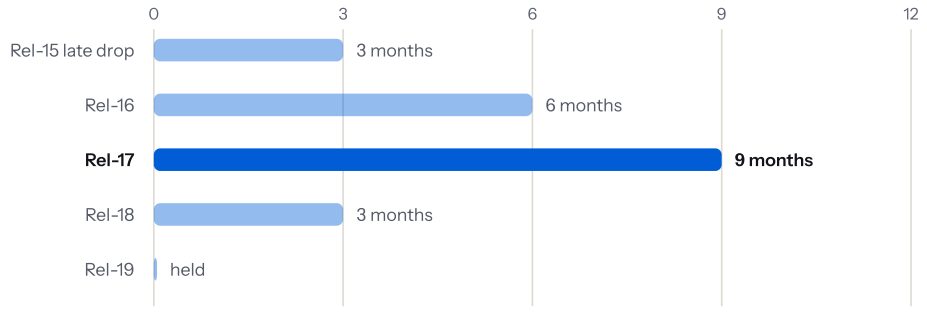
RELEASE	FREEZE AS FIRST PLANNED	DECISIONS	ACTUAL FREEZE	MOVED BY
Rel-15 late drop	Dec 2018 (functional), Mar 2019 (ASN.1)	RAN#82, Dec 2018: +3 months	Mar 2019; ASN.1 Jun 2019	**3 months**
Rel-16	Dec 2019 (Stage 3)	Dec 2018: +3 · Mar 2020: +3	3 Jul 2020 (SA#88-e)	**6 months**
Rel-17	Jun 2021 (Stage 3)	Mar 2020: +3 · Dec 2020: +6	18 Mar 2022 (SA#95-e)	**9 months**
Rel-18	Dec 2023 (Stage 3)	Dec 2022: +3	Mar 2024 (SA#103)	**3 months**
Rel-19	Sep 2025 (Stage 3)	none	Sep 2025 (SA#109); code 12 Dec 2025	held

Release 16's first plan is the December 2019 completion in the RAN#80 webinar of June 2018. Release 17's is the June 2021 date the March 2020 decision moved. Release 18's is the December 2023 date its own 3GPP page records as moved. Release 19's Stage 3 date of September 2025 was published in April 2024 and held.

Source: 3GPP news on RAN#82 (15 December 2018) and the Release 17 timeline (14 December 2020); the Release 16 and Release 18 pages; Light Reading, 25 March 2020; Fierce, 16 December 2020; 3GPP release pages for the actual dates (Published).

EXHIBIT 5

The 5G slips ran from three to nine months, and every one of them was later



Source: 3GPP news items and release pages as in Exhibit 4 (Published); months counted by Blue Prysm from the first published plan to the actual freeze (Calculated).

> Of the five 5G releases whose first plan is on the record, four moved and one held, and every move was later: three, six, nine and three months. A 6G plan that puts December 2028 in without a margin is relying on the kind of date that held once in five.

Commercial 5G launched before the ITU specification existed

The ITU side moved less, and it mattered less to the shipping date. The IMT-2020 framework, Recommendation M.2083, was approved in September 2015. The radio interface specifications, Recommendation M.2150, were adopted in draft by Study Group 5 on 23 November 2020 and approved on 1 February 2021, five years and five months after the framework. Verizon's 5G mobile service had gone live in parts of Chicago and Minneapolis on 3 April 2019, on Release 15 equipment and on the same day as the three Korean carriers, twenty-two months before the ITU specification existed (Exhibit 6).

EXHIBIT 6

IMT-2020 took five years and five months from framework to specification, and the first US 5G service came twenty-two months before the end

STEP	IMT-2020 (5G)	IMT-2030 (6G)
Framework recommendation	M.2083, September 2015	M.2160, November 2023 (RA-23)
Minimum technical performance requirements	Report M.2410, November 2017	Draft completed February 2026; to SG 5 on 30 November to 1 December 2026
Radio interface specifications	M.2150, adopted in draft 23 November 2020, approved 1 February 2021	Mid-2030 at the latest, per 3GPP
Framework to specification	**5 years 5 months**	**6 years 7 months** to the mid-2030 target
First 3GPP freeze built to	Release 15 non-standalone, December 2017 (RAN#78)	Release 21 Stage 3, December 2028
First commercial service	**Verizon, Chicago and Minneapolis, 3 April 2019**, 22 months before M.2150	Vendors expect 2029 to 2030

The three Korean carriers went live on the same day as Verizon. The commercial date followed the 3GPP freeze and preceded the ITU specification.

Source: ITU-R WP 5D IMT-2020 and IMT-2030 pages; Recommendations ITU-R M.2083, M.2160 and M.2150 and Report M.2410; 3GPP release pages; Verizon newsroom and Telecompaper, 4 April 2019 (Published); intervals calculated by Blue Prysm (Calculated).

Applied to 6G, that history says the date to watch is the Release 21 freeze and the vendor hardware that follows it, rather than the ITU's mid-2030 target. The three vendors that have published a year read it the same way. Qualcomm said in March 2026 that it expects commercial systems from 2029 onwards, with

specification-compliant pre-commercial devices in 2028. Nokia puts the first commercial networks in late 2029 in early-adopter countries, and large-scale deployment in 2030. Ericsson expects the first commercial systems in 2030. If Release 21 moves, the move will show first as a 3GPP plenary decision with a news item attached. A plenary news item is easy to watch for, and it is the first entry on the list in part 7.

A freeze is a commitment to stop changing a document

A freeze is a commitment by a membership organisation to stop changing a document. It binds no carrier to buy anything, no vendor to ship anything and no regulator to sell spectrum. The dates therefore fall into three kinds. The conference dates are fixed by treaty and have not moved. The 3GPP dates are fixed by consensus and move when the consensus decides, as it did four times in the 5G cycle. The commercial date is fixed by nobody and is inferred, which is why it appears in the calendar once, attributed to the three vendors that have published a year.

The calendar is useful because a named body with a named meeting owns each date. A slip is announced rather than discovered, and a roadmap built on the calendar can be re-dated in an afternoon rather than rebuilt.

Terms used

- **Stage 1, 2, 3.** 3GPP's three layers of a release: the service requirements, the architecture, and the protocol detail. A Stage 3 freeze is the point after which the radio protocols stop changing, and it is what vendors build to.
- **ASN.1 and OpenAPI freeze.** The later point at which the machine-readable encodings of those protocols are frozen, so that implementations can be tested against each other. 3GPP also calls it the code freeze, or the end date of a release.
- **IMT-2030.** The ITU-R's name for the family of radio technologies it will recognise as 6G, as IMT-2020 is for 5G. 3GPP submits its specifications as a candidate; the ITU-R evaluates and publishes.
- **Identification.** What a World Radiocommunication Conference gives a band when it marks it for IMT in the Radio Regulations. It is permission for administrations to use the band for mobile under agreed conditions, and neither an allocation to any carrier nor a sale.

Implications

CARRIER STRATEGIST	Put December 2028 in the plan with a six-month band either side, and tie any 6G capital line to the Release 21 freeze rather than to a year. The 5G base rate is three to nine months late, and never early.
VENDOR	Name the 3GPP meeting beside every date on the roadmap. The dates a customer can check are the ones in Exhibit 3, and a slide whose dates run ahead of them will be read against them.
INVESTOR	Model the 6G cycle as starting after a March 2029 code freeze plus a hardware cycle, because the three vendors that have named a year say 2029 to 2030. Treat any earlier revenue claim as a claim about 5G-Advanced.

Method and limits

HOW THIS WAS BUILT

Every date is taken from the body that owns it. 3GPP's release pages, plenary news and Release 21 timeline give the freezes. The ITU-R Working Party 5D pages and its submission document give the IMT-2020 and IMT-2030 process, and the ITU's WRC-27 page gives the conference. Where a 3GPP date is marked projected on the source, it is marked projected here. Each date was checked against at least one independent report, listed in the sources.

The 5G slips are taken from 3GPP's own news items and release pages, each compared with the plan as it stood before the decision. The trade press of the day is the second source.

WHAT IT DOES NOT SHOW

A freeze date is the date a specification stops changing; a product ships later. The gap between the two is the subject of part 6. The three vendor expectations of a first commercial system (Qualcomm from 2029, Nokia late 2029 for early adopters, Ericsson 2030) are vendors' statements and are reported as such. Nothing here predicts whether the 6G dates will hold; the 5G history is offered as a base rate only.

Data as of: 3GPP and ITU-R pages as read 2 Oct 2026 · Method version 1.1 (fact-checked against second sources).

Sources. 3GPP release pages, the Release 21 timeline news of 10 June 2026 and the Release 21 page; 3GPP news on RAN#82 (December 2018) and the Release 17 timeline (December 2020); the Release 18 and Release 16 pages; the ITU-R WP 5D IMT-2030 and IMT-2020 pages and Document IMT-2030/2; the ITU WRC-27 page; Ericsson's 6G standardisation note of 12 June 2026; Nokia's 6G page; Qualcomm's 2 March 2026 statement as reported; Light Reading (25 March 2020, 16 June 2026) and Fierce (16 December 2020) as second sources. Retrieved and cross-checked 2 Oct 2026.

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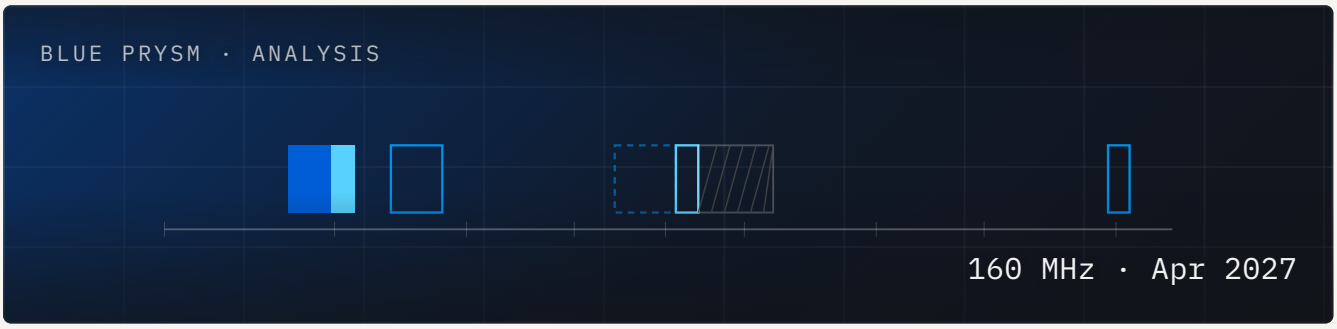
Where the spectrum comes from

Which bands can it run in, and when are they sold?

American 6G spectrum comes from a statute, an order and a conference. Congress has told the FCC to get 800 MHz to auction by 2034 and has written the dates into law. The Commission has picked the first 160 MHz and set a sale for April 2027. Everything above that waits on a conference in Shanghai in late 2027, and every range on its agenda costs more signal to use than the band 5G was built on.



IN BRIEF

- Public Law 119-21, signed on 4 July 2025, requires **800 MHz** between 1.3 and 10.5 GHz to reach auction. Five hundred of it is federal spectrum, due by 4 July 2033; the other 300 MHz is due by 30 September 2034. Two ranges, 3.1 to 3.45 GHz and 7.4 to 8.4 GHz, are kept out of both.
- The FCC has moved on its first deadline. On 22 July 2026 it adopted FCC 26-46, which takes **160 MHz** at 3.98 to 4.14 GHz to Auction 115. Bidding starts on 27 April 2027, and service may begin on 31 December 2030 in the top 75 licence areas.
- Everything above that is for WRC-27 to decide, in Shanghai from 18 October to 12 November 2027: whether 4.4 to 4.8, 7.125 to 8.4 and 14.8 to 15.35 GHz are identified for mobile. The American advisory committee has split twice on what to ask for.
- Higher frequencies cost signal. Free-space path loss at 7.125 GHz is **6.2 dB** higher than at 3.5 GHz, a factor of four in power. Price the upper C-band as 5G capacity, and treat 7 GHz as a 2027 decision that comes with a 6 dB bill.

Congress wrote the pipeline and six deadlines into law

more important change is that Congress, for the first time, attached a quantity of spectrum and a set of dates to that authority (Exhibit 1).

The requirement comes in two halves. The NTIA has to identify 500 MHz of federal spectrum between 1.3 and 10.5 GHz for reallocation, 200 MHz within two years of enactment and the rest within four. The FCC has to auction at least 300 MHz on top of that, with at least 100 MHz of it from 3.98 to 4.2 GHz within two years. It must also sell the federal spectrum as the NTIA identifies it, 200 MHz within four years and the remainder within eight. The two halves make up the 800 MHz.

Two ranges are written out of both halves. Congress kept 3.1 to 3.45 GHz and 7.4 to 8.4 GHz, where federal radar and satellite systems live, out of the covered band and out of the auction authority itself. The 6 GHz band is a different case. Earlier drafts of the bill would have kept it out of the pipeline too, and the law as passed does not.

EXHIBIT 1

The statute's six deadlines fall between 4 July 2027 and 30 September 2034

WHO	MUST	BY	CLAUSE
NTIA	Identify 200 MHz of federal spectrum for reallocation	**4 Jul 2027**	40002(c)(2)(A)
FCC	Auction at least 100 MHz in 3.98 to 4.2 GHz	**4 Jul 2027**	40002(b)(2)
NTIA	Identify the rest of the 500 MHz	4 Jul 2029	40002(c)(2)(B)
FCC	Auction at least 200 MHz of the identified federal spectrum	4 Jul 2029	40002(d)(1)
FCC	Auction the remaining identified federal spectrum	4 Jul 2033	40002(d)(2)
FCC	Auction 300 MHz in all, the 100 MHz above included	30 Sep 2034	40002(b)(2)

The covered band is 1.3 to 10.5 GHz less 3.1 to 3.45 GHz and 7.4 to 8.4 GHz. Section 40002(f) separately gives the NTIA $50 million, available to 2034, to study 2.7 to 2.9, 4.4 to 4.9 and 7.25 to 7.4 GHz.

Source: P.L. 119-21, section 40002, 139 Stat. 128; CRS report R48862, 25 February 2026 (Published). Note: every deadline is counted from enactment on 4 July 2025.

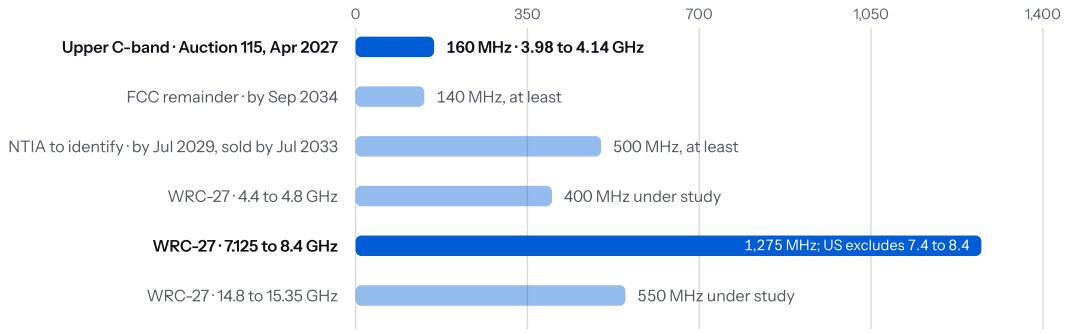
The Congressional Budget Office put a value on the pipeline in October 2025: $84.95 billion of reduced direct spending over 2025 to 2034. Most of that, $81.3 billion, is auction proceeds under the restored general authority. A further $3.7 billion comes from the auctions the Act singles out, and the $50 million study appropriation comes off. The Congressional Research Service rounds the whole to over $85 billion. The figure is a receipts estimate across nine years of auctions; it does not say what any one band will fetch. Part 4 gives the two recent prices that do.

$84.95B CBO's estimate of what section 40002 brings in over 2025 to 2034. It covers nine years of auctions and prices no band in particular.

One exclusion matters as much as any target. The 7.4 to 8.4 GHz that Congress kept out is the upper thousand megahertz of the range WRC-27 is studying for IMT, so the United States wrote itself out of most of the 7 GHz question more than two years before the conference meets. Whatever Shanghai decides about 7.125 to 8.4 GHz, the American part of the answer can lie only in the 275 MHz between 7.125 and 7.4 GHz. The executive branch has since told the NTIA to work on that range, and the carriers and their vendors have asked the FCC to back it. Beside the ranges Shanghai is studying, the statute's floors are small (Exhibit 2).

EXHIBIT 2

The 160 MHz with an auction date is the smallest piece on the table, and the largest, 7.125 to 8.4 GHz, is partly excluded by statute



Source: P.L. 119-21, section 40002, as summarised by CRS R48862; FCC 26-46, 22 July 2026; ITU Resolution 256 (WRC-23) and FCC DA 26-182 (Published). Note: the FCC remainder is the 300 MHz floor less the 160 MHz ordered. The WRC-27 rows are widths under study, not identifications.

The FCC moved first with 60% more than the law requires

On 22 July 2026 the FCC adopted FCC 26-46, the order that sends 3.98 to 4.14 GHz to auction. The band is 160 MHz wide, which the Commission itself describes as 60% more than the 100 MHz the statute demands. Two days later it gave the sale a number, Auction 115, and a date: bidding starts on 27 April 2027 (Exhibit 3).

The order is specific where the statute is general. It creates 3,248 flexible-use licences across the contiguous United States, eight unpaired 20 MHz blocks in each partial economic area, each with a fifteen-year term. It joins the new band to the 280 MHz sold in 2021, so that what the Commission calls a single

harmonised super band runs from 3.70 to 4.14 GHz, 440 MHz in all. A 20 MHz guard band at 4.14 to 4.16 GHz keeps it clear of the satellite downlinks that stay in 4.16 to 4.2 GHz.

The satellite incumbents leave on two dates. The top 75 licence areas, which held 72.1% of the population at the 2020 census, must be clear by 30 December 2030; the rest by 30 June 2031. Terrestrial service may start the day after each, on 31 December 2030 and 1 July 2031, or sooner in any area whose clearing has been certified. A winner therefore pays in 2027 for something it can switch on at the end of 2030.

EXHIBIT 3

Auction 115 sells 160 MHz in April 2027 for service from the end of 2030

ITEM	AS ADOPTED
Band	**3.98 to 4.14 GHz**, 160 MHz; guard band 4.14 to 4.16 GHz
Auction	**Auction 115**, bidding from 27 April 2027; statutory completion by 4 July 2027
Licences	3,248; eight 20 MHz unpaired blocks per partial economic area; 15-year terms
Combined band	3.70 to 4.14 GHz, 440 MHz, with the 2021 C-band
Satellite clearing	Top 75 areas by 30 Dec 2030; all remaining areas by 30 Jun 2031
Terrestrial service may begin	**31 Dec 2030** in the top 75 areas; 1 Jul 2031 elsewhere, or on certified clearing
Device rule	New mobile devices for any part of 3.70 to 4.14 GHz must work across all of it, from 31 Dec 2030
Statutory basis	Section 40002(b)(2); 60% above the 100 MHz minimum

The order was adopted on 22 July and released on 24 July 2026 in GN Dockets 25-59 and 18-122, with one commissioner dissenting in part.

Source: FCC 26-46 and news release, 22 July 2026; DA 26-769, 24 July 2026; Davis Wright Tremaine and Jones Walker summaries (Published).

For a 6G plan the useful fact is the band number, which comes with a footnote. 3.98 to 4.14 GHz lies inside 3GPP band n77, which runs from 3.3 to 4.2 GHz, so the radios built for the 2021 C-band are already built for the right band. The handsets are a separate matter, and the order treats them as one.

THE DEVICE FOOTNOTE

Note 12 to TS 38.101-1 restricts band n77 in the United States to 3450 to 3550 MHz and 3700 to 3980 MHz. A phone certified to the current specification is therefore under no obligation to work at 3.98 to 4.14 GHz.

Lifting the note takes a change request in 3GPP's RAN4 working group, and somebody has to file it.

FCC 26-46 adds a rule of its own. From 31 December 2030, every new mobile device sold for any part of 3.70 to 4.14 GHz must work across all of it.

The four years between the order and the service date are the window in which the handset base has to be built.

The upper C-band is therefore new capacity for the generation already in the ground. Whoever wins it can use it from the end of 2030, and nothing about it waits for Release 21. Part 6 places it accordingly.

Everything above 4.2 GHz waits for Shanghai

Every range above 4.2 GHz that 6G is being designed around is on the WRC-27 agenda, and in nobody's hands. The agenda is narrower, region by region, than the headline ranges suggest, and the American advisory committee has split on it twice (Exhibit 4).

Resolution 256, adopted at WRC-23, is the text behind agenda item 1.7, and the regions in it matter. It invites the 2027 conference to consider identifying 4.4 to 4.8 GHz, but in Regions 1 and 3 only. The 7.125 to 8.4 GHz range is on the table in Regions 2 and 3 in full, and in Region 1 only at its two ends, 7.125 to 7.25 and 7.75 to 8.4 GHz. The third range, 14.8 to 15.35 GHz, is on the table everywhere. The United States is in Region 2, so 4.4 to 4.8 GHz is off the American table altogether and could reach it only by a footnote of its own, while 7.125 to 8.4 GHz is on it in full.

EXHIBIT 4

Resolution 256 puts 7.125 to 8.4 GHz on the Region 2 table in full and 4.4 to 4.8 GHz not at all

RANGE	WIDTH	REGIONS IN WHICH IDENTIFICATION IS ON THE TABLE	WHERE THE UNITED STATES STANDS
4.4 to 4.8 GHz	400 MHz	Regions 1 and 3	Off the Region 2 table; advisory committee split in August 2026 on whether to ask for 4.5 to 4.8 GHz
7.125 to 8.4 GHz	1,275 MHz	Regions 2 and 3 in full; Region 1 only 7.125 to 7.25 and 7.75 to 8.4 GHz	**Three views**; 7.4 to 8.4 GHz excluded by statute; NTIA draft 7.125 to 7.4 GHz
14.8 to 15.35 GHz	550 MHz	All regions	Not addressed in either notice

Region 1 is Europe, Africa, the Middle East and the former Soviet Union; Region 2 the Americas; Region 3 Asia and the Pacific. The conference meets from 18 October to 12 November 2027.

Source: ITU Resolution 256 (WRC-23); FCC DA 26-182, 23 February 2026, and DA 26-835, 10 August 2026; ITU WRC-27 page (Published). Note: an identification is permission for administrations to use a band for IMT under the Radio Regulations. It is not an allocation to any carrier and does not itself put spectrum on sale.

The FCC's WRC-27 Advisory Committee could not agree a single view on 7 GHz. In February 2026 it sent the Commission three of them, in DA 26-182, with the NTIA's own draft attached.

- **View A.** CTIA, AT&T, Ericsson, GSMA, Nokia, Qualcomm, T-Mobile and Verizon want 7.125 to 7.45 GHz identified.
- **View B.** Apple, Boeing, Broadcom, Charter, Comcast, Lockheed Martin, NCTA, the Satellite Industry Association, the UWB Alliance and four others want no change in 7.4 to 8.4 GHz. They call any position on 7.125 to 7.4 GHz premature while the studies are pending.
- **View C.** The View A companies, minus CTIA, would go further and ask for 7.125 to 8.4 GHz or portions of it.
- **The NTIA's draft.** 7.125 to 7.4 GHz, with the upper figure in brackets.

In August the committee split again, in DA 26-835, this time over 4.4 to 4.8 GHz. The carriers and vendors asked for 4.5 to 4.8 GHz to be identified; three aviation and aerospace members opposed any change at all, on radio-altimeter grounds. The Commission's own words on every one of these views are that they do not constitute final United States positions. The industry has not agreed among itself, and the Commission has not committed.

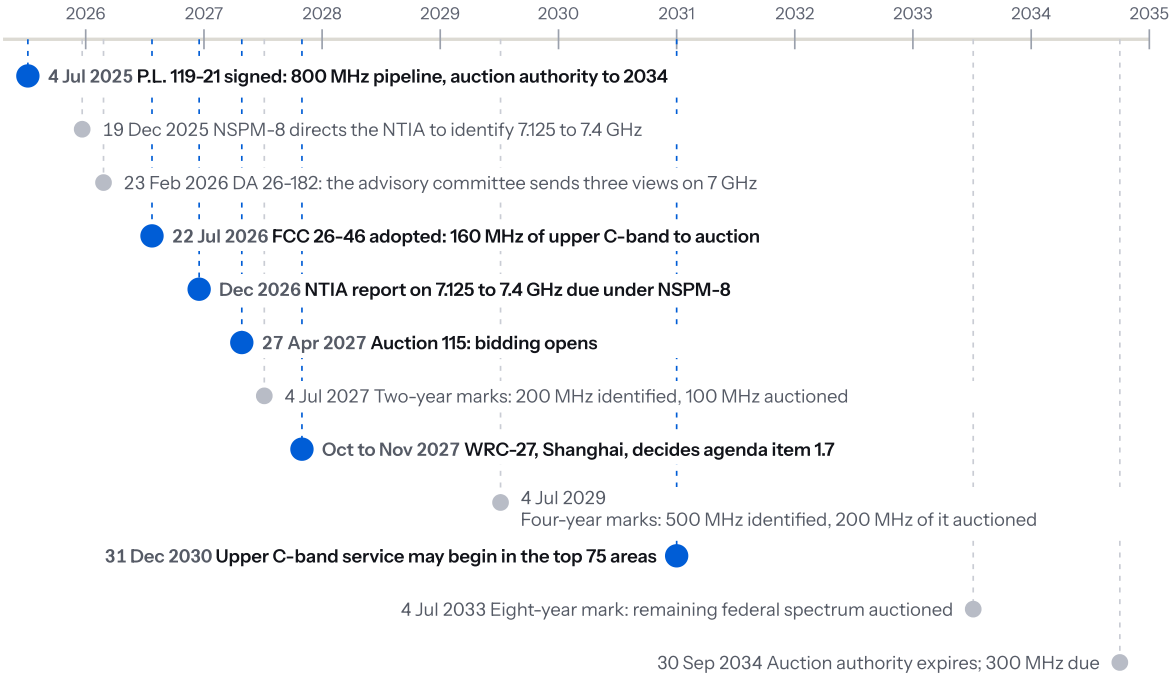
The federal side has a clock of its own. National Security Presidential Memorandum 8, issued on 19 December 2025, directs the NTIA to begin identifying 7.125 to 7.4 GHz for reallocation under section 40002.

It also orders a study of where the federal systems in that range could go instead, 7.4 to 8.4 GHz included, with a report due within twelve months. That puts the report in December 2026, and in May the NTIA's administrator told a conference it was on track. The band is one of four on the NTIA's published study list. An older and wider study, of all of 7.125 to 8.4 GHz, began under the National Spectrum Strategy in March 2024 and is due to report in October 2026.

The American 7 GHz question therefore runs in sequence: an NTIA report at the end of 2026, a conference decision in November 2027, and then an auction the statute allows until July 2033 (Exhibit 5).

EXHIBIT 5

The American spectrum calendar runs from an NTIA report in December 2026 to the end of auction authority in September 2034



Source: P.L. 119-21, section 40002; NSPM-8, 19 December 2025; FCC DA 26-182 and DA 26-835; FCC 26-46 and DA 26-769; ITU WRC-27 page; Light Reading, 8 May 2026, on the NTIA report (Published). Note: the statutory marks are counted from enactment on 4 July 2025.

The last conference's decision on the band just below is the precedent. WRC-23 identified 6.425 to 7.125 GHz for IMT across Region 1 and in Brazil and Mexico. It identified 7.025 to 7.125 GHz across all of Region 3, and 6.425 to 7.025 GHz in Cambodia, Laos and the Maldives. Those identifications are footnotes 5.457D to 5.457F of the Radio Regulations, and the United States is named in none of them. It had opened the whole of 5.925 to 7.125 GHz to unlicensed use in April 2020, and it went to Dubai proposing no change. The first 6G-era band in Europe, if the identification is used, is therefore one the American market has given to Wi-Fi.

PUBLISHED

Radio Regulations, 2024 edition, Article 5 · ITU closing release, 15 December 2023 · GSMA summary, February 2024 · FCC 20-51, 23 April 2020

Every range on the agenda costs more signal than the C-band

Free-space path loss rises with the square of frequency, so every range on the agenda costs more signal than the band 5G was priced on, and no regulator can waive the difference. Against 3.5 GHz, the middle of that band, 7.125 GHz costs 6.2 dB and 15.35 GHz costs 12.8 dB (Exhibit 6).

The relation is equation 6 of Rec. ITU-R P.525-5: 20 $\log_{10}$ of the frequency ratio, in decibels. It is the floor on the extra loss, before anything the environment adds. The top of the upper C-band, 4.14 GHz, costs 1.5 dB against 3.5 GHz. At 4.8 GHz, the top of the first WRC-27 range, the cost is 2.7 dB, still modest. The step comes above that: 7.125 GHz costs 6.2 dB, 7.45 GHz 6.6 dB, and 15.35 GHz 12.8 dB. Six decibels is a factor of four in power, and in free space it halves the distance at which the same link closes.

+6.2 dB The free-space penalty at 7.125 GHz against 3.5 GHz: a factor of four in power, settled before any regulator or vendor has a say.

Building entry loss rises less with frequency than free-space loss does, and far more with the type of building. Rec. ITU-R P.2109-2 models it for two classes of building. For traditional construction, the median at horizontal incidence rises from 15.7 dB at 3.5 GHz to 17.0 dB at 7.125 GHz. For thermally efficient construction, the kind with metallised glass and foil-backed panels, it rises from 30.9 dB to 32.7 dB. The move to 7 GHz therefore costs one to two decibels indoors, and the class of building costs about fifteen. WInnForum's measurements at 6.5 GHz in 2021 found the same two populations, at 17.8 dB and 33.7 dB, which is consistent with the model.

EXHIBIT 6

Moving from 3.5 to 7.125 GHz adds 1 to 2 dB indoors, and the building class adds about 15 dB at every frequency

FREQUENCY	FREE-SPACE LOSS AGAINST 3.5 GHZ	BUILDING ENTRY LOSS, TRADITIONAL	BUILDING ENTRY LOSS, THERMALLY EFFICIENT
3.5 GHz, the 5G mid-band	0 dB	15.7 dB	30.9 dB
4.14 GHz, top of the upper C-band	**+1.5 dB**	16.0 dB	31.2 dB
4.8 GHz, top of the first WRC-27 range	+2.7 dB	16.2 dB	31.5 dB
7.125 GHz, bottom of the 7 GHz range	**+6.2 dB**	17.0 dB	32.7 dB
15.35 GHz, top of the third WRC-27 range	+12.8 dB	18.7 dB	36.8 dB

Free-space loss is 20 $\log_{10}$ of the frequency ratio. Building entry losses are medians at 0° elevation from the P.2109-2 model. WInnForum's 2021 measurements at 6.5 GHz gave means of 17.8 dB and 33.7 dB for the two classes.

Source: Rec. ITU-R P.525-5 (11/2024), equation 6; Rec. ITU-R P.2109-2 (08/2023), Table 1 coefficients; WInnForum TR-1011, 7 June 2021 (Calculated). Note: the model values are calculated by Blue Prysm and are not measurements.

> Before any new feature of the standard earns revenue, a 6G coverage plan has to pay back 6 dB between the C-band and 7.125 GHz, with antenna gain, more sites or lower expectations, and the bill does not change with whatever Shanghai decides. The same arithmetic makes the upper C-band, at 1.5 dB, worth more to a near-term plan than its width alone suggests.

The statute, the order, the agenda and the equation together give the spectrum story its shape. The next 160 MHz is American and mid-band, sold from April 2027 and usable from the end of 2030, on radios already built for the band, with handsets the order requires to follow. The 7 GHz range that 6G is designed around is, for now, an NTIA report in December 2026, a conference decision in November 2027 and an auction the statute allows until 2033, with a 6 dB bill attached. Anything a roadmap says about 6G coverage before those dates is, whatever the label on the slide, a statement about the C-band.

Terms used

- **Covered band.** The statute's name for 1.3 to 10.5 GHz less the two excluded ranges. The 500 MHz the NTIA identifies has to come from it.
- **Partial economic area.** One of 416 licence areas the FCC uses for mid-band auctions. The top 75 by population are the first to be cleared and served.
- **Region 1, 2, 3.** The three ITU regions, roughly Europe and Africa, the Americas, and Asia and the Pacific, in which the Radio Regulations can differ. An identification can apply to one region, to all three, or to named countries by footnote.
- **MHz-POP.** Megahertz of bandwidth multiplied by the population of the licence area. Auction prices are compared in this unit, and direct-to-device part 4 prices the recent sales in it.

Implications

CARRIER STRATEGIST	Price the upper C-band as 5G capacity on the radios you already have, because from the day it is usable it can be nothing else. Put the device footnote in the plan: the handset base that covers 3.98 to 4.14 GHz has to be built between now and the end of 2030. For 7 GHz, use 6 dB as the planning number, and date the plan after the NTIA report, the conference and an auction, in that order.
INVESTOR	Treat the spectrum line in any 6G thesis as a statute with six deadlines and one auction with a start date. Do not read CBO's $84.95 billion as a price, because it is a receipts estimate across nine years of auctions. The 2021 C-band, at $0.852 per MHz-POP, is the better comparable for the 160 MHz coming next.
VENDOR	Build to band n77, which covers the first tranche on the radio side, and plan the device side around a RAN4 change request and an interoperability rule dated 2030. Expect a market for a 7 GHz radio only after the NTIA report, the identification and the auction, and in the United States only below 7.4 GHz.

Method and limits

HOW THIS WAS BUILT

The pipeline is read from the enrolled statute itself, with the Congressional Research Service's report and a law firm's client alert as second sources. The receipts estimate is the Congressional Budget Office's own figure rather than a rounding of it. The upper C-band facts come from the Commission's order and the auction public notice, checked against two law-firm summaries. The WRC-27 ranges come from Resolution 256 itself, and the American views from the two public notices that carried them, read against Senate testimony that described the split from outside.

The path-loss differences are free-space path loss at each frequency relative to 3.5 GHz, calculated as $20 \log_{10}$ of the frequency ratio from Rec. ITU-R P.525-5. The building entry losses are the medians the model in Rec. ITU-R P.2109-2 gives at horizontal incidence for its two building classes. All are calculated; none is measured.

WHAT IT DOES NOT SHOW

The statute sets floors and deadlines; it does not name bands. Beyond the upper C-band the NTIA has not said which megahertz it will identify, and none is guessed at here. The views in the FCC's notices are an advisory committee's and, in the Commission's words, do not constitute final United States positions. The n77 device limit is read from the current revision of the specification, and a later revision may lift it. Free-space loss is the floor on the extra loss at higher frequencies, and the P.2109 medians come from a model; foliage, vehicles and bodies add loss that is not quantified here.

Data as of: statute, FCC and ITU documents as read 2 Oct 2026 · Method version 1.1 (fact-checked against second sources).

Sources. The enrolled text of P.L. 119-21, section 40002 (139 Stat. 128); the Congressional Research Service's report R48862 on its spectrum provisions (25 February 2026); CBO's supplemental estimate for section 40002 (28 October 2025); Wiley's client alert on the Act; the FCC's upper C-band order FCC 26-46, its news release of 22 July 2026 and the Auction 115 notice DA 26-769; Davis Wright Tremaine's summary of the order and Jones Walker's note on Auction 115; 3GPP TS 38.101-1 as transposed by ETSI (V18.15.0), Table 5.2-1; ITU Resolution 256 (WRC-23) and the ITU-R WRC-27 studies page; FCC public notices DA 26-182 (23 February 2026) and DA 26-835 (10 August 2026) on the WRC-27 Advisory Committee's views, with Michael Calabrese's Senate testimony of 17 March 2026 as a second account; the Radio Regulations, 2024 edition, footnotes 5.457D to 5.457F, the ITU's closing release for WRC-23 and the GSMA's outcome summary (February 2024); FCC 20-51 on the 6 GHz band; NSPM-8 (19 December 2025), the NTIA's implementation plan release (12 March 2024), the spectrum.gov study list and Light Reading's report of 8 May 2026; Recommendations ITU-R P.525-5 and P.2109-2, with WInnForum TR-1011 as a second source on building entry loss. Retrieved and cross-checked 2 Oct 2026.

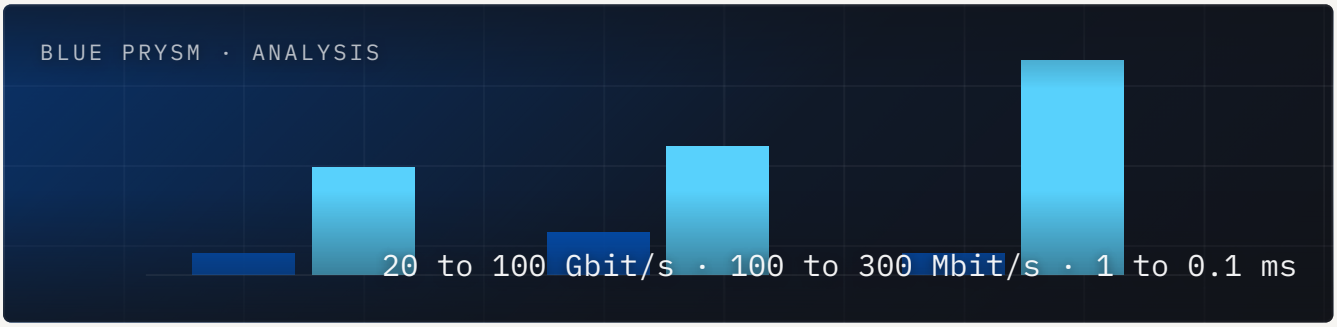


THE 6G TECHNOLOGY SERIES · PART 3 OF 8

What 6G adds beyond 5G-Advanced

Which capabilities need the new standard, and which exist today?

Every 6G claim traces back to one ITU document, and that document gives its numbers as targets for research rather than as requirements. The releases that make up 5G-Advanced, by contrast, have work-item identifiers and devices on sale. Side by side, four of the six 6G scenarios already have a 5G-Advanced pathway, and the one draft 6G requirement that has reached the public asks for less than the headlines.



IN BRIEF

- Recommendation ITU-R M.2160, approved in November 2023, names **six** usage scenarios and fifteen capabilities for IMT-2030. Its numbers are estimated targets for research, and it says itself that they may not all be reached at once in any one scenario.
- The first draft of the minimum requirements, which Working Party 5D finished in February 2026, asks for a peak rate of **36 Gbit/s** in 600 MHz and 1 ms of latency for the reliable scenario. The first is 1.8 times what IMT-2020 required; the second is what 5G has to meet already. Study Group 5 is due to approve the requirements on 1 December 2026.
- Four of the six scenarios have a Release 17, 18 or 19 work item that addresses them by name. Two have a commercial service to show for it: RedCap on T-Mobile since 17 October 2024, and nationwide on AT&T since 16 July 2025.
- What 6G adds beyond 5G-Advanced is sensing and the sub-millisecond, centimetre-grade end of the targets. A carrier should audit its 6G slide against the 5G-Advanced table before it dates any revenue to Release 21.

The framework gives targets for research rather than requirements

Recommendation ITU-R M.2160, approved in November 2023, defines what IMT-2030 means and is where every 6G claim begins. It sets out six usage scenarios, four overarching aspects and fifteen capabilities. For the capabilities it gives numbers, and it describes them, in its own words, as estimated targets for research and investigation (Exhibit 1).

The six scenarios are immersive communication, hyper reliable and low-latency communication, massive communication, ubiquitous connectivity, artificial intelligence and communication, and integrated sensing and communication. The first three are IMT-2020's three, extended. Two, AI and sensing, are new as scenarios. Ubiquitous connectivity is the satellite and remote-area case, which the direct-to-device series covers. Across all six run four aspects: sustainability, security and resilience, connecting the unconnected, and ubiquitous intelligence.

Of the fifteen capabilities, the framework counts nine as enhanced from IMT-2020. Those are the eight that had numbers in 2017, plus security and resilience. The other six it counts as new: coverage, positioning, sensing, AI, sustainability and interoperability. Only one of the new six, positioning, arrives with a number attached.

EXHIBIT 1

IMT-2030's example peak rate is two and a half to ten times IMT-2020's minimum, and most of its new capabilities have no number

CAPABILITY	IMT-2020 (M.2410, 2017)	IMT-2030 (M.2160, 2023)
Peak data rate	**20 Gbit/s** down, 10 up	Greater; **50, 100, 200 Gbit/s** given as possible examples
User experienced data rate	**100 Mbit/s** down, 50 up (dense urban)	**300 and 500 Mbit/s** given as possible examples
Latency, user plane	**1 ms** URLLC; 4 ms eMBB	**0.1 to 1 ms**, research target
Reliability	$1 - 10^{-5}$	$1 - 10^{-5}$ to $1 - 10^{-7}$
Connection density	**10^6** per km^2	**10^6 to 10^8** per km^2
Area traffic capacity	10 Mbit/s/m^2 (indoor hotspot)	30 and 50 Mbit/s/m^2 as possible examples
Mobility	500 km/h	500 to 1,000 km/h
Peak spectral efficiency	30 bit/s/Hz down, 15 up	1.5× and 3× IMT-2020 as possible examples
Positioning accuracy	Not a minimum requirement	**1 to 10 cm**, research target
Coverage, sensing, AI, sustainability, security and resilience, interoperability	Not capabilities	Described without numeric targets; sustainability names its metric, bit per joule

IMT-2020's values are minimum requirements a candidate had to meet. IMT-2030's are the framework's research targets, which the Recommendation says may not be reached simultaneously in any one scenario. The two columns are not the same kind of number.

Source: Report ITU-R M.2410-0, November 2017; Rec. ITU-R M.2160-0, November 2023, section 4; ITU release, 1 December 2023 (Published).

Side by side, the multiples are less dramatic than the headlines. The example peak rate is two and a half to ten times IMT-2020's, and the example user rate three to five times. Latency improves tenfold at the bottom of its range and not at all at the top. Positioning is the only capability that is wholly new as a number, at one to ten centimetres, and the two capabilities that are wholly new as categories, sensing and AI, have no number at all. Those two are where the standard still has the most to decide, and the Release 20 study is where it is being decided.

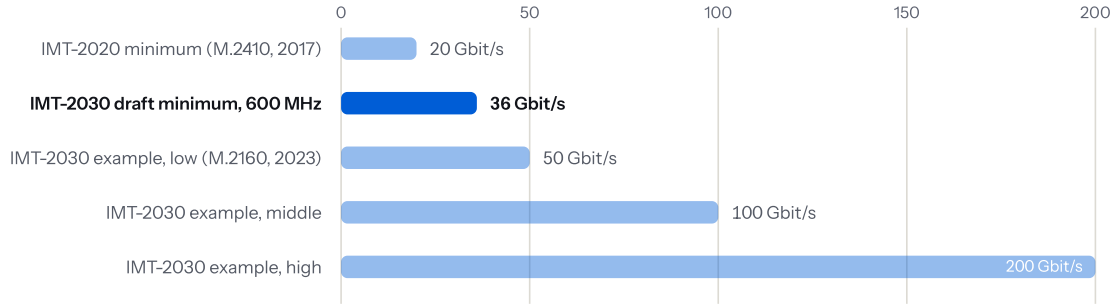
The draft minimum requirements ask for less than the targets

In February 2026 Working Party 5D turned the framework's targets into a first draft of minimum requirements. Only two of its figures have reached the public so far, and both of them are close to what 5G-Advanced does already (Exhibit 2).

The draft lists twenty technical performance requirements. How many of them are new depends on who is counting: the ITU says seven, and the delegations that have published the list say six, naming composite requirements, link distance, positioning, sensing, AI, and resilience and extended connectivity. The full table stays a working document until Study Group 5 approves it on 1 December 2026. The APT's meeting update gives the two public figures. The theoretical peak rate is 36 Gbit/s down and 18 Gbit/s up, assuming 600 MHz of bandwidth. User-plane latency is 4 ms for immersive communication and 1 ms for hyper reliable and low-latency communication.

EXHIBIT 2

The draft 6G minimum peak rate is 1.8 times 5G's, while the framework's examples run to ten times



Source: Report ITU-R M.2410-0 (11/2017); APT, WP 5D updates as of WP 5D#51, March 2026; Rec. ITU-R M.2160-0 (11/2023) (Published). Note: the draft minimum is a theoretical peak assuming 600 MHz of bandwidth and remains a working document until Study Group 5 approves it.

Against the framework, those two figures shrink the distance between the generations. A peak of 36 Gbit/s in 600 MHz is 1.8 times IMT-2020's 20 Gbit/s, where the example values had suggested anything from two and a half to ten times. The 1 ms latency requirement for the reliable scenario is the figure 5G has to meet today. The minimum is therefore being set near the top of what 5G-Advanced does, and the headline multiples live in the research targets above it. A product that meets the minimum will be 6G; a product that meets the targets is the research programme.

1 ms

The draft 6G latency requirement for the reliable scenario, which is the same figure IMT-2020 set for URLLC in 2017.

Four of the six scenarios already have a 5G-Advanced work item

3GPP's Project Coordination Group approved the name 5G-Advanced in April 2021, for Release 18 onward. Release 19, the second 5G-Advanced release, froze in December 2025, and it is the last whose content was

settled before the 6G study opened. Its work items, read against the IMT-2030 scenarios, look like a first draft of several of them (Exhibit 3).

Release 18's page lists three new topics beside the continuing ones: energy efficiency, artificial intelligence and machine learning, and extended reality. Release 19's radio projects were laid out in the ATIS and 3GPP webinar of April 2024, each with an identifier that resolves to a document on 3GPP's server. Its Stage 3 froze in September 2025 at SA#109 and its code on 12 December 2025 at SA#110, the dates the webinar had published twenty months earlier.

- **AI and machine learning.** A normative work item for the NR air interface (RP-240774), which was the largest project in the release, and a study on AI for mobility (RP-240082).
- **Sensing and new bands.** Channel-model studies for integrated sensing and communication (RP-240799) and for 7 to 24 GHz (RP-234018).
- **Devices and power.** A study on ambient IoT (RP-240826), work on low-power wake-up signals and receivers (RP-240801), and network energy saving enhancements (RP-240170).
- **Radio capacity.** A fifth phase of MIMO (RP-240087) and subband full duplex (RP-240789).
- **Services.** A third phase of XR (RP-240791), and a third phase of non-terrestrial networks with regenerative payloads and RedCap over satellite (RP-240775).

EXHIBIT 3

Four scenarios have a 5G-Advanced work item and two have a commercial service; sensing has one narrow work item and nothing more

IMT-2030 SCENARIO	RELEASE 17 TO 20 WORK ON IT	STATE ON 2 OCT 2026
Immersive communication	XR phases 1 to 3 (Rel-18; Rel-19 RP-240791); MIMO phase 5 (RP-240087)	Specified; devices and services are the carriers' to report
Hyper reliable, low latency	URLLC from Rel-15, enhanced in Rel-16; Rel-19 duplex evolution (RP-240789)	Specified to 1 ms, the draft 6G minimum; sub-millisecond is a research target
Massive communication	RedCap (Rel-17), eRedCap (Rel-18), ambient IoT study (Rel-19 RP-240826)	**Commercial**: RedCap on T-Mobile since 17 October 2024; AT&T nationwide since 16 July 2025
Ubiquitous connectivity	NTN from Rel-17; Rel-19 phase 3 (RP-240775) with regenerative payloads	**Commercial**, by other routes: see the direct-to-device series
AI and communication	Rel-18 new topic; Rel-19 air-interface work item RP-240774 and mobility study RP-240082; Rel-20 two-sided model work item RP-251870	Specified in Rel-19 for one-sided models; no operator has published a deployment
Integrated sensing and communication	Rel-19 channel model study RP-240799; Rel-20 work item RP-261566 (June 2026), base-station drone detection only	**One narrow work item**; the sensing capability M.2160 describes waits for Release 21

Commercial means an operator has published that the feature is in service. The absence of such a publication is not evidence that a feature is unused, only that it has not been announced.

Source: 3GPP Release 17, 18 and 19 pages; ATIS and 3GPP webinar deck, 3 April 2024, checked against the RAN#103 document list; 3GPP RP-261566 (RAN#112, June 2026) and RP-251870; T-Mobile newsroom, 16 October 2024; AT&T, 16 July 2025 (Published).

RedCap is the clearest case of a 5G-Advanced feature with a date and a device behind it. It is a Release 17 device class, frozen in March 2022, and it put the massive-communication scenario into service more than four years before the first 6G specification will exist.

REDCAP HAS A DATE AND A DEVICE

T-Mobile put the first commercial RedCap device in North America, TCL's LINKPORT IK511, into its stores on 17 October 2024, running on its nationwide standalone 5G network.

AT&T declared nationwide RedCap coverage, more than 200 million points of presence, on 16 July 2025.

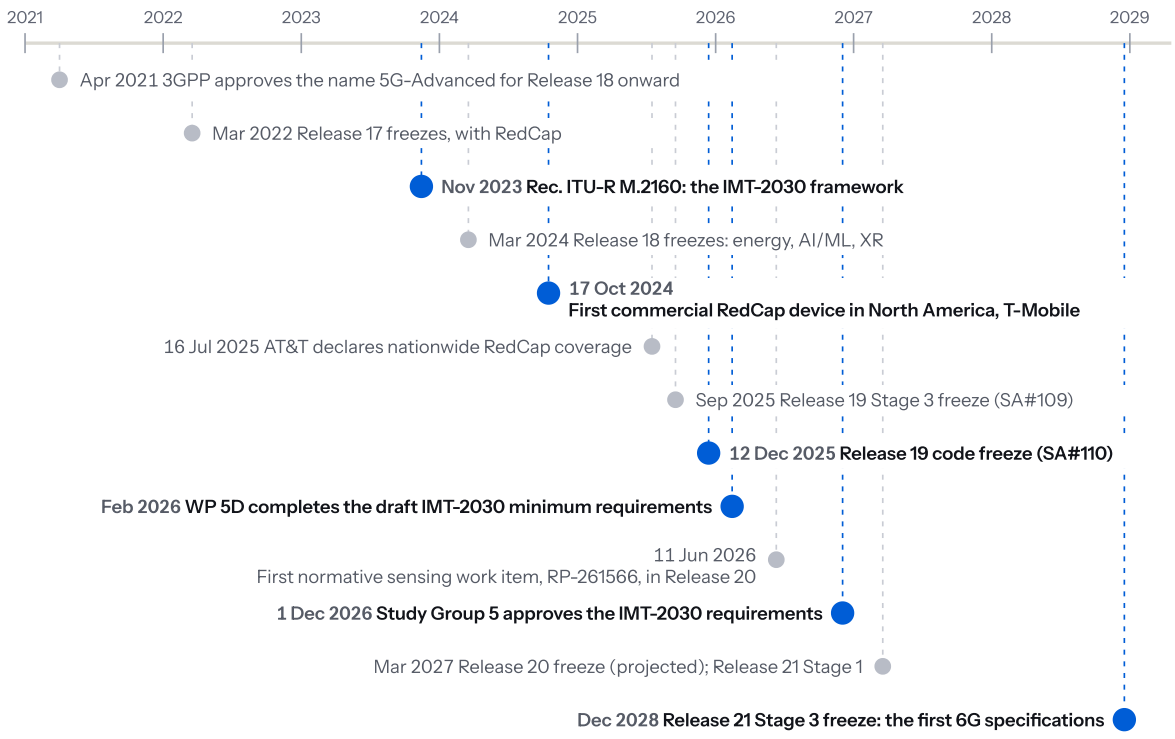
By September 2025 the Apple Watch line was using RedCap on both carriers. Verizon has published no launch date, so none is given here.

eRedCap, in Release 18, caps the peak rate at 10 Mbit/s to take still more cost out of the device.

Both generations have dated milestones, and the two sets do not overlap (Exhibit 4). Every 5G-Advanced milestone, from the naming in 2021 to the Release 19 code freeze, has a month against it. The first 6G document with the force of a requirement is due for approval on 1 December 2026, and the first 6G specifications freeze two years after that.

EXHIBIT 4

Every 5G-Advanced milestone has a date behind it, and the first 6G requirement is approved in December 2026



Source: 3GPP release pages and Highlights 2021; ATIS and 3GPP webinar deck, 3 April 2024; Rec. ITU-R M.2160-0; ITU note, 17 March 2026; T-Mobile, 16 October 2024; AT&T, 16 July 2025; 3GPP RP-261566 (Published). Note: the March 2027 and December 2028 dates are 3GPP's current plan, as part 1 of this series records.

The line between the generations runs through the middle of most capabilities

On these documents, the line between the generations runs through the middle of most capabilities rather than between them. Immersive, massive and ubiquitous communication are 5G-Advanced features with 6G targets at the top of their range. AI in the air interface is a Release 19 specification whose 6G form is being studied. Sensing has a channel-model study, one Release 20 work item for drone detection by base stations, and a 6G form that waits for Release 21. The only capabilities that live wholly on the 6G side of the line are the ones with the smallest numbers attached: a tenth of a millisecond, a centimetre.

> Four of the six IMT-2030 scenarios have a Release 17, 18 or 19 work item that addresses them by name, and two of those four have a commercial service behind them. Sensing has a channel-model study and one Release 20 work item, limited to drone detection by base stations. The sub-millisecond, centimetre-grade end of latency and positioning has nothing before Release 21. Those two are what 6G adds beyond 5G-Advanced, and the draft minimum requirements, where public, fall on the 5G-Advanced side of that line.

For a business case the consequence is direct. A plan that lists immersive, massive or ubiquitous communication as 6G revenue is listing revenue that Release 19 equipment can earn now, and it ought to say why it is not earning it. A plan that lists sensing or sub-millisecond control is listing revenue that waits for the Release 21 freeze and a radio designed to it, which puts its first date in the next decade. Part 6 sorts the candidates on that basis, and the integrated sensing series sets out what the sensing standard has agreed so far.

Terms used

- **Usage scenario.** The ITU-R's name for a family of uses a generation is designed around. IMT-2020 had three; IMT-2030 has six. A scenario is a heading rather than a feature.
- **Research target and minimum requirement.** The framework gives targets for research. The later Report gives the minimum a candidate technology has to demonstrate to be recognised as IMT-2030. Only the second is a pass mark.
- **Work item and study item.** A 3GPP study item produces a technical report and no specification text. A work item produces normative text. RP-numbered documents are the RAN plenary's approvals of each.
- **RedCap.** Reduced capability, a Release 17 device class with fewer antennas and narrower bandwidth, for wearables and sensors. eRedCap in Release 18 caps the peak rate at 10 Mbit/s to cut cost further.

Implications

CARRIER STRATEGIST	Audit the 6G slide against Exhibit 3. Anything in its first four rows is a 5G-Advanced feature with a work item behind it and, in two cases, a competitor's commercial service. For those rows the 6G question is one of timing on hardware you already own, and a new network does not come into it.
VENDOR	Quote the Release 19 work item and say what the product does with it, because that is a claim a buyer can check. The framework's numbers are research targets, and the one published draft minimum is 36 Gbit/s in 600 MHz. A datasheet that quotes 200 Gbit/s as a 6G requirement is quoting a target.
INVESTOR	Attribute no revenue before 2030 to sensing or to sub-millisecond control. Those two scenarios have no commercial record and no spectrum, while the four that are partly 5G-Advanced have both. Treat a 6G revenue line dated earlier than that as a claim about 5G-Advanced.

Method and limits

HOW THIS WAS BUILT

The IMT-2030 capability values are the ranges and example values the framework Recommendation gives, read from its published text. Where the framework calls a value a possible example or a research target, that word is kept, because the distinction matters. The IMT-2020 values are the minimum requirements in Report M.2410. The draft IMT-2030 minimum requirements are quoted only where a public document gives a figure, which at the time of writing means the APT's meeting update. The 5G-Advanced work items are named with their 3GPP identifiers from the ATIS webinar deck, each checked against the RAN#103 document list.

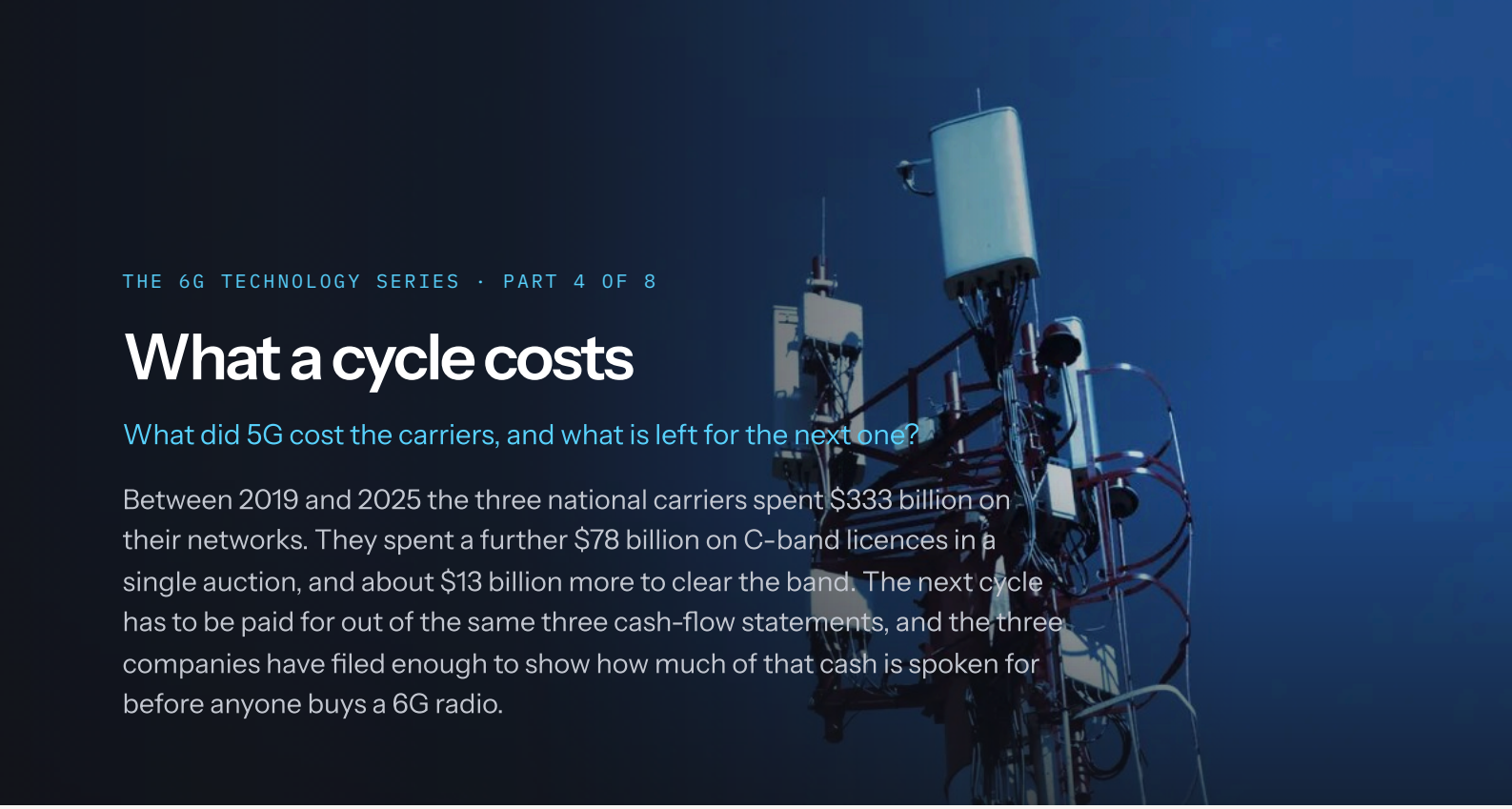
A scenario counts as having a 5G-Advanced pathway when a Release 17, 18 or 19 work item or study item addresses it by name. Commercial status is shown only where an operator has published it. The Release 20 sensing and AI work items are taken from part 8 of this series, which reads the plenary documents.

WHAT IT DOES NOT SHOW

The IMT-2030 minimum requirements completed in draft in February 2026 are an ITU-R working document until Study Group 5 approves them. The full table is not public; only the figures the APT and Samsung have published are quoted. A work item in a frozen release means a specification exists; it does not mean any network has turned it on. Verizon's RedCap date has no newsroom release behind it, so none is given.

Data as of: ITU-R and 3GPP documents as read 2 Oct 2026 · Method version 1.1 (fact-checked against second sources).

Sources. Recommendation ITU-R M.2160-0 (11/2023), read in the published text, with the ITU's release of 1 December 2023 and RCR Wireless's summary as second sources; Report ITU-R M.2410-0 (11/2017); the ITU's note of 17 March 2026 on the draft minimum requirements, the APT's WP 5D update by the IMT-TECH sub-group chair and Samsung Research's account; 3GPP's Release 17, Release 18 and Release 19 pages and its Highlights of 2021 on the 5G-Advanced name; the ATIS and 3GPP webinar deck of 3 April 2024, with each work and study item checked against the RAN#103 document list; the GSA's RedCap note on 3gpp.org and an overview of URLLC in Releases 15 and 16; T-Mobile's newsroom on 16 October 2024 and 9 December 2025, AT&T's 16 July 2025 post, and RCR Wireless and Fierce (17 October 2024, 16 July 2025, 19 September 2025) as second sources. Retrieved and cross-checked 2 Oct 2026.

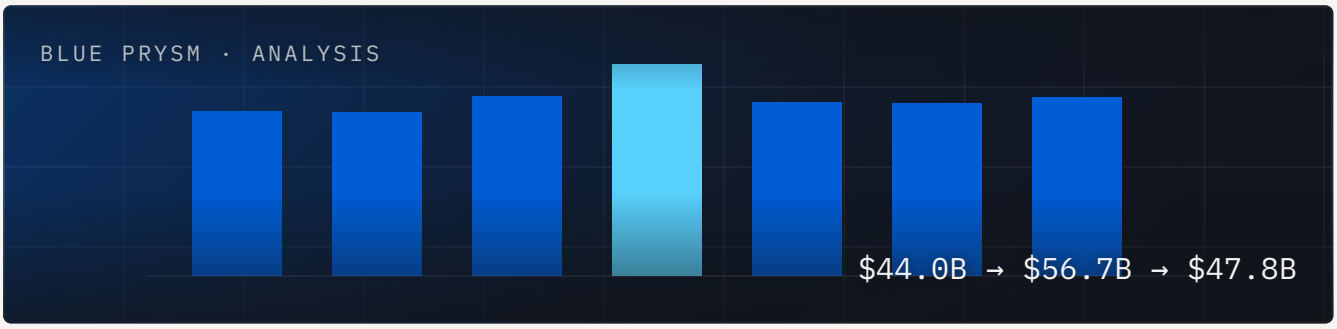


THE 6G TECHNOLOGY SERIES · PART 4 OF 8

What a cycle costs

What did 5G cost the carriers, and what is left for the next one?

Between 2019 and 2025 the three national carriers spent $333 billion on their networks. They spent a further $78 billion on C-band licences in a single auction, and about $13 billion more to clear the band. The next cycle has to be paid for out of the same three cash-flow statements, and the three companies have filed enough to show how much of that cash is spoken for before anyone buys a 6G radio.



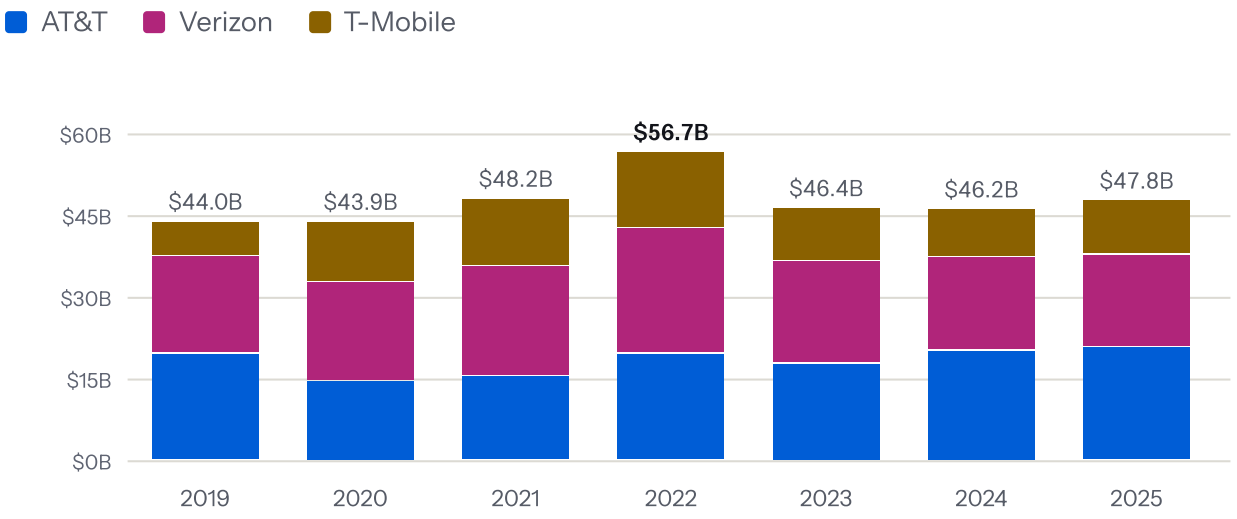
IN BRIEF

- AT&T, Verizon and T-Mobile filed combined capital expenditure of **$333.1 billion** for 2019 to 2025. The series peaked at $56.7 billion in 2022, 29% above where it started, and has run between $46 billion and $48 billion a year since.
- The three bid **$78.2 billion** between them in the C-band auction that closed in February 2021, and $12.0 billion more for 3.45 GHz in January 2022. Their 10-Ks put the clearing and incentive payments at about $13 billion on top.
- After capex and dividends, FY2025 left **$33.8 billion** across the three. AT&T's $22.65 billion purchase of EchoStar's licences, which closed in July 2026, is the first new claim on it.
- The next 160 MHz of upper C-band works out at $36.0 billion at the 3.45 GHz price and $46.4 billion at the C-band price (our calculation). A 6G capital plan has to fit after the 2027 auction and the capex rise that follows it, rather than beside them.

Combined capex peaked at $56.7 billion in 2022

EXHIBIT 1

Combined capex rose 29% to a one-year peak of $56.7 billion in 2022 and fell back to $46 to $48 billion



Source: Forms 10-K, FY2019 to FY2025, consolidated statements of cash flows, the three lines named in the method; SEC XBRL company facts (Filed). Note: AT&T's 2019 figure includes WarnerMedia and its 2020 and 2021 figures are recast without it. T-Mobile's 2019 figure is the company before Sprint.

The shape is a single hump. Combined capex was $44.0 billion in 2019 and much the same, $43.9 billion, in 2020. It climbed through 2021 to $56.7 billion in 2022, the year the C-band radios went up, and then settled between $46 billion and $48 billion for each of the three years since. The peak was 29% above the 2019 base, and it lasted one year. Verizon and T-Mobile both peaked in 2022. AT&T's highest year on the filed line is 2025, but that reflects its fibre build as much as its wireless one. On its own capital-investment measure, which adds back vendor financing, AT&T peaked in 2022 as well, at $24.3 billion (Exhibit 2).

EXHIBIT 2

Verizon and T-Mobile peaked in 2022; AT&T's filed line peaked in 2025, but its capital-investment measure peaked in 2022

FY	AT&T	VERIZON	T-MOBILE	THREE CARRIERS
2019	19.6	17.9	6.4	**44.0**
2020	14.7	18.2	11.0	**43.9**
2021	15.5	20.3	12.3	**48.2**
2022	19.6	**23.1**	**14.0**	**56.7**
2023	17.9	18.8	9.8	**46.4**
2024	20.3	17.1	8.8	**46.2**
2025	**20.8**	17.0	10.0	**47.8**
2019 to 2025	**128.5**	**132.4**	**72.3**	**333.1**

Capital expenditure as filed, $ billions. AT&T's 2019 is as first reported, with WarnerMedia; its 2020 and 2021 are the recast continuing-operations figures ($15.7B and $16.5B as first reported). AT&T also pays for equipment through vendor financing outside this line, which its own capital-investment measure adds back: $21.6B in 2021, $24.3B in 2022, $22.0B in 2025. T-Mobile's 2019 is the standalone company; the Sprint merger closed on 1 April 2020. Figures are rounded from the filed values; the sums are of the unrounded values.

Source: Forms 10-K, FY2019 to FY2025, consolidated statements of cash flows; SEC XBRL company facts; AT&T fourth-quarter releases for the capital-investment measure (Filed).

$333B What the three national carriers filed as capital expenditure for 2019 to 2025, with the only peak in 2022.

Three features of that cycle matter for the next one.

- **Order.** The spectrum came first, in the first quarter of 2021, and the build peaked the year after.
- **Scale.** The spectrum payments on the 2021 cash-flow lines, $82.4 billion (our calculation), were larger than the biggest single year of network capex, which was $56.7 billion.
- **Duration.** The peak lasted one year. Combined capex fell to $46.4 billion in 2023, only 5% above the 2019 base, and has been between $46.2 billion and $47.8 billion in every year since.

Most of the spectrum bill fell in one year

The network was the larger bill and the spectrum the more concentrated one. Most of the spectrum money left the three companies in a single quarter of 2021 (Exhibit 3).

Auction 107, the C-band, stopped bidding on 17 February 2021, and a week later the FCC closed it in public notice DA 21-207. The headline was $81,168,677,645 in gross bids, $81,114,481,921 net, from 21 winning bidders, with all 5,684 licences sold. Verizon, bidding as Cellco Partnership, took 3,511 of those licences for $45,454,843,197, more than half the total. AT&T Spectrum Frontiers LLC was next, with 1,621 licences for $23,406,860,839, and T-Mobile License LLC a distant third, with 142 for $9,336,125,147. United States Cellular paid $1,282,641,542 for 254.

Auction 110, the 3.45 GHz band, was smaller. Bidding ended on 4 January 2022 and the Commission closed it in DA 22-39: $22,513,601,811 gross, from 23 winning bidders, for 4,041 of the 4,060 licences on offer. This time AT&T Auction Holdings LLC was the largest buyer, with 1,624 licences for $9,079,177,491, and Dish's Weminuche the second, with 1,232 for $7,327,989,290. T-Mobile won 199 for $2,898,418,995, UScellular 380 for $579,646,526 and Columbia Capital's Three Forty-Five Spectrum 18 for $1,379,489,483.

EXHIBIT 3

Verizon paid $45.5 billion of the $103.7 billion the two mid-band auctions raised, and AT&T paid $32.5 billion

BIDDER	AUCTION 107, C-BAND (CLOSED FEB 2021)	AUCTION 110, 3.45 GHZ (CLOSED JAN 2022)	BOTH
Verizon	**$45.455B** · 3,511 licences	nil	**$45.5B**
AT&T	$23.407B · 1,621 licences	**$9.079B** · 1,624 licences	**$32.5B**
T-Mobile	$9.336B · 142 licences	$2.898B · 199 licences	**$12.2B**
Dish	not a top bidder	$7.328B · 1,232 licences	$7.3B
US Cellular	$1.283B · 254 licences	$0.580B · 380 licences	$1.9B
Three Forty-Five Spectrum	nil	$1.379B · 18 licences	$1.4B
Gross, all bidders	**$81.169B** · 21 bidders · 5,684 licences	**$22.514B** · 23 bidders · 4,041 licences	**$103.7B**

Gross bids, before bidding credits, incentive payments and clearing costs. The C-band winners also owed the satellite incumbents $9.7 billion of accelerated relocation payments and their relocation costs, which the Commission estimated at $3.3 to $5.2 billion in FCC 20-22. The carriers' 10-Ks put their shares at about $7.7 billion for Verizon, $4.2 billion for AT&T and $1.0 billion for T-Mobile.

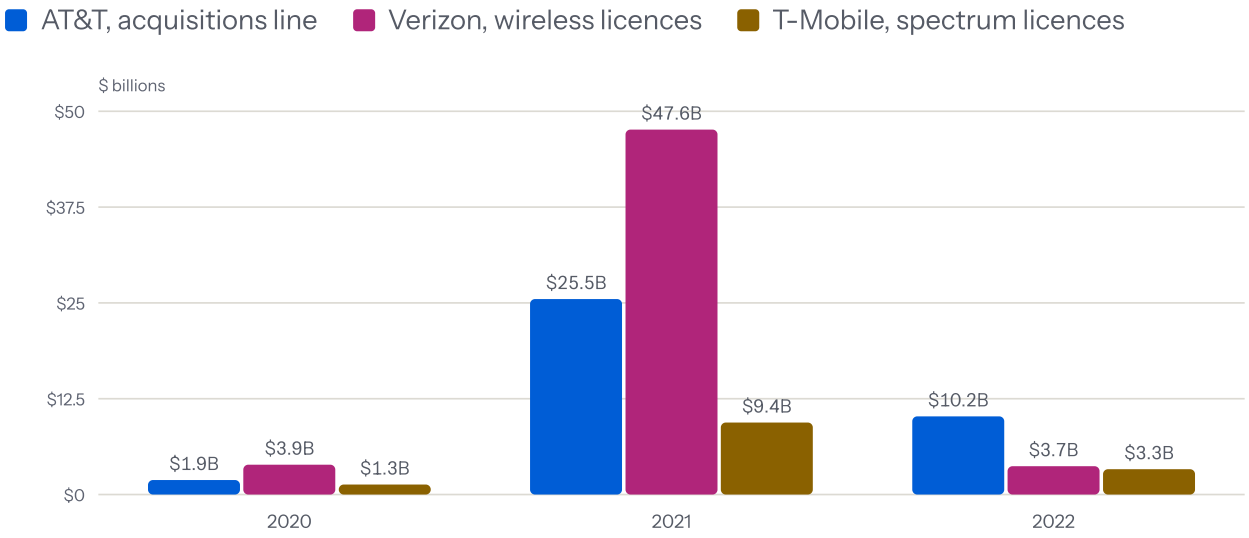
Source: FCC DA 21-207 and Attachment A, 24 February 2021; DA 22-39 and Attachment A, 14 January 2022; DA 21-655; FCC 20-22, 3 March 2020 (Published).

The cash-flow statements show the same money leaving, with the clearing on top. Verizon's payments for wireless licences were $47.6 billion in 2021, against $3.9 billion the year before and $3.7 billion the year after.

Its 10-K ties $45.9 billion of that to the C-band, including $1.3 billion toward clearing. T-Mobile's were $9.4 billion in 2021, against $1.3 billion and $3.3 billion either side. AT&T is harder to read, because its acquisitions line bundles spectrum with capitalised interest and clearing payments. That line was $25.5 billion in 2021 and $10.2 billion in 2022, against auction prices of $23.4 billion and $9.1 billion. The three together put the 2021 spectrum payments at $82.4 billion (our calculation), more than any single year of their combined network build (Exhibit 4).

EXHIBIT 4

The three carriers paid $82.4 billion for spectrum in 2021, against $7.1 billion the year before and $17.2 billion the year after



Source: Forms 10-K FY2021 and FY2022, consolidated statements of cash flows: Verizon, acquisitions of wireless licenses; T-Mobile, purchases of spectrum licenses and other intangible assets; AT&T, acquisitions net of cash acquired, which includes capitalised interest, incentive and relocation payments (Filed); yearly sums by Blue Prysm (Calculated). Note: AT&T's 2020 figure is $1.9 billion as filed in the FY2021 10-K.

The buying did not stop with the auctions. The two largest spectrum transactions agreed since 2022 are both private sales by EchoStar, one to a carrier and one to a satellite company.

PRIVATE SPECTRUM SALES SINCE THE AUCTIONS

EchoStar agreed on 25 August 2025 to sell AT&T about 30 MHz of nationwide 3.45 GHz and 20 MHz of 600 MHz for roughly $23 billion. The sale closed on 28 July 2026: $20.25 billion went to EchoStar and $2.4 billion into a trust the FCC required for claims from the shutdown of the Dish network, $22.65 billion in all.

That payment lands in AT&T's 2026 cash flows, so it appears in none of the tables above.

EchoStar's AWS-4, H block and unpaired AWS-3 holdings, 65 MHz in all, go to SpaceX for $17 billion in cash and stock plus $2.6 billion in stock. The two sum to $19.6 billion, which EchoStar rounds to $20 billion. SpaceX also funds about $2 billion of EchoStar's interest payments until the economic closing, expected on or about 30 November 2027.

On 8 October 2026 SpaceX agreed to buy a third block: T-Mobile's former 800 MHz licences, up to 14 MHz paired, from Grain Management, at a price neither party has stated. The Wall Street Journal reports about $8 billion.

Direct-to-device part 4 prices and compares all three. They matter here because the second-largest purchase of American spectrum agreed since the C-band auction was made by a satellite company rather than a carrier, and the company has kept buying.

What is left after the dividend

The next cycle will be funded from the same three cash-flow statements. Direct-to-device part 6 worked out what they leave over once the dividend is paid, and the same figures apply here (Exhibit 5).

EXHIBIT 5

After capex and dividends, FY2025 left $33.8 billion across the three carriers

FY2025, $ MILLIONS	AT&T	VERIZON	T-MOBILE	THREE
Operating cash flow	40,284	37,137	27,950	**105,371**
Capex	20,842	17,011	9,955	**47,808**
Dividends paid	8,180	11,481	4,121	**23,782**
Left after both	**11,262**	**8,645**	**13,874**	**33,781**

The same figures as direct-to-device part 6, which also shows the debt beside them: roughly $337 billion of combined long-term debt less cash at the time of writing. AT&T's 2025 line does not include the EchoStar purchase, which closed in July 2026.

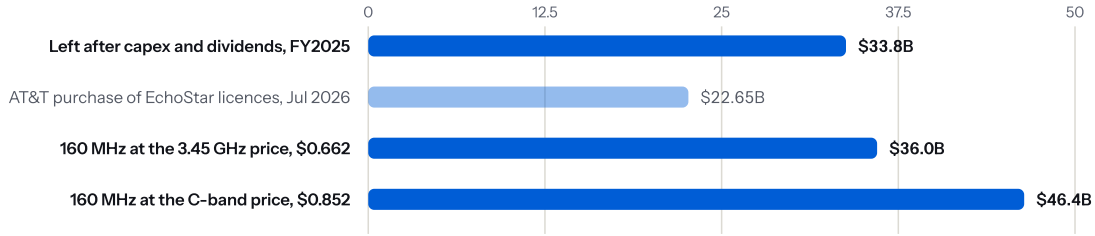
Source: FY2025 Forms 10-K, consolidated statements of cash flows; fourth-quarter 2025 releases (Filed).

The next spectrum bill is bigger than a year of what is left

Against that $33.8 billion a year, the first 6G-era purchase already has a date. The 160 MHz of upper C-band goes to Auction 115, with bidding from 27 April 2027. Two recent prices give its likely scale. At the $0.852 per MHz-POP the 2021 C-band cleared at, across a population of 340,110,988, the 160 MHz works out at $46.4 billion; at the $0.662 the 3.45 GHz band cleared at, $36.0 billion (our calculation). Either figure is more than a year of what the three carriers have left after the dividend (Exhibit 6), and it buys capacity for the existing generation, on existing radios, rather than anything the word 6G describes. The order also requires incentive payments to the satellite incumbents, which are outside this comparison, and a device base that has to be built, which part 2 explains.

EXHIBIT 6

At either recent price, the next 160 MHz costs more than a year of what the three carriers have left after dividends



Source: FY2025 Forms 10-K; AT&T and EchoStar Forms 8-K, 28 July 2026 (Filed); 160 MHz × 340,110,988 (Census Vintage 2024) × $0.852 and $0.662 per MHz-POP, the prices in direct-to-device part 4 (Calculated).

> The 5G cycle cost the three national carriers $333 billion of network, about $90 billion of mid-band spectrum and about $13 billion of clearing. The spectrum arrived in one year and the network peaked the year after. The next cycle opens with a spectrum bill in 2027 that, at either recent price, is more than a year of what the three have left after the dividend. No 6G hardware will have a specification to be built to until 2029.

In our view the ordering is the useful lesson. Last time the spectrum was bought first, in 2021, and the build peaked in 2022. If the sequence repeats, Auction 115 in the spring of 2027 is followed by a capex rise from 2028, which is Release 21's freeze year and two years before any vendor expects a 6G system. The money is therefore committed to 5G capacity right through the period in which 6G is being specified, and a 6G capital plan has to fit after it rather than beside it.

Terms used

- **Gross and net bids.** Gross is the sum of winning bids; net deducts the bidding credits small and rural bidders receive. Auction 107's gap was $54 million, Auction 110's $95 million.
- **Accelerated relocation payment.** The $9.7 billion FCC 20-22 offered the C-band satellite operators to clear early. The auction winners pay it in proportion to their holdings, on top of their bids and the operators' actual relocation costs.
- **Capital investment.** AT&T's own measure of capex plus cash paid under vendor financing, which its cash-flow statement books as a financing outflow rather than capex.
- **MHz-POP.** Megahertz of bandwidth multiplied by the population covered. A price per MHz-POP is how one auction is compared with another.

Implications

CARRIER STRATEGIST	Take two numbers into any 6G board paper: $33.8 billion a year across the three of you after dividends, and $36 billion to $46 billion for the next 160 MHz at recent prices. Any 6G capex line queues behind both, and AT&T's $22.65 billion for EchoStar's licences is ahead of them in the queue.
INVESTOR	Apply the last cycle's shape to 2028. Capex fell back to $46.4 billion the year after the 2022 peak, 5% above the 2019 base, and has stayed there since. On that precedent a 6G cycle that follows the upper C-band would peak around 2029 to 2030, and a plan that shows it earlier is showing something other than the last cycle. Read AT&T on its capital-investment measure as well as on the capex line.
VENDOR	Size the addressable radio capex for 2026 to 2028 at the $46 billion to $48 billion a year the three now spend, most of it on bands they already hold. The 6G radio competes for the budget that follows the 2027 auction, because that is when the next spectrum arrives.

Method and limits

HOW THIS WAS BUILT

Capex is the cash-flow line each company files for it, read in the latest 10-K that reports the year and checked against the SEC's XBRL company facts. The three companies do not tag it the same way. For AT&T the tag is `PaymentsToAcquireProductiveAssets`; its statement calls the line capital expenditures and includes interest during construction. For Verizon it is `PaymentsToAcquireOtherProductiveAssets`, a line that includes capitalised software. For T-Mobile it is `PaymentsToAcquirePropertyPlantAndEquipment`, a line that includes capitalised interest. Spectrum spend is `PaymentsToAcquireIntangibleAssets` for Verizon and T-Mobile. AT&T reports spectrum inside `PaymentsToAcquireBusinessesNetOfCashAcquired`, together with capitalised interest, incentive and relocation payments, so for AT&T the price paid is taken from the auction public notices instead.

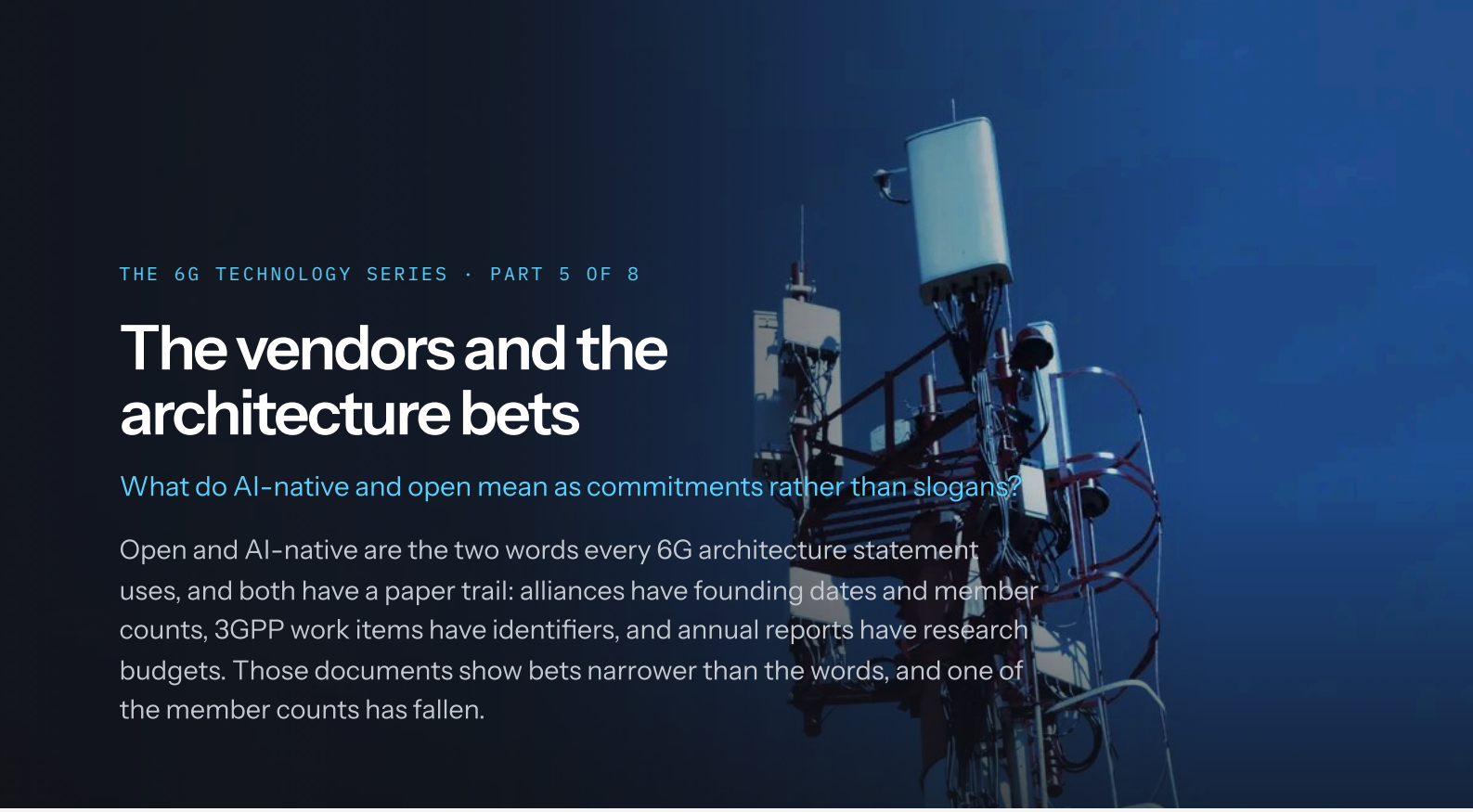
The upper C-band estimate multiplies 160 MHz by the Census Bureau's Vintage 2024 resident population of 340,110,988, the figure the direct-to-device series uses. It applies the $0.852 per MHz-POP the 2021 C-band cleared at and the $0.662 the 3.45 GHz band cleared at, from direct-to-device part 4.

WHAT IT DOES NOT SHOW

Capex as filed includes everything a carrier builds, and the 5G share is neither disclosed nor estimated here. AT&T's series mixes two bases: its 2019 figure was reported with WarnerMedia inside the company, its 2020 and 2021 figures were later recast without it. No recast 2019 figure was ever filed, and the table says so. T-Mobile's 2019 figure is the company before Sprint. The upper C-band estimate is an illustration at two historical prices and one population vintage, and it does not forecast the Auction 115 result. At the Vintage 2025 count of 341,784,857 it would be half a percent higher. EchoStar is left out of the capex series because it is leaving the business the series measures.

Data as of: SEC filings retrieved 2 Oct 2026 · auction results as published · Method version 1.1 (fact-checked against second sources).

Sources. FCC public notices DA 21-207 (24 February 2021) with its bidder summary, DA 22-39 (14 January 2022) with its summary, and DA 21-655 on the licences offered; the C-band order FCC 20-22 for the relocation payments; Fierce (24 February 2021) and the IEEE ComSoc technology blog (14 January 2022) as second sources on the auctions. Forms 10-K for AT&T (FY2021, FY2022, FY2025), Verizon (FY2021, FY2024, FY2025) and T-Mobile (FY2021, FY2024, FY2025), with the SEC's XBRL company-facts API and each company's fourth-quarter release (AT&T 28 January 2026, Verizon January 2026, T-Mobile January 2026) as second sources; T-Mobile's 8-K of 1 April 2020 on the Sprint closing; the Census Bureau's Vintage 2024 and Vintage 2025 tables. On EchoStar: AT&T's announcement of 26 August 2025 and 8-K of 28 July 2026, EchoStar's 8-K of the same day and second-quarter 10-Q, its releases of 8 September and 6 November 2025, and Light Reading (6 November 2025, 29 July 2026) and Mobile World Live (13 May 2026) as second sources. Retrieved and cross-checked 2 Oct 2026.

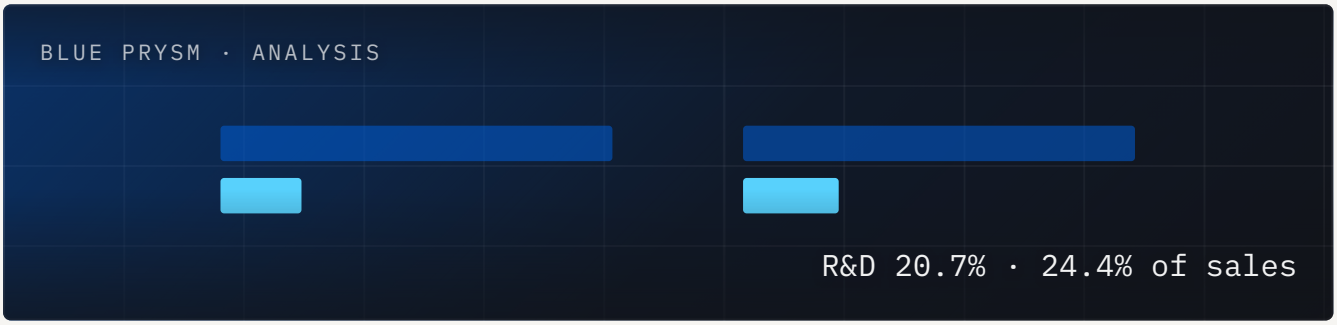


THE 6G TECHNOLOGY SERIES · PART 5 OF 8

The vendors and the architecture bets

What do AI-native and open mean as commitments rather than slogans?

Open and AI-native are the two words every 6G architecture statement uses, and both have a paper trail: alliances have founding dates and member counts, 3GPP work items have identifiers, and annual reports have research budgets. Those documents show bets narrower than the words, and one of the member counts has fallen.



IN BRIEF

- The O-RAN Alliance's own overview counted **over 220** participants in July 2026, against over 300 in March 2025, while its specification count rose past 150. Its membership page listed 28 operator members and 194 contributors on 2 October 2026.
- The AI-RAN Alliance grew from eleven founders in February 2024 to **132** members in February 2026, and 150 were listed on 2 October 2026. Amazon Web Services, one of the founders, no longer appears on the list.
- In 3GPP, AI-native comes down to one frozen Release 19 work item (RP-240774) and one Release 20 work item on two-sided models (RP-251870). The 6G study description says the 6G system must also work without AI.
- Ericsson, Nokia and Huawei spent 20.7%, 24.4% and 21.8% of 2025 revenue on R&D. Network sales fell at both European vendors, and Ericsson expects the RAN market to be flat in 2026. A buyer should ask every architecture claim for a work-item number or a named deployment.

The O-RAN Alliance's participant count has fallen

Open RAN has an eight-year paper trail, from a founding release to a membership page, and the most recent participant count in it is lower than the one before (Exhibit 1).

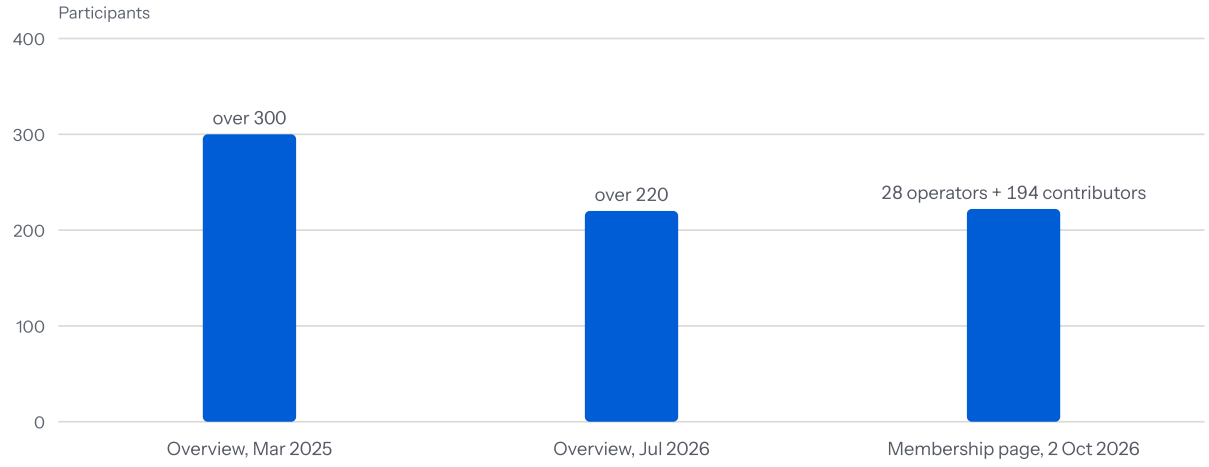
Five operators announced the O-RAN Alliance on 27 February 2018: AT&T, China Mobile, Deutsche Telekom, NTT DOCOMO and Orange. It merged two earlier groups, the xRAN Forum and the C-RAN Alliance, and was set up as a German entity that August. By the first board meeting, in Shanghai on 28 June 2018, twelve operators had signed its constitution.

Eight years on, its own overview, dated July 2026, reports over 220 participants, over 150 published specifications and eleven working groups. It counts twelve PlugFests since 2019, with 31 participants across nine labs at the spring 2026 event, and it records that its specifications are being transposed into national standards through ATIS, ETSI and TTA. During 2026 its software community is moving under Linux Foundation Networking. On that record the alliance is doing what it was set up to do.

The participant count, though, has fallen. The March 2025 edition of the same overview reported over 300 participants. The membership page, read on 2 October 2026, listed 28 operator members and 194 contributors, 222 in all. The alliance has not said whether the fall is attrition or a change in who is counted. Its own documents show the number down by about a quarter in sixteen months while the specification count rose.

EXHIBIT 1

The O-RAN Alliance's own participant count fell by about a quarter in sixteen months



Source: O-RAN ALLIANCE overview presentations, March 2025 and July 2026; o-ran.org membership page as read 2 October 2026; NTT DOCOMO releases, 27 February and 28 June 2018 (Published). Note: the two overviews give lower bounds. The October figure is Blue Prysm's tally of the operator and contributor lists on the membership page (Calculated).

The alliance's documents establish that open interfaces are specified, tested and transposed, and that an operator-founded body does the work. They do not establish market share. The overview counts documents and participants, and no primary source gives a figure for the open share of deployed RAN. A 6G architecture that assumes open interfaces therefore assumes two things: a specification base, which exists, and a market share, which has to be shown separately.

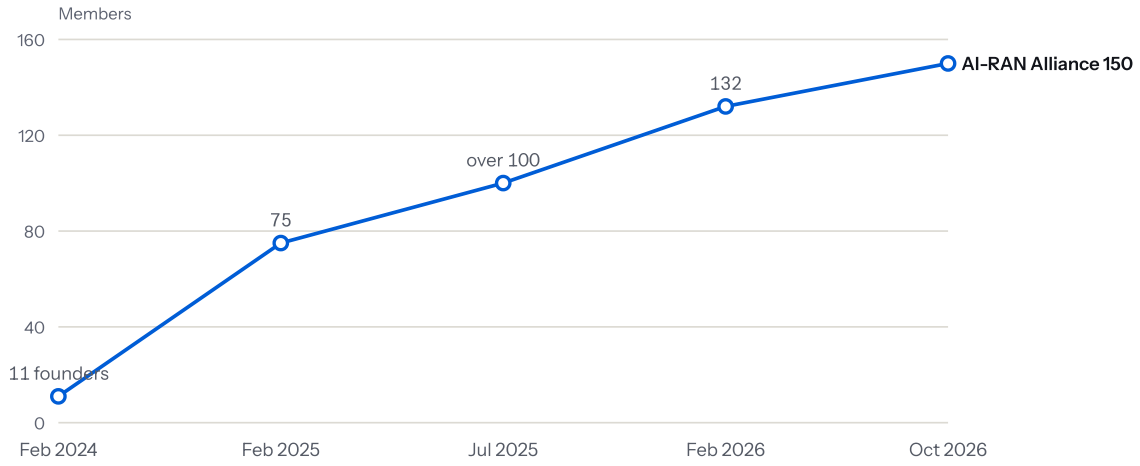
AI-native has a short record in the alliance and in 3GPP

AI-native has existed for two years as an industry body and for three releases as a 3GPP work area. The two records tell different stories (Exhibits 2 and 3).

SoftBank launched the AI-RAN Alliance on 26 February 2024 at Mobile World Congress, with ten other founders: Amazon Web Services, Arm, DeepSig, Ericsson, Microsoft, Nokia, Northeastern University, NVIDIA, Samsung Electronics and T-Mobile USA. Its stated goal was to make mobile networks more efficient, cut their power consumption and retrofit existing infrastructure, so that telecommunications companies could open new economic opportunities with AI. It has grown quickly: the alliance reported 75 members in February 2025 and passed 100 in July 2025, and on 26 February 2026 it reported 132 and seated Qualcomm, SK Telecom and Vodafone on its board (Exhibit 2).

EXHIBIT 2

The AI-RAN Alliance grew from eleven founders to 150 listed members in thirty-two months



Source: SoftBank and DeepSig founding releases, 26 February 2024; AI-RAN Alliance releases of 27 February 2025, 9 July 2025 and 26 February 2026; SDxCentral, 3 March 2026; ai-ran.org members page as read 2 October 2026 (Published). Note: the July 2025 point is the alliance's "surpasses 100 members" release and is plotted at 100. The October 2026 figure is a count of the organisations listed on the members page.

On 2 October 2026 its members page listed 150 organisations: ten on the executive board, three on the general board and 137 general members. Amazon Web Services, a founder, was no longer among them. The alliance works in three groups, named for the three relationships it sees between its two subjects: AI for

RAN, AI and RAN, and AI on RAN. The showcases around its 2026 congress, as SDxCentral reported them, were a Nokia radio line, a Samsung virtualised RAN test with Vodafone on Intel hardware, and a SoftBank edge deployment with NVIDIA.

In 3GPP the same subject has identifiers that can be checked. Release 18 listed artificial intelligence and machine learning as one of its three new topics. Release 19 made it normative, in a work item on AI and machine learning for the NR air interface, RP-240774, which the ATIS webinar called the largest project in the release. It also opened a study on AI for mobility, RP-240082. The work item covers one-sided models, meaning models that live wholly in the phone or wholly in the network, for beam prediction and positioning. Release 20 goes a step further with a work item on two-sided models, RP-251870, in which a phone and a base station from different companies have to share a trained model. Release 20's fourteen 6G study items include the radio study whose report, TR 38.914, was approved in June 2026. The normative decision belongs to Release 21, which is scoped from March 2027.

The study description sets the boundary. It requires the 6G radio and RAN design to ensure that the 6G system can also operate without AI and machine learning. AI is therefore optional by design in the standard, and AI-native describes products built on top of it rather than the standard itself. The normative text goes no further than one frozen work item, one two-sided work item in progress and a 6G study report waiting for its work items (Exhibit 3).

EXHIBIT 3

The checkable AI-native record is one frozen work item, one in progress and a study description that keeps AI optional

RECORD	WHAT EXISTS	DATE
AI-RAN Alliance	Founded by 11 companies; 75, then over 100, then 132 members reported; 150 listed	26 Feb 2024; Feb and Jul 2025; 26 Feb 2026; 2 Oct 2026
3GPP Release 18	AI/ML named as a new topic	Frozen Mar 2024
3GPP Release 19	AI/ML for the NR air interface, work item RP-240774: one-sided models for beam prediction and positioning; AI for mobility, study RP-240082	Frozen Dec 2025
3GPP Release 20	Two-sided model work item RP-251870, with three interoperability routes still open; 6G radio study report TR 38.914 approved; the 6G system "can also operate without AI/ML"	Jun 2026; freeze projected Mar 2027
Operator deployments	None published as AI-native in a primary source	As of 2 Oct 2026

A work item produces normative text; a study item produces a report. The Release 21 decision on an AI-native air interface is scoped from March 2027.

Source: SoftBank release, 26 February 2024; AI-RAN Alliance site, 2 October 2026; SDxCentral, 3 March 2026; ATIS and 3GPP webinar deck and RAN#103 documents; 3GPP Release 20 page; RP-251881 and RP-251870 as read in part 8 of this series (Published).

> The AI-native commitment that can be checked is one Release 19 work item, one Release 20 work item and one study report. The alliance list shows who has signed, and most of the industry has. The showcases show trials. A vendor roadmap sits in the gap between the two, and a buyer should ask for that gap to be filled with a work-item number or a deployment rather than a membership.

THE GRAPHICS-PROCESSOR QUESTION

A third use of AI-native sits outside 3GPP altogether: whether the base station's signal processing should run on general-purpose graphics processors, so that the same hardware can run AI workloads between calls.

Nokia, which took a $1.0 billion investment from NVIDIA for 2.9% of its shares, says its graphics-processor RAN gives 1.5 times the capacity and twice the spectral efficiency on its own testing. It plans a first commercial trial at the end of 2026 and a release in 2027. SoftBank reports threefold spectral efficiency on its AITRAS platform and plans commercial use from its 2026 financial year.

Ericsson's position is that GPUs are one option for 6G and AI RAN rather than the only one. It points out that it has 500 microseconds to process each slot, and a million-parameter model cannot run in that. Samsung says it does not believe GPUs are a prerequisite for 6G, and it runs its Korean AI-RAN deployments on ordinary processors.

Verizon's chief technology officer said that if you divide performance by cost, one day it makes sense, and today, no. The AI in operations series sets out what the standards define for AI in the network.

Three vendors spend a fifth to a quarter of revenue on research

Standards work and alliance memberships are paid for from research budgets, so the size of those budgets and the market they face both matter. The four largest radio vendors publish enough to compare, though not all in the same shape (Exhibit 4).

EXHIBIT 4

Ericsson and Nokia reported network sales down 5% and 4% for 2025, and Ericsson expects a flat RAN market in 2026

FY2025	ERICSSON (SEK)	NOKIA (EUR)	HUAWEI (CNY)	SAMSUNG ELECTRONICS (KRW)
Revenue	**236.7B** (2024: 247.9B)	**19,889M** (2024: 19,220M)	**880.9B** (+2.2%)	Company-wide, not compared
R&D expense	**48.9B** (2024: 53.5B)	**4,855M** (2024: 4,512M)	**192.3B**	37.7T, company-wide
R&D as share of revenue	20.7%	24.4%	21.8%, as stated	Not comparable
Network segment	Networks 151.0B (2024: 158.2B), down 5%	Mobile Networks 7,806M (2024: 8,158M), down 4% reported, flat in constant currency	ICT Infrastructure 375.0B (+2.6%)	Networks about 3.0T, implied
Outlook stated	"For 2026, we expect the RAN market to be flat."	Mobile Networks net sales grew by 6% in Q4 and were flat for the full year	No RAN outlook stated	Q4 Networks earnings improved on North American sales

Nokia reorganised on 1 January 2026, and Mobile Infrastructure is the segment from then; the row shows the segment that reported 2025. Huawei's ICT Infrastructure includes enterprise and computing. Samsung's Networks figure is the difference between the MX/NW and MX lines in its earnings deck (129.5T less 126.5T). Shares of revenue are calculated from the rows above them except Huawei's, which the report states.

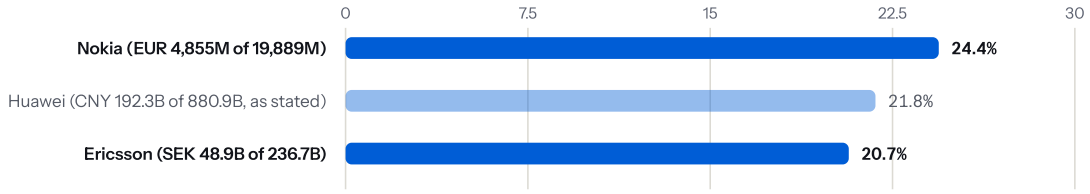
Source: Ericsson fourth quarter and full-year report 2025, 23 January 2026; Nokia Q4 and full-year 2025 report, 29 January 2026; Huawei annual report 2025, 31 March 2026; Samsung Electronics Q4 2025 earnings deck, 29 January 2026 (Filed).

The three vendors that disclose a research line spend between a fifth and a quarter of every sale on it (Exhibit 5). Three things follow.

- **Direction.** Ericsson's R&D fell from SEK 53.5 billion to SEK 48.9 billion in 2025, and Nokia's rose from EUR 4,512 million to EUR 4,855 million. Network sales fell at both, by 5% and 4% as reported, and Ericsson expects the RAN market to be flat in 2026. A 6G radio has to sell into that market.
- **Geography.** The largest research budget in the table, Huawei's CNY 192.3 billion, belongs to a company whose equipment is shut out of the American market this series covers. The largest budget and the budgets that sell into this market are therefore different money.
- **Scale.** SEK 48.9 billion is the whole of Ericsson's research, across every product, and the 6G share is not disclosed. A vendor roadmap that implies a research programme beyond what these lines can fund is making a claim its own annual report does not support.

EXHIBIT 5

Nokia, Huawei and Ericsson each spent between a fifth and a quarter of 2025 revenue on research



Source: Ericsson, Nokia and Huawei full-year 2025 reports (Filed); shares calculated from reported R&D and revenue, except Huawei's, which it states (Calculated). Note: Samsung Electronics does not disclose network R&D.

Three questions sort a roadmap from a slide

Together, the three sets of documents give a buyer three questions for any vendor.

1. **Architecture.** Which 3GPP work item or O-RAN specification does the claim rest on, by number? A claim without one is a plan, and a plan is not a commitment.
2. **AI.** Which operator has published a deployment? A trial at a trade show is a trial, however good the demonstration.
3. **Timeline.** Which research budget pays for it, and what does the same annual report say about the market the product is meant to sell into?

A roadmap that answers all three is a document; one that answers none of them is a slide.

On the documents, the bets are narrower than the words. Open is a specification base with an operator-founded body behind it, an undisclosed share and a participant count lower than it was. AI-native is one frozen work item, one in progress, a study description that keeps AI optional, and a membership list that has grown and lost a founder. Both are real and both are early. Neither, in our view, is a reason to move the dates in part 1.

Terms used

- **Open RAN.** A radio access network whose interfaces between radio, baseband and controller follow published specifications, so that equipment from different suppliers can be mixed. The O-RAN Alliance writes the specifications, which extend the interfaces 3GPP defines.
- **AI-RAN.** The alliance's umbrella for three things. AI for RAN uses AI to run the radio better. AI and RAN shares the same hardware between AI workloads and the radio. AI on RAN runs applications on that

hardware at the edge.

- **Work item and study item.** In 3GPP a study produces a technical report and no specification text. A work item produces normative text. RP-numbered documents are the RAN plenary's approvals of each.
- **R&D intensity.** Research and development expense as a share of revenue. It measures how much of each sale is reinvested, and says nothing about what any single programme costs.

Implications

CARRIER STRATEGIST	Ask every 6G architecture proposal for its work-item numbers and its deployment references. The answers sort vendors faster than their decks do, and the tables above are what you check the answers against.
VENDOR	Build the roadmap from identifiers: RP-240774, RP-251870, TR 38.914, an O-RAN specification number, a named customer deployment. Each of those can be checked against a public document, so a roadmap built from them survives a buyer who has done the checking.
INVESTOR	Read the R&D line and the market-outlook sentence in each full-year report before you read the product announcements. R&D at a fifth to a quarter of revenue, against a flat RAN market, is the constraint on the 6G supply side. Watch the alliance counts too, because they are published and they have moved.

Method and limits

HOW THIS WAS BUILT

Alliance facts are taken from each alliance's own overview, membership page or launch release, with a dated trade report or a founding member's release as the second source. Where an alliance publishes two counts, both are given with their dates. Vendor figures are from the four companies' own full-year 2025 reports, in the currency each reports in. R&D intensity is R&D expense divided by revenue from the same report, except for Huawei, which states the share itself. The 3GPP items are named by their work-item identifiers, each checked against the plenary document list. The Release 20 items and the vendors' positions on graphics processors are taken from part 8 of this series, which reads the plenary documents and the trade reports.

WHAT IT DOES NOT SHOW

Samsung does not disclose its network business separately. The figure here is the difference between two lines it does disclose, and its network R&D is not disclosed at all. Huawei's ICT Infrastructure segment includes enterprise and computing business as well as carrier equipment, and the company is privately held, so its figures are as it reports them. Membership of an alliance is a signature rather than a product, and a specification count measures documents rather than deployments. Nothing here says whether any vendor's architecture is better than another's.

Data as of: alliance and company documents as read 2 Oct 2026 · Method version 1.1 (fact-checked against second sources).

Sources. The O-RAN ALLIANCE's about page, its overview presentation of July 2026 and the March 2025 edition, its membership page and the PlugFest release of 4 June 2026; NTT DOCOMO's releases of 27 February and 28 June 2018, with The Mobile Network's report of the first board meeting as a second source. The AI-RAN Alliance's site, including its members and working groups pages as read 2 October 2026; the founding release as carried by SoftBank and DeepSig; SDxCentral's report of 3 March 2026. Ericsson's fourth quarter and full-year report 2025 (23 January 2026); Nokia's Q4 and full-year 2025 report and release (29 January 2026); Huawei's 2025 annual report and release (31 March 2026); Samsung Electronics' fourth-quarter 2025 earnings deck and release (29 January 2026). The ATIS and 3GPP webinar deck of 3 April 2024, the RAN#103 document list and 3GPP's Release 20 page. Retrieved and cross-checked 2 Oct 2026.



THE 6G TECHNOLOGY SERIES · PART 6 OF 8

What pays before the freeze

Which bets pay on today's hardware and which need the standard?

What a carrier can sell between now and the Release 21 freeze in December 2028 is 5G features on spectrum it already holds. Ten capabilities that appear on 6G roadmaps are scored here on three tests: whether the specification is frozen, whether the band is licensed and whether a device is on sale. Five pass today, and all five are 5G features. Two wait for the upper C-band at the end of 2030, and three wait for Release 21 and WRC-27. Nothing on the list earns as 6G before 2030.



IN BRIEF

- Five of the ten capabilities scored here have a frozen release, a licensed band and a device on sale, so they earn now. They are fixed wireless, RedCap, direct-to-device, private networks and network energy saving, and all five are 5G features.
- The upper C-band is capacity rather than a generation: 160 MHz of mid-band on radios already built for band n77. The licences go on sale on **27 April 2027**, but service in the top 75 areas may not start until **31 December 2030**, and no American handset is yet specified for 3.98 to 4.14 GHz. The FCC's order requires every new device to cover the band from that date.
- Sensing, the 7 GHz radio and sub-millisecond positioning have no specification until Release 21 freezes in **December 2028**, with the code freeze in March 2029. Set that against the last cycle, in which four 5G releases in five froze later than first planned, by three to nine months, and 2030 looks like the early end of the range.
- The roadmap should run as two lines: a 5G-Advanced line dated now and funded from existing capex, and a 6G line dated 2030 at the earliest. The upper C-band falls between them as a capacity purchase, with a spectrum bill in 2027.

A capability earns nothing until release, band and device all exist

Before a capability earns anything, three things have to be true at once: the specification that defines it is frozen, the spectrum it runs in is licensed, and a device that uses it is on sale. Different bodies control each, so they slip independently, and each has a date on the record (Exhibit 1).

3GPP publishes its dates, so the specifications are the easiest to check. Release 17 froze in March 2022, Release 18 in March 2024 and Release 19 in December 2025. Release 20 is projected to freeze in March 2027. The one that matters for 6G is Release 21, the first to carry normative 6G specifications. It is planned to freeze in December 2028, with its code freeze three months later in March 2029 (part 1).

Spectrum is slower, and its dates come from a statute, an FCC order and a conference rather than from one body. The bands a carrier holds today, the C-band and 3.45 GHz, have been licensed since 2021 and 2022, so for them this dependency is already met. The upper C-band is next. Auction 115 opens for bidding on 27 April 2027, but the clearing comes after the sale. Terrestrial service may not begin until 31 December 2030 in the top 75 areas, and 1 July 2031 everywhere else. Above 4.2 GHz nothing is dated at all. An NTIA report is due in December 2026, WRC-27 meets in Shanghai from 18 October to 12 November 2027, and the statute then allows an American auction as late as July 2033 (part 2).

Devices are the dependency most often overlooked, and the only evidence accepted here is a published commercial launch. T-Mobile put the first commercial RedCap device in North America on sale on 17 October 2024, and AT&T declared nationwide RedCap coverage on 16 July 2025. Direct-to-device phones are in service, as the direct-to-device series records. The upper C-band is the exception, because its device date is a rule rather than a launch. Note 12 to TS 38.101-1 restricts band n77 in the United States to 3450 to 3550 and 3700 to 3980 MHz, so no American handset is specified for 3.98 to 4.14 GHz today. The FCC's order requires every new device sold for the band to cover it from 31 December 2030, which gives the handsets four years to catch up.

EXHIBIT 1

The dependency dates run from December 2026 to July 2031, and no 6G specification exists before March 2029



Source: 3GPP Release 20 and Release 21 pages, timeline agreed at TSGs#112 in June 2026; FCC 26-46 and DA 26-769 (July 2026); NSPM-8 (19 December 2025); ITU WRC-27 page; Qualcomm, Nokia and Ericsson statements of 2026, as carried in parts 1 and 2 (Compiled). Note: 3GPP dates are its own current plan; the conference and auction dates are scheduled.

The five that earn today are all 5G features

Scored on those three dependencies, the ten fall into three groups. Five earn now; two more are dated, one by its spectrum and one by its devices; and the last three have nothing to build to until Release 21 freezes (Exhibit 2).

EXHIBIT 2

Five candidates have a release, a band and a device today; three have no device and no frozen specification

● Exists today ◐ Dated, or in progress with a meeting set ✕ No date

	Release	Band	Device
Fixed wireless on mid-band	●	●	●
RedCap devices and wearables	●	●	●
Direct-to-device supplement	●	●	●
Private networks, neutral host	●	●	●
Network energy saving	●	●	●
Immersive and XR	●	●	◐
Upper C-band capacity	●	◐	◐
Integrated sensing	◐	✕	✕
6G radio at 7 GHz	◐	◐	✕
Sub-ms, centimetre positioning	◐	◐	✕

Source: 3GPP release pages and the Release 19 work items named in part 3; FCC 26-46 and DA 26-769; TS 38.101-1 note 12; operator launch releases as cited in parts 2 and 3 (Compiled). Note: the energy row counts vendor software on installed radios as the device.

The five that earn now are all 5G features, and most are old ones: fixed wireless, private networks and direct-to-device come from Releases 15, 16 and 17. Fixed wireless has the hardest numbers. T-Mobile reported 8.45 million 5G broadband customers at the end of 2025, Verizon 6.2 million fixed wireless subscribers at mid-2026, and list prices run from $35 to $70 a month. Those two counts are the only hard evidence we have found of what mid-band capacity sells for. None of the five appears on a 6G slide under its own name, yet they are what a carrier earns with across the whole window the 6G plan covers.

The energy row is the nearest any of the five comes to the AI-native story that part 5 examines. Release 18 introduced network energy saving and Release 19 enhanced it, in work item RP-240170. What a carrier buys is software for radios it already owns. No new band is involved and no architecture changes, so vendor software counts as the device.

Two candidates are dated and three wait for Release 21

A capability earns on the date its last dependency arrives. For the upper C-band that is the licence and the clearing; for XR it is a device and a service; for the last three rows it is the specification itself, which does not yet exist (Exhibit 3).

EXHIBIT 3

Ten candidates sorted by the date all three dependencies exist, from now to 2030 onward

CAPABILITY	RELEASE IT NEEDS	SPECTRUM IT NEEDS	DEVICE	EARLIEST REVENUE
Fixed wireless access on mid-band	Rel-15/16	C-band, 3.45 GHz: licensed	Customer equipment on sale	**Now**
RedCap devices and wearables	Rel-17; eRedCap Rel-18	Existing bands	Commercial since Oct 2024; nationwide on two carriers	**Now**
Direct-to-device supplement	Rel-17 NTN, or proprietary	Leased PCS G block and 700 MHz	Phones in service	**Now**; see the direct-to-device series
Private networks and neutral host	Rel-15/16	CBRS, licensed and shared	On sale	**Now**
Network energy saving, AI-assisted	Rel-18; Rel-19 enhancements (RP-240170)	None new	Vendor software	**Now to 2026**
Immersive and XR	Rel-18; Rel-19 phase 3 (RP-240791)	Mid-band, licensed	Partial; no operator service published	2026 onward, device-bound
Mid-band capacity, upper C-band	Rel-15 (band n77)	3.98 to 4.14 GHz: Auction 115 from Apr 2027	Radios built for n77; US handsets need note 12 lifted, which the order requires by the service date	**31 Dec 2030**, top 75 areas
Integrated sensing	Rel-21; Rel-20 specifies base-station drone detection only	Under study; 7 to 24 GHz channel model	None	**2029 onward**
6G radio at 7 GHz	Rel-21	7.125 to 7.4 GHz: NTIA report, WRC-27, then auction by 2033	None	**2030 onward**
Sub-millisecond, centimetre positioning	Rel-21, above the draft minimum requirement	Dependent on the above	None	**2030 onward**

Bold rows have all three dependencies met or dated. The 2029 and 2030 dates are the Release 21 freeze plus the time a specification needs to become a product; part 1's base rate would move them later. The last row's targets are above the draft IMT-2030 minimum of 1 ms that part 3 reports, so a Release 21 radio that meets the minimum need not deliver them.

Source: parts 1 to 5 of this series and the direct-to-device series for the satellite row (Compiled). Note: Rel-20's sensing work item, RP-261566, covers base-station monostatic drone detection with no device impact; no regulator has ruled on whether a mobile licence covers sensing.

The upper C-band is the simplest case. The band lies inside n77, so the radios and the release both exist. A carrier lacks the licence, which Auction 115 sells from April 2027, and the clearing, which does not allow service in the top 75 areas until 31 December 2030. The handset base is missing too, and the order requires it by the same date. XR is the opposite case: its specifications are frozen and its band is licensed, but no operator has yet published a device and a service for sale.

THE HANDSET FOOTNOTE ON THE UPPER C-BAND

In 3GPP's table of bands, n77 runs from 3.3 to 4.2 GHz, so 3.98 to 4.14 GHz is already inside it and the radios built for the 2021 C-band can serve it without a new band.

The constraint is on the handset side. Note 12 to TS 38.101-1 restricts n77 in the United States to 3450 to 3550 MHz and 3700 to 3980 MHz. A phone built to the current specification is therefore under no obligation to work above 3980 MHz in the American market.

FCC 26-46 closes the gap by rule: every new mobile device sold for any part of 3.70 to 4.14 GHz must work across the whole 440 MHz from 31 December 2030.

Lifting the note is a change request in 3GPP's RAN4 working group. The four years between the order of July 2026 and the service date are the window for it, and for the handset base to turn over.

The three rows that wait for Release 21 each wait on something different. Sensing has a channel-model study from Release 19 and, in Release 20, a work item that covers base-station drone detection and nothing else. The 7 GHz radio has a federal report, a conference decision and an auction ahead of it, in that order, and the statute gives the auction until July 2033. The sub-millisecond and centimetre targets depend on both of the others, and they are finer than the 1 ms minimum the draft IMT-2030 requirements ask for, so a radio that meets the minimum need not deliver them. The earliest any of the three has a specification to build to is March 2029, with a radio to follow, and every 6G revenue case inside the decade falls after that.

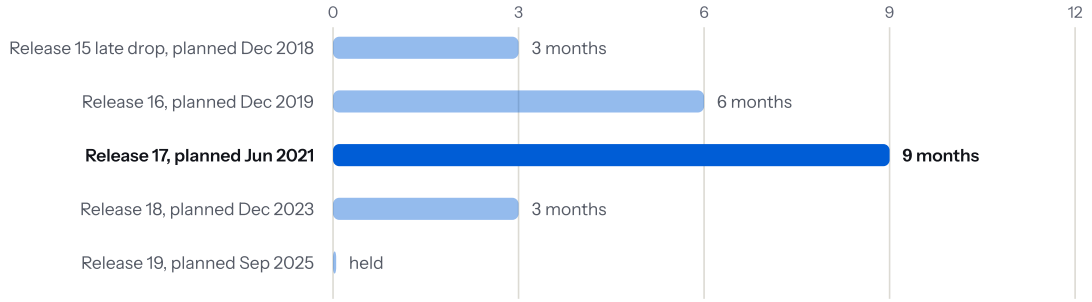
The rule only ever moves a date later

The rule is simple: a capability earns on the day its last dependency arrives, and not before. Applied to the table, the earliest anything earns as 6G is 2030. New mid-band capacity earns from 31 December 2030. Everything a carrier earns before then is 5G-Advanced, on bands it already holds.

The rule works in one direction only. Nothing earns before its last dependency, so no date can come forward; a date can only go back, and it does so every time a dependency slips. In the 5G cycle that happened to four releases in five (Exhibit 4). Release 15's late drop and Release 18 each lost three months at a December plenary. Release 16 moved twice, six months in all. Release 17 also moved twice, in March and December 2020, and froze on 18 March 2022, nine months after the date it was first scoped to. Only Release 19 held the date it had published, September 2025, set in April 2024.

EXHIBIT 4

Four of the five 5G releases froze three to nine months late and none froze early



Source: 3GPP news items of December 2018, March 2020, December 2020 and December 2022 and the 3GPP releases page, as carried in part 1 (Filed). Note: Release 16 moved twice by three months; Release 17 by three and then six; Release 19 froze on its published date at SA#109.

Applied to a roadmap, the rule produces two lines. The 5G-Advanced line starts now. The 6G line starts around 2030, and on the last cycle's record it starts later rather than earlier. The next three years of revenue fall in the gap between the two, and the first six rows of Exhibit 3 fill it.

A roadmap should carry two lines and a capacity purchase between them

Each question on our 6G roadmap decision page has a specific answer in the table. The plan itself is two lines with one purchase between them (Exhibit 5).

EXHIBIT 5

The plan has a 5G-Advanced line dated now, a 6G line dated 2030 at the earliest, and a spectrum bill in 2027 between them

LINE	EARLIEST DATE	PAID FROM	CHECKED AGAINST
5G-Advanced: rows 1 to 6 of Exhibit 3, fixed wireless, RedCap, direct-to-device, private networks, energy saving and XR	**Now**; XR when a device and a service exist	Existing capex: $46 billion to $48 billion a year across the three national carriers in 2023 to 2025	Revenue per band held; competitors' published services
Capacity: row 7, the upper C-band	**31 Dec 2030**, top 75 areas; 1 Jul 2031 elsewhere	Auction 115 bids from April 2027: $36.0 billion to $46.4 billion for 160 MHz at the two recent mid-band prices	The handset base for 3.98 to 4.14 GHz, built before 2030
6G: rows 8 to 10, sensing, the 7 GHz radio and sub-millisecond positioning	**2030** at the earliest, after a March 2029 code freeze	The capex that follows the auction; the three carriers had $33.8 billion left after capex and dividends in FY2025	A frozen specification and a device, neither of which exists

The capex, auction and cash figures are the three national carriers' filed values from part 4. The auction range applies the C-band price of $0.852 and the 3.45 GHz price of $0.662 per MHz-POP to 160 MHz.

Source: parts 1 to 4 of this series: 3GPP release pages; FCC 26-46 and DA 26-769; Forms 10-K for FY2023 to FY2025; FCC DA 21-207 and DA 22-39 (Compiled and Calculated).

Each question on the decision page has a place to look. The milestones are in part 1's table. The capabilities that carry a business case before the freeze are the first six rows of Exhibit 3, and the spectrum pipeline and its dates are in part 2. The dependencies that gate each bet are the three columns of Exhibit 2. The indicators that would move the timeline are the subject of part 7.

A roadmap should not say that any row below the sixth earns before 2030. Nothing on the record supports it, and a plan that depends on it rests on the kind of date that held once in five in the last cycle.

Terms used

- **Release and freeze.** A 3GPP release is a numbered set of specifications; its Stage 3 freeze is the point after which the radio protocols stop changing, and is what vendors build to. The later code freeze fixes the machine-readable encodings.
- **Band n77.** 3GPP's name for 3.3 to 4.2 GHz as a time-division band. The C-band of 2021 and the upper C-band of 2027 are both inside it; a footnote restricts the American part of it to 3980 MHz until changed.
- **RedCap.** Reduced capability, a Release 17 device class with fewer antennas and narrower bandwidth, for wearables and sensors. eRedCap in Release 18 caps the peak rate at 10 Mbit/s to cut cost further.

- **Partial economic area.** One of 416 licence areas the FCC uses for mid-band auctions. The top 75 by population held 72.1% of Americans at the 2020 census and are the first to be cleared and served.
- **Customer equipment.** The fixed wireless router or outdoor unit a subscriber installs; for the fixed wireless row it is the device on sale.

Implications

CARRIER STRATEGIST	Build the plan in two lines. Date the 5G-Advanced line now, fund it from existing capex and measure it in revenue per band you hold. Date the 6G line 2030 at the earliest. Put the upper C-band between them as a capacity purchase, because the licence arrives in 2027 and service in 2030 whatever Release 21 does. Start the handset work before the April 2027 auction rather than after it, since no American handset is specified for the band today and the order requires one by the service date.
INVESTOR	When a carrier claims 6G revenue, ask which row of Exhibit 3 it belongs to. The first six rows you can check against competitors' published services and prices. The last three have no device, no licence and no frozen specification, so a figure attached to any of them before 2030 has nothing on the record behind it and should be treated as an assumption.
VENDOR	Sell what is in the first six rows, on radios already in the field, because that is where carrier revenue falls before 2030. The 7 GHz radio has a date, and it comes after WRC-27 in Shanghai and after an auction. The n77 handset change has a date too, 31 December 2030. The work for it belongs before the April 2027 auction, because a carrier bidding for the band will want to know the phones are coming.

Method and limits

HOW THIS WAS BUILT

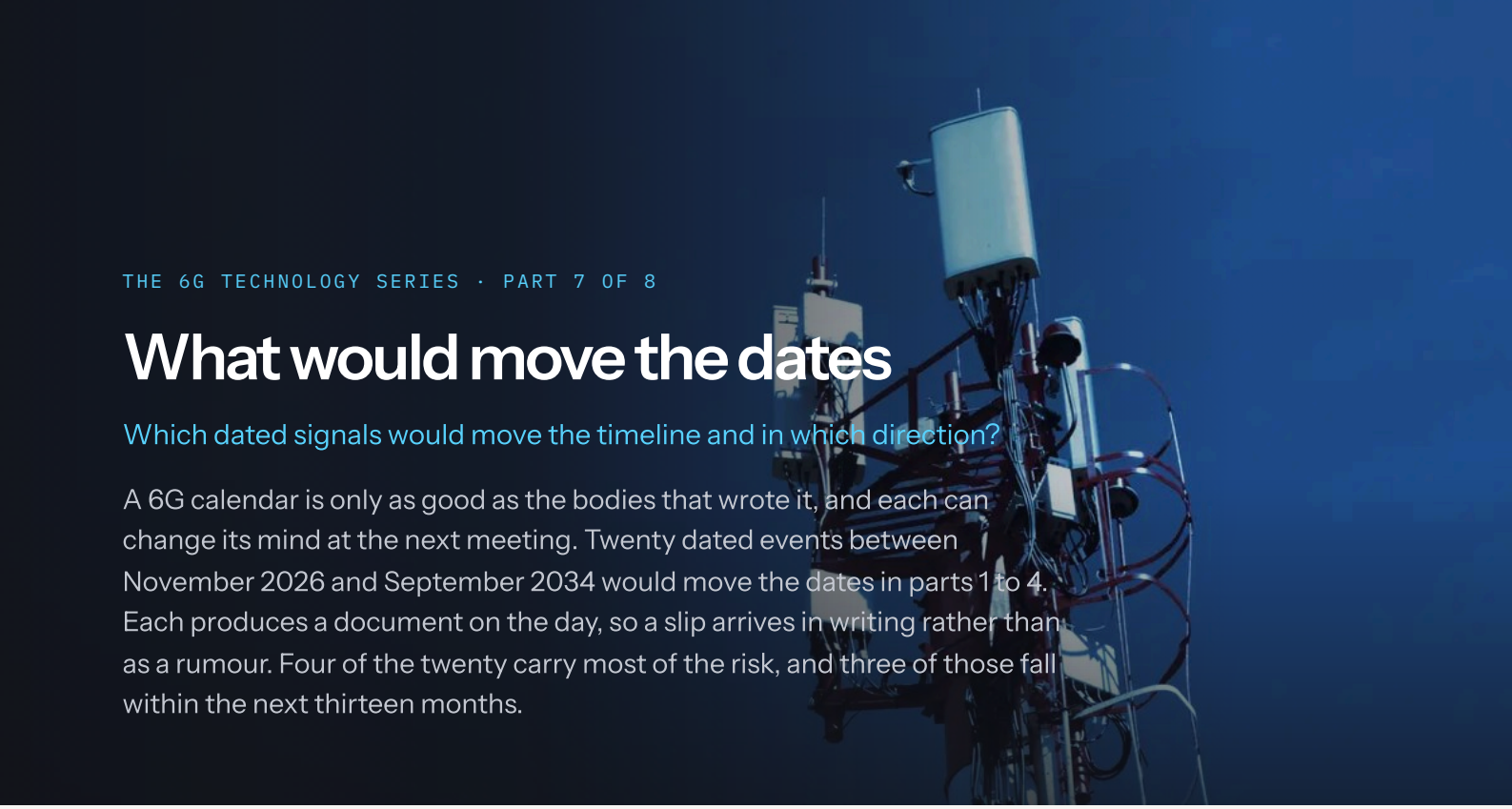
Each candidate is scored on three things only. The first is the release, meaning the earliest 3GPP release whose specifications define the capability, taken from part 3. The second is the band it needs, and whether that spectrum is licensed, dated or still under study, taken from part 2. The third is the device, meaning a commercial product an operator has publicly launched, taken from part 3 and from the direct-to-device series. The earliest revenue date is then the latest of the three. The capex, auction and cash figures in Exhibit 5 are the three national carriers' filed values from part 4. The months in Exhibit 4 are counted from the first published freeze date to the actual one, as part 1 records them.

WHAT IT DOES NOT SHOW

A table sorted by dependency shows when a capability can earn, not how much. Device availability is judged on published commercial launches, so a feature quietly in use somewhere will be placed later than it deserves. The upper C-band dates are the transition deadlines in the FCC's order, and the auction or the clearing could move them. The three 6G rows use the Release 21 date as 3GPP publishes it, without the margin part 1 argues for, so those rows are optimistic. Everything here is the record as it stood on 7 October 2026, and a plenary or a public notice can change it.

Data as of: the dates in parts 1 to 5, as read and checked 2 Oct 2026 · Method version 1.1.

Sources. Every figure in this part is carried from part 1, part 2, part 3, part 4 and part 5, each of which carries its primary and second sources, and from the direct-to-device series where noted. No new primary source is introduced.

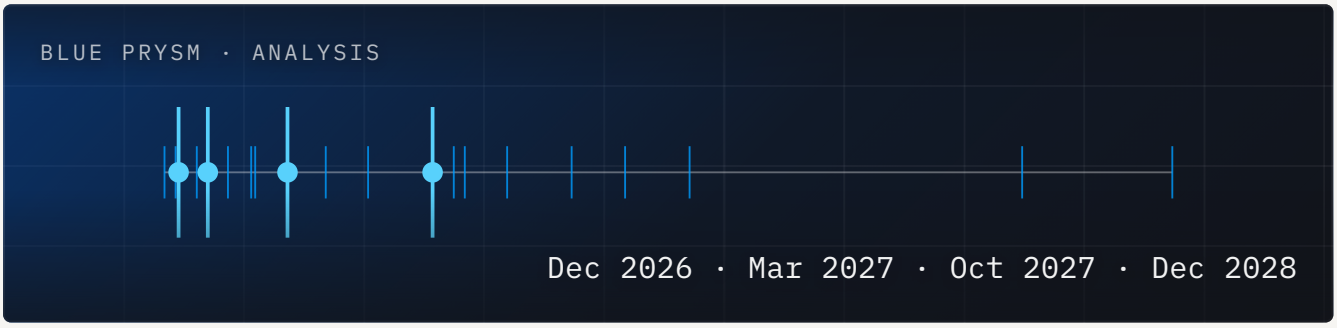


THE 6G TECHNOLOGY SERIES · PART 7 OF 8

What would move the dates

Which dated signals would move the timeline and in which direction?

A 6G calendar is only as good as the bodies that wrote it, and each can change its mind at the next meeting. Twenty dated events between November 2026 and September 2034 would move the dates in parts 1 to 4. Each produces a document on the day, so a slip arrives in writing rather than as a rumour. Four of the twenty carry most of the risk, and three of those fall within the next thirteen months.



IN BRIEF

- Twenty dated events between 30 November 2026 and 30 September 2034 decide whether the dates in parts 1 to 4 hold. Each is owned by a body that publishes what it decided, so a slip arrives as a document rather than as a rumour.
- Four of the twenty are hinges, because most of the rest depend on them. Two are 3GPP freezes, Release 20 in **March 2027** and Release 21 in **December 2028**. One is the pair of plenaries on **7 to 11 December 2026** that decide how a 5G network becomes a 6G one, and one is WRC-27, from **18 October to 12 November 2027**. Three of the four fall within thirteen months.
- There are only three ways the timeline can move. A standards slip moves it later, and only later, by three to nine months on the last cycle's form. A spectrum decision can move it either way, and the NTIA report of December 2026 and WRC-27 are the two to watch. A change in what the carriers can spend shows first in the FY2027 guidance of early 2028.
- The plan should be re-dated on the four hinge days and otherwise left alone, because nothing else on the list moves a date in it. The four belong in the board calendar now, each with the document it produces.

Three of the four hinges fall within thirteen months

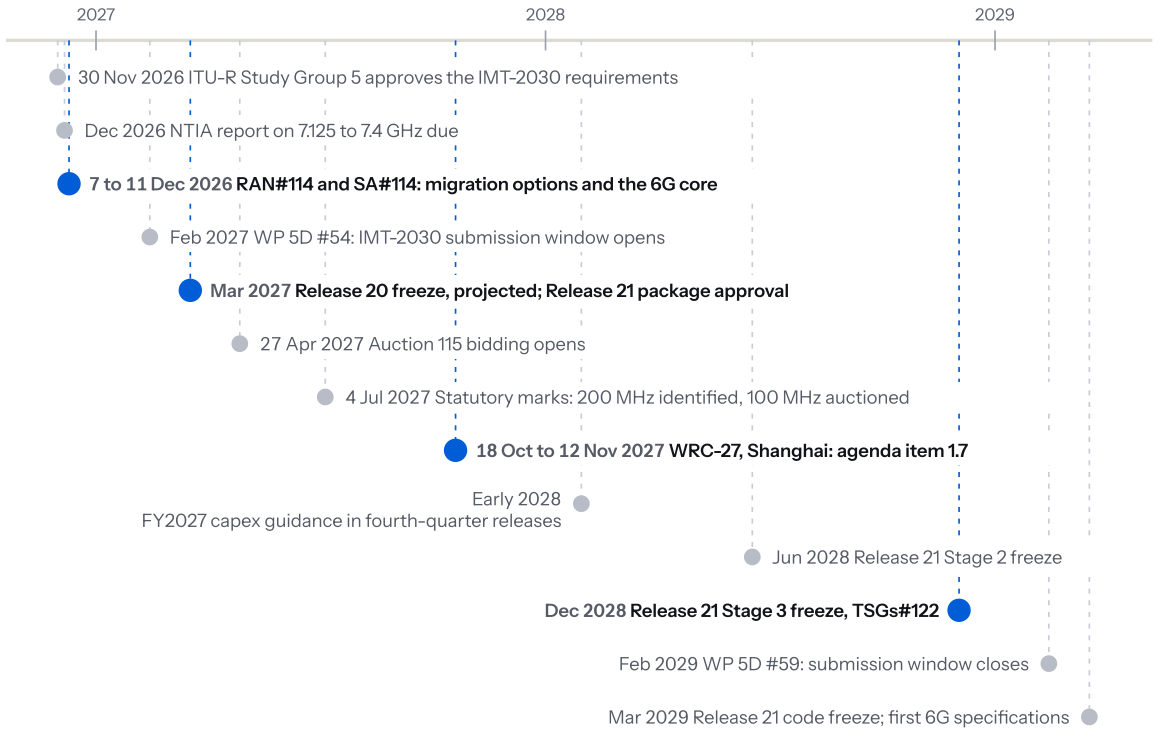
Every date on the list belongs to a body that publishes what happened on it, which makes watching cheap. Four dates carry most of the risk, because most of what comes later depends on them (Exhibit 1).

The first hinge is the pair of 3GPP plenaries in Boston on 7 to 11 December 2026. RAN#114 has to decide whether any migration path from 5G to 6G beyond spectrum sharing is allowed at all, a question RAN#112 and RAN#113 both left open. In the same week SA#114 receives the architecture decision on the 6G core that the SA plenary has told its working group to reach by November. The NTIA's report on 7.125 to 7.4 GHz, due twelve months after the memorandum of 19 December 2025, is also due in December.

The second is March 2027, when Release 20 is projected to freeze and the Release 21 package is approved, so a slip there is inherited by 6G before 6G has begun. The third is WRC-27 in Shanghai, from 18 October to 12 November 2027, which decides agenda item 1.7 and with it the spectrum. The fourth is the Release 21 Stage 3 freeze in December 2028 at TSGs#122. Counted from 7 October 2026, the four fall at two, five, twelve and twenty-six months. Most of the risk is concentrated in the first year.

EXHIBIT 1

The four hinges fall at two, five, twelve and twenty-six months, and the first shares its month with the NTIA report



Source: 3GPP Release 20 and Release 21 pages and the RAN#113 report; ITU IMT-2030 page and WRC-27 page; NSPM-8 (19 December 2025); FCC DA 26-769; P.L. 119-21 section 40002, as carried in parts 1, 2 and 8 (Compiled). Note: the four emphasised events are the hinges; 3GPP dates are its plan on 7 October 2026.

The twenty dates in order

The full list runs from an ITU-R Study Group 5 meeting at the end of November 2026 to the day the FCC's auction authority ends, 30 September 2034. Each row names the body that owns it, the document it produces and the part of the series whose table would change (Exhibit 2).

EXHIBIT 2

Ten of the twenty events are meetings with a report, seven are deadlines no plenary can move, and one is a vendor expectation

WHEN	WHAT	WHERE THE OUTCOME IS PUBLISHED	WHAT IT CHANGES
30 Nov to 1 Dec 2026	ITU-R Study Group 5 approves the IMT-2030 minimum requirements and evaluation guidelines	SG 5 meeting report; the published Report	Part 3: the draft requirements become the pass mark
Dec 2026	NTIA report on 7.125 to 7.4 GHz, due twelve months after NSPM-8	NTIA publication	Part 2: the American 7 GHz band gets a federal position, or a longer study
7 to 11 Dec 2026	RAN#114 and SA#114 decide the 5G-to-6G migration options beyond spectrum sharing, and the direction of the 6G core	3GPP plenary reports	**Part 8: whether 6G is a software upgrade or a hardware cycle; part 4's next capex**
Feb 2027	WP 5D #54: IMT-2030 submission window opens	WP 5D meeting report	Part 1: the ITU clock starts
Mar 2027	Release 20 functional freeze (projected), closing the 6G study; Release 21 package approval and Stage 1 freeze	3GPP SA#115 and RAN#115 reports	**Part 1: a slip here moves Release 21 before it has started**
27 Apr 2027	Auction 115, 160 MHz of upper C-band: bidding opens	FCC auction public notices	Part 4: the price sets the capacity bill
4 Jul 2027	Two-year statutory marks: 200 MHz identified by the NTIA, 100 MHz auctioned by the FCC	NTIA notice; FCC closing public notice	Part 2: the pipeline is or is not on schedule
Mid 2027	Early Release 21 architecture to WP 5D #55 as information	WP 5D contribution list	Part 1: 3GPP and the ITU-R are aligned, or not
18 Oct to 12 Nov 2027	WRC-27 decides agenda item 1.7	WRC-27 Final Acts	**Part 2: which of 4.4 to 4.8, 7.125 to 8.4 and 14.8 to 15.35 GHz is identified, and for which regions**
Early 2028	Carrier capex guidance following the auction	FY2027 Forms 10-K and fourth-quarter releases	Part 4: whether the 2022 pattern repeats
Jun 2028	Release 21 Stage 2 freeze, after an 80% checkpoint in March	3GPP plenary reports	Part 1: the architecture is fixed on time, or not
Dec 2028	Release 21 Stage 3 freeze (TSGs#122)	3GPP plenary reports; a news item if it moves	**Parts 1 and 6: every 6G revenue date**
Feb 2029	WP 5D #59: submission window closes	WP 5D meeting report	Part 1: the candidate set is fixed

Mar 2029	Release 21 ASN.1 and OpenAPI freeze; first 6G specifications	3GPP specification numbering	Part 6: the three Release 21 rows get a product clock
4 Jul 2029	Four-year statutory marks: 500 MHz identified, 200 MHz of it auctioned	NTIA and FCC records	Part 2: the second tranche exists
2029 to 2030	First commercial 6G systems, on the expectations of Qualcomm, Nokia and Ericsson	Vendor and operator announcements	Part 6: the 6G line starts, or does not
Mid 2030	IMT-2030 specifications, at the latest	Recommendation ITU-R M. [IMT-2030.SPECS]	Part 1: the ITU process completes
31 Dec 2030; 1 Jul 2031	Upper C-band terrestrial service may begin, top 75 areas then the rest; new devices must cover 3.70 to 4.14 GHz	FCC transition certifications; carrier notices	Part 6: the capacity row earns
4 Jul 2033	Eight-year statutory mark: the remaining identified federal spectrum auctioned	FCC closing public notices	Part 2: the 7 GHz band, if identified, is sold by here
30 Sep 2034	Auction authority ends; 300 MHz due	Statute	Part 2: the outer limit of the pipeline

Bold rows are the four on which the most later rows depend. A date marked projected or planned is 3GPP's current plan; the statutory and conference dates are fixed by law or treaty.

Source: parts 1 to 4 and 8 of this series, with the sources given there: 3GPP release pages and plenary reports; ITU IMT-2030 and WRC-27 pages; P.L. 119-21 section 40002; NSPM-8; FCC 26-46 and DA 26-769; Forms 10-K (Compiled).

The twenty sort by owner. Ten are meetings of 3GPP, the ITU-R or the conference, so the date is the meeting and the outcome is its report or its Final Acts. Seven are deadlines set by statute, by the December 2025 memorandum or by the FCC's order, which no plenary can move. The remaining three are softer: the ITU-R's mid-2030 target, the carriers' annual guidance and the vendors' expectation of first commercial systems. The last has no body behind it at all.

The timeline moves in only three ways

Whatever happens on the list moves the dates in one of three ways: the standard slips, a spectrum decision goes one way or the other, or the carriers change what they can spend. Each has a precedent, a document and a direction (Exhibit 3).

EXHIBIT 3

A standards slip moves dates later, a spectrum decision moves them either way, and a capex change moves the budget rather than the date

MECHANISM	EVENT TO WATCH	DOCUMENT ON THE DAY	DIRECTION AND PRECEDENT
Standards slip	Release 20 freeze, March 2027; Release 21 freeze, December 2028	3GPP release page, where projected becomes an actual date; a news item	Later only. Four 5G releases in five moved, by three, six, nine and three months
Spectrum decision	NTIA report, December 2026; WRC-27, October to November 2027	NTIA publication; WRC-27 Final Acts footnote naming regions and countries	Either way. An identification allows an auction by July 2033; no change moves the American 6G band question back to the C-band
Carrier spend	FY2027 capex guidance, early 2028, after Auction 115	Forms 10-K and fourth-quarter releases	The budget, not the date. In 2021 to 2022 spectrum came first and capex peaked the year after, at $56.7 billion

The 5G base rate is part 1's; the statutory auction deadline is part 2's; the capex peak is part 4's.

Source: 3GPP news items and releases page (part 1); NSPM-8, Resolution 256 and P.L. 119-21 section 40002 (part 2); Forms 10-K FY2019 to FY2025 (part 4) (Compiled).

A standards slip is the likeliest of the three and the easiest to see coming. Part 1 puts the base rate at three to nine months, in one direction only, announced at a plenary with a news item. The first event to watch is the March 2027 freeze of Release 20, because the 6G study has to close before the normative work can be scoped; a slip there is a slip in Release 21 before work on Release 21 has begun. The test is simple: the 3GPP release page shows a projected date today, and on the day it should show an actual one.

RELEASE 17: HOW A SLIP WAS ANNOUNCED

When 3GPP scoped Release 17, it set the Stage 3 freeze for June 2021.

At the electronic plenaries of March 2020 it moved the date to September 2021, and gave the move to electronic meetings as the reason.

In December 2020 it moved the date again, to March 2022, with a protocol coding freeze in June 2022. The news item announcing the new timeline is dated 14 December 2020.

Release 17 froze on 18 March 2022 at SA#95-e, nine months after the date it had been scoped to. Each move was a plenary decision, each produced a news item, and the trade press recorded the plan each one replaced. A slip is announced in public, and no analyst is needed to spot one.

A spectrum decision is the one move that can go either way, and it arrives in two documents about a year apart. The first is the NTIA's report on 7.125 to 7.4 GHz, due in December 2026 under the December 2025 memorandum, which either identifies the band for reallocation or explains why it cannot. The second is

WRC-27, whose Final Acts say whether 7.125 to 7.4 GHz, or more, or nothing, is identified, and for which regions. An identification does not put American spectrum on sale; it allows the NTIA and the FCC to sell it, under a statute that excludes 7.4 to 8.4 GHz and sets July 2033 as the deadline for the federal spectrum.

Either outcome lands in one row of part 6. If the conference does what the carriers asked for in February 2026 and identifies 7.125 to 7.45 GHz, the 7 GHz row stays at 2030 onward. If it does nothing, the question of an American 6G band goes back to the C-band and the upper C-band, which are 5G bands served by 5G radios.

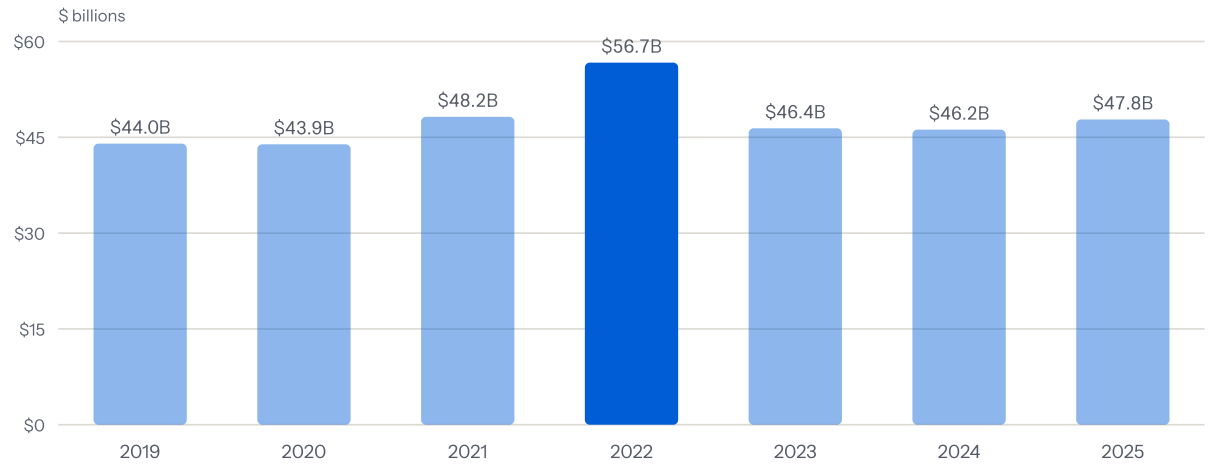
Carrier spending is the slowest signal

The three national carriers file their capital expenditure every year under a machine-readable tag, so the shape of the last cycle is on the record without any estimate of ours (Exhibit 4).

The last cycle had a simple shape. The carriers bought spectrum in 2021, their capex peaked in 2022, and it was back near the base within three years. In money, the three spent $44.0 billion in 2019, $56.7 billion at the 2022 peak, the year after the C-band auction, and $47.8 billion in 2025. The equivalent signal for the next cycle is the FY2027 capex guidance, published in early 2028 once the upper C-band has been bought. If it rises the way 2022 did, the budget for 2028 to 2030 is committed to mid-band capacity on existing radios, right through the Release 21 freeze. The 6G build then has to compete for whatever comes after.

EXHIBIT 4

Combined capex peaked at $56.7 billion in 2022, the year after the C-band auction, and returned to within $4 billion of its 2019 level by 2025



Source: Forms 10-K, FY2019 to FY2025, consolidated statements of cash flows, as tabulated in part 4 (Filed); sums of the unrounded filed values (Calculated). Note: the three carriers bid $78.2 billion in the C-band auction that closed in February 2021; the Sprint merger closed on 1 April 2020.

Two numbers from part 4 show how much room there is. After capex and dividends, the three carriers had $33.8 billion left between them in FY2025. At the two recent mid-band prices, the 160 MHz on offer in Auction 115 would cost $36.0 billion to $46.4 billion, which is more than the whole of that surplus. The

auction closes in 2027, and the FY2027 releases of early 2028 are the first filings that will show what the carriers mean to spend around it.

Each outcome changes one table in one part

Watching the list costs little, because the bodies that own the dates publish what they did. Someone reads the document on the day, and the change is then a single edit to a single table (Exhibit 5).

EXHIBIT 5

Each of the eight nearest events changes the tables of one or two parts and leaves the rest alone

● Changes a table in that part ○ No change

	Part 1	Part 2	Part 3	Part 4	Part 6	Part 8
SG 5 approval, 30 Nov 2026	○	○	●	○	○	○
NTIA 7 GHz report, Dec 2026	○	●	○	○	●	○
RAN#114 and SA#114, Dec 2026	○	○	○	●	○	●
Release 20 freeze, Mar 2027	●	○	○	○	●	○
Auction 115 result, 2027	○	○	○	●	○	○
WRC-27 Final Acts, Nov 2027	○	●	○	○	●	○
FY2027 capex guidance, early 2028	○	○	○	●	○	○
Release 21 freeze, Dec 2028	●	○	○	○	●	○

Source: the watch-list in Exhibit 2 and the tables of parts 1, 2, 3, 4, 6 and 8 (Compiled). Note: part 1 is the standards calendar, part 2 the spectrum pipeline, part 3 the capabilities, part 4 the cost of a cycle, part 6 the bets and part 8 the features.

Six kinds of document carry all twenty outcomes, and none needs an analyst to interpret it.

1. **A 3GPP release page.** It shows the word projected beside a freeze date until the freeze happens, then the actual date. Compare the two on the day.
2. **A WP 5D meeting report.** It lists what was received, so it shows whether the IMT-2030 window opened in February 2027 and closed in February 2029 with 3GPP's submission inside it.
3. **A Final Acts footnote.** It names the regions and countries that took an identification at WRC-27, and so settles the ranges in part 2.
4. **An FCC public notice.** It closes an auction with a gross total and a list of winners, and so settles the price in part 4.

5. **An NTIA report.** It names a band for reallocation or it does not, and either way it settles the federal position on 7.125 to 7.4 GHz.
6. **A Form 10-K.** It states the coming year's capex guidance in a sentence, and so shows whether the 2022 pattern repeats.

The edits are just as contained. A migration decision in December 2026 changes part 8's map and part 4's cycle. A Release 21 slip changes the dates in parts 1 and 6 and touches nothing else. A WRC-27 outcome changes the ranges in part 2 and the 7 GHz row in part 6, and an auction result changes the price in part 4. The IMT-2030 requirements, once approved, replace the draft figures in part 3. Nothing on the list rewrites the series.

Terms used

- **Plenary.** A numbered decision meeting of one of 3GPP's technical specification groups: RAN#114 is the 114th meeting of the radio group, SA#114 the 114th of the architecture group. The plenary approves work items, freezes releases and publishes a report.
- **Projected.** The word 3GPP's release page uses for a freeze date it plans and has not reached. The page replaces it with the actual date when the freeze happens.
- **WP 5D.** Working Party 5D, the ITU-R group that writes the IMT-2030 requirements and receives candidate technologies. Its meetings are numbered; the submission window runs from #54 in February 2027 to #59 in February 2029.
- **Final Acts.** The treaty text a World Radiocommunication Conference adopts. Its footnotes to the Radio Regulations name the regions and countries that take an identification.
- **Identification.** What a conference gives a band when it marks it for IMT in the Radio Regulations. It is permission for administrations to use the band for mobile under agreed conditions; it is not an allocation to any carrier and not a sale.

Implications

CARRIER STRATEGIST	Put the four hinge dates in the board calendar now, with the document each one produces, and re-date the plan on each of them. The first falls in the second week of December 2026, two months away. Between those days leave the plan alone, because nothing else on the list moves a date in it.
INVESTOR	Treat the December 2026 plenaries as the first test of the capex thesis, because they decide whether the next cycle is a software number or a hardware one. A 6G position taken before March 2027 is a position on whether a projected date becomes an actual one, and the base rate says later, by three to nine months.
VENDOR	Name these twenty dates in your roadmap and say which row of it moves on each, because a customer who has read the calendar will ask. A date that matches a numbered 3GPP meeting will be believed. A date that runs ahead of one will be read against it.

Method and limits

HOW THIS WAS BUILT

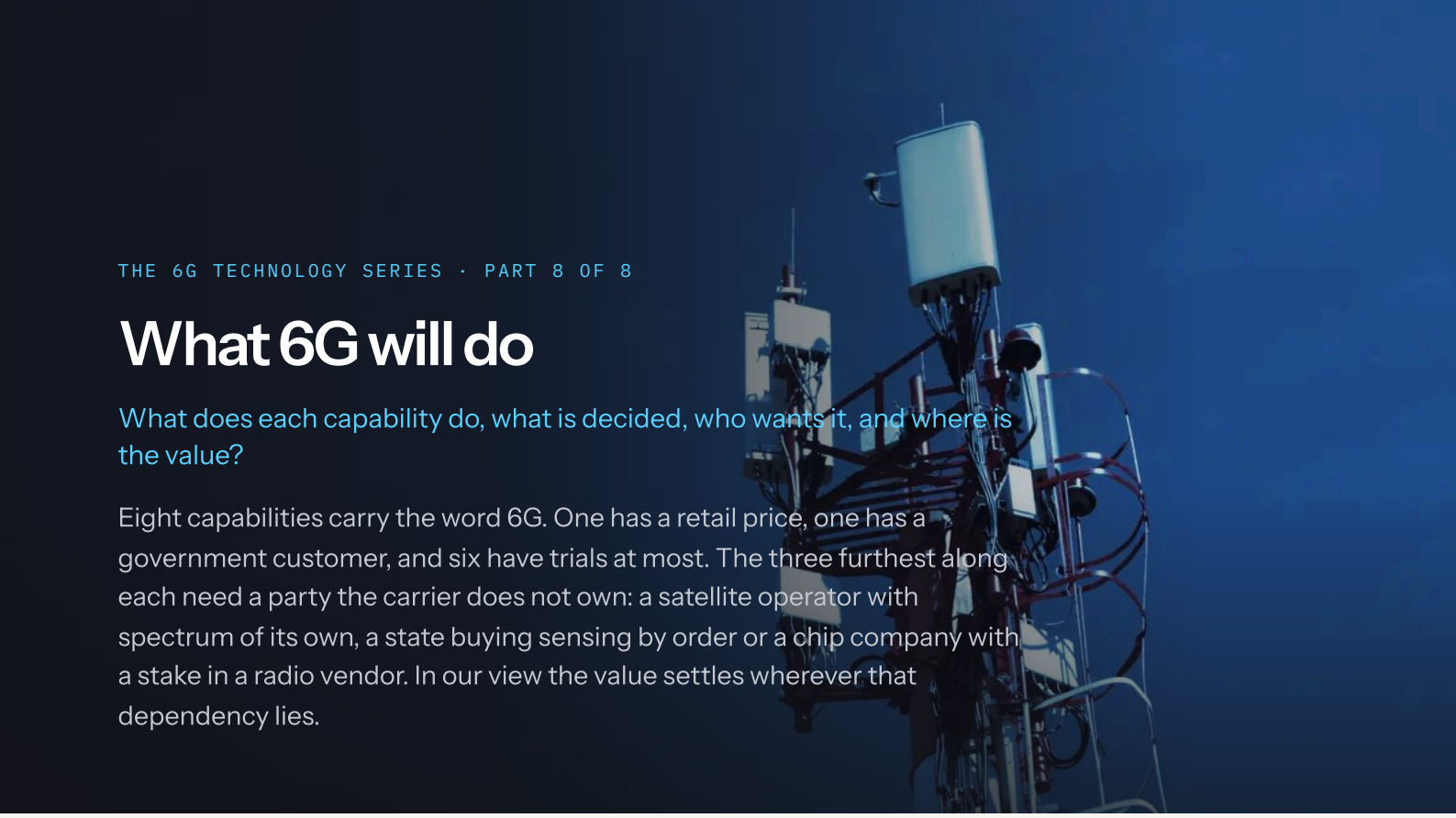
The watch-list is every dated event in parts 1 to 4 and 8 that a third party could observe, placed in order with the document that records each outcome and the part whose table it would change. An event is a hinge when the most later events depend on it; there are four. The capex series in Exhibit 4 is the three national carriers' filed capital expenditure from part 4, summed from the unrounded values. The months to each hinge are counted from 7 October 2026.

WHAT IT DOES NOT SHOW

The list holds only events that are scheduled, required or published as a plan. It has no room for a new statute, a merger or a vendor leaving the market, and any of those would move the dates as surely as a plenary. Where a direction is given, it is what each outcome would do to the dates in parts 1 to 8, which is not the same as predicting which outcome will occur. A 3GPP plan is a membership decision that the next plenary can revise, so every date marked projected or planned is the plan as it stood on 7 October 2026.

Data as of: the dates in parts 1 to 4 and 8, as read and checked 2 Oct 2026 · Method version 1.1.

Sources. Every date is carried from part 1, part 2, part 3, part 4 and part 8, with their primary and second sources. No new primary source is introduced.

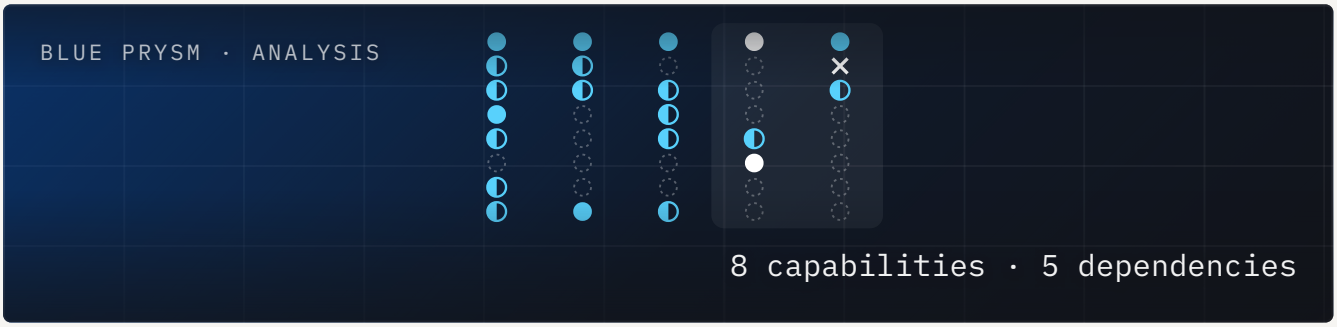


THE 6G TECHNOLOGY SERIES · PART 8 OF 8

What 6G will do

What does each capability do, what is decided, who wants it, and where is the value?

Eight capabilities carry the word 6G. One has a retail price, one has a government customer, and six have trials at most. The three furthest along each need a party the carrier does not own: a satellite operator with spectrum of its own, a state buying sensing by order or a chip company with a stake in a radio vendor. In our view the value settles wherever that dependency lies.



IN BRIEF

- Of the eight capabilities on every 6G roadmap, one has a retail price: T-Mobile sells satellite messaging at **$10 a month** and says satellite is 0.0002% of its network usage. One has a paying customer, and it is a state: China Mobile had more than 500 sensing base stations by April 2025. The other six have trials at most.
- 3GPP has decided that 6G runs on OFDM, stands alone, shares spectrum with 5G from one radio, stops at 52.6 GHz and must work without AI. It has not decided how a 5G phone becomes a 6G one or what the core looks like, and both are due at the plenaries of **7 to 11 December 2026**.
- The three capabilities furthest along each depend on a party outside the carrier. A satellite operator now owns **$19.6 billion** of spectrum, a government buys sensing by order, and a chip company paid $1.0 billion for 2.9% of a radio vendor.
- The operators have written down four demands: no forced hardware refresh, spectrum sharing as the only baseline, an evolved core they control, and a business case before capex. The vendors agree with three in public and have not named the radios that satisfy the first.

Three of the eight capabilities depend on a party outside the carrier

Part 6 sorted the candidates by a release, a band and a device, which was enough for 5G. Three of the eight capabilities called 6G also need a partner the carrier does not own, or a permission no carrier can grant itself (Exhibit 1).

The eight appear in 3GPP's study description and in every vendor's 6G paper. They are satellites built into the standard, sensing, a new band around 7 GHz, three different things called AI, energy, and the migration from 5G with the core it lands on. Each is scored on five dependencies rather than three, and a cross marks one that is needed, unresolved and assigned to no one.

EXHIBIT 1

Three of the eight capabilities need a partner or a permission the carrier does not control, and those three are the furthest along

				Outside the carrier	
	Release	Band	Device	Partner	Permission
Satellites in the standard	●	●	●	●	●
Sensing	◐	◐	○	○	✕
7 GHz band	◐	◐	◐	○	◐
AI in the radio (one-sided)	●	○	◐	○	○
AI across the link (two-sided)	◐	○	◐	◐	○
AI-RAN compute	○	○	○	●	○
Energy	◐	○	○	○	○
Migration and core	◐	●	◐	○	○

● exists or dated ◐ in progress, meeting set ○ not needed
● needs a partner outside the carrier ✕ needed, unresolved, nobody's

Source: 3GPP TR 38.914, RP-251881, RP-261566 and RP-251870; the RAN#113 and SA#113 reports of September 2026; price pages and releases as cited below (Compiled). Note: scored as of 2 October 2026.

The map inverts the roadmaps. The capabilities furthest along lean on someone else, while the two the operators argue hardest about, energy and the migration, are wholly inside their own fence, because those two decide the next capital cycle.

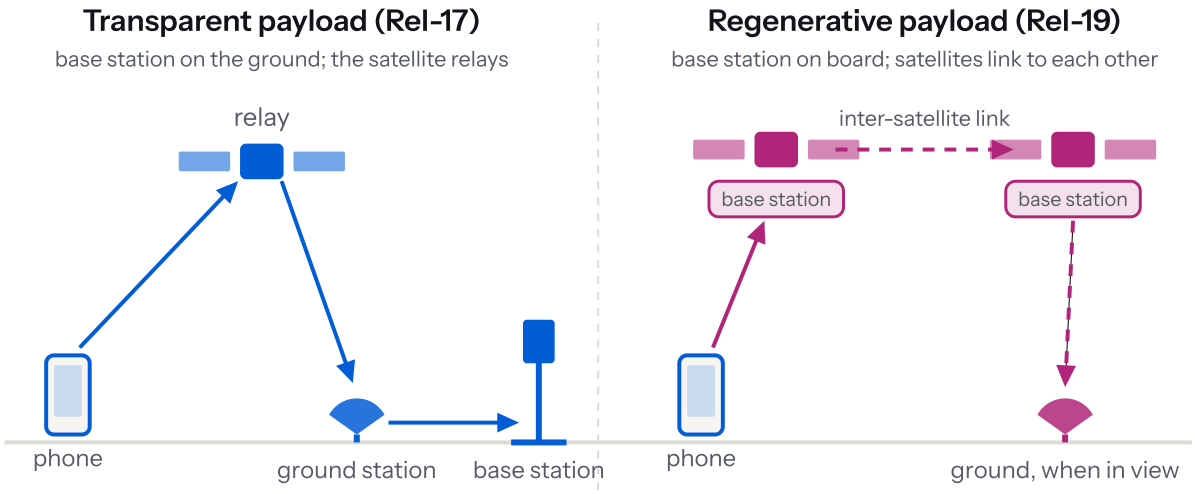
Satellite service is the only capability with a retail price

Where there is no tower, a phone can keep working by talking to a satellite as if the satellite were one. Whether that is simple or hard depends on where the base station is, on the ground or in orbit, and the standard allows both (Exhibit 2).

A mobile base station is a radio and a computer, and the question is which goes up. In the Release 17 design the computer stays on the ground and the satellite only relays the phone's signal to a ground station; 3GPP calls that a transparent payload. In the Release 19 design, RP-240775, the whole base station is on board, which 3GPP calls regenerative. It costs more, and it is the only one that works when no ground station is in view, which over an ocean is most of the time. Either way, the orbit sets the delay.

EXHIBIT 2

The satellite relays in Release 17 and hosts the base station in Release 19, and the orbit sets the delay either way



One-way delay, calculated

Low orbit at 550 km: 1.8 ms overhead, 3.8 ms at 25° above the horizon
Geostationary at 35,786 km: 119 ms

Source: 3GPP TR 38.821 and RP-240775 (March 2024) (Filed). Delays are distance divided by the speed of light; the 25° slant range is 1,123 km (Calculated).

For 6G, 3GPP has decided that the satellite is part of the design from the first release. The study description, RP-251881, tells the working groups to aim at a harmonised radio design for terrestrial and non-terrestrial networks. Still open are unpaired satellite spectrum, operation without satellite positioning and the core's satellite principles.

T-Mobile priced T-Satellite at $10 a month at its launch on 23 July 2025, and in July 2026 told investors that satellite accounts for 0.0002% of its network usage. Rogers charges C$15 a month, One NZ folds texting

into its plans, and Verizon gives texting away. No American carrier has disclosed satellite revenue or a take-rate.

The larger sums are elsewhere. Apple committed up to $1.1 billion to Globalstar for 85% of its network capacity. SpaceX did not wait for 3GPP; by independent measurement its satellites fly conventional LTE base stations with proprietary adaptations. In September and November 2025 it agreed to buy EchoStar's spectrum, $19.6 billion in all, to build next-generation satellites with what its president called a step change in performance. By mid-2026 it was reported to be considering a retail mobile service of its own, and on 8 October 2026 it agreed to buy a second position, up to 14 MHz of paired low band at 800 MHz from Grain Management, at a price neither party has stated, saying it would deploy "both satellite and terrestrial spectrum" under the Starlink Mobile name (SpaceX update; see direct-to-device part 4).

> Satellite service is the only 6G capability with a retail price, and the price is for coverage insurance. In our view the native design is a commercial move as much as a technical one: it keeps the subscription with the carrier and makes the satellite operator a supplier. Every vendor and every operator that has spoken supports it. The party with $19.6 billion of mid band, and since October 2026 a low-band position beside it, has not spoken.

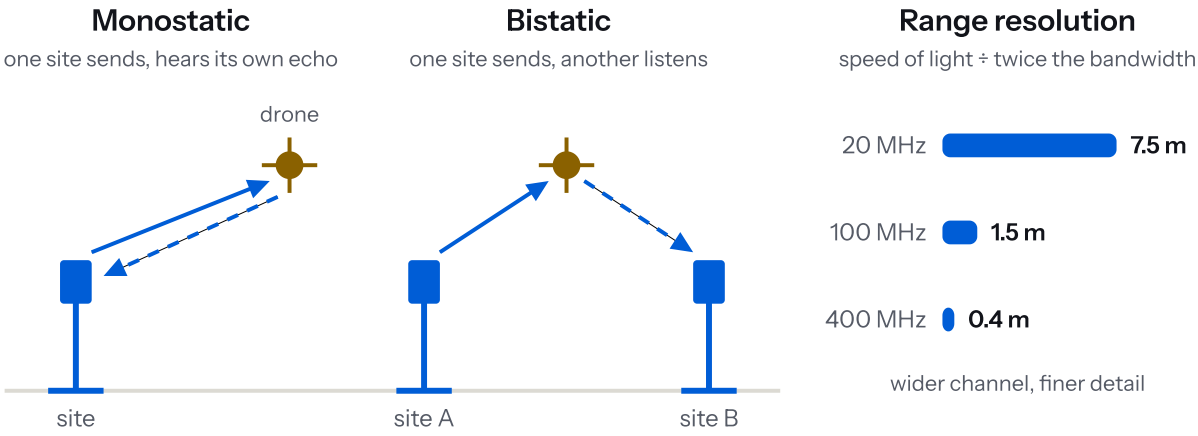
Sensing has a government customer and no permission from any regulator

The signals that carry calls also bounce off things that are not phones, so a network that listens for echoes can detect a drone or count a crowd. That is radar, and the standard has so far specified only its simplest form (Exhibit 3).

Distance comes from the delay of the echo and speed from its frequency shift, and finer detail needs a wider signal. A 20 MHz channel separates objects about 7.5 metres apart; 400 MHz gets down to 40 centimetres, which is why sensing is tied to the wide channels of part 2. In monostatic sensing one base station listens for its own echo. In bistatic sensing a second site listens, which lets ordinary sites act as one large radar; the AT&T and Ericsson demonstration outside a stadium in July 2026 tracked drones at 300 to 400 feet that way.

EXHIBIT 3

Release 20 specifies base-station monostatic sensing for drones only, and channel width sets the detail a network can resolve



Specified so far (Release 20, RP-261566)
Base-station monostatic sensing, drones only, no change to phones.
Required of 6G: drones, people, vehicles and AGVs; the modes and signals are open.

Source: 3GPP RP-240799; RP-261566 (RAN#112, 11 June 2026) and TS 23.137; TR 38.914 (Filed). Resolution is the speed of light over twice the bandwidth (Calculated).

What 3GPP has written down is narrower than the demonstrations. The first normative work item, RP-261566, approved at RAN#112 on 11 June 2026, specifies base-station monostatic sensing for drone detection only, with no impact on devices. For 6G, TR 38.914 requires detection and tracking of drones, people, vehicles and automated guided vehicles. Still open are the waveform, the reference signals, who operates the sensing function and who may see its output.

The vendors agree on the headline and split on the physics. Samsung's trial with Verizon in Dallas in September 2026 drew crowd-density maps from ordinary phones over 40 MHz of CBRS, and Ericsson expects defence and public safety users first. On the waveform, Samsung says "OFDM already provides strong sensing capabilities" and Ericsson does not think a new one is needed. A United States Department of Defense programme lead said OFDM is not optimal for sensing. 3GPP's decision to keep OFDM settles the question for Release 21. The defence buyer, if it wants better, will have to buy something else.

So far the paying customer is the state. Outside China every sensing deployment is a trial. Inside China, China Mobile had more than 500 sensing-capable base stations on 42 low-altitude routes by April 2025, and in February 2026 the ministry ordered the operators to track drones below 300 metres in ten pilot cities. Verizon's chief technology officer said in September 2026 that businesses that saw its drone-detection work would be glad to pay for it. Lockheed Martin plans a drone-detection service on Verizon's network for 2027. Those buyers buy by tender, with a specification, a liability clause and a multi-year term, against the dedicated radar they use today.

> Sensing has the clearest first customer and the least clear permission. Because the customer is the state, sensing is a procurement business, and no regulator has yet said whether a licence to carry traffic is a licence to watch. 3GPP has left the phone out of sensing for now, which keeps the market smaller than the demonstrations imply. Our integrated sensing series takes the cost and the buyers further in part 5.

The terahertz ambition has given way to a 7 GHz band

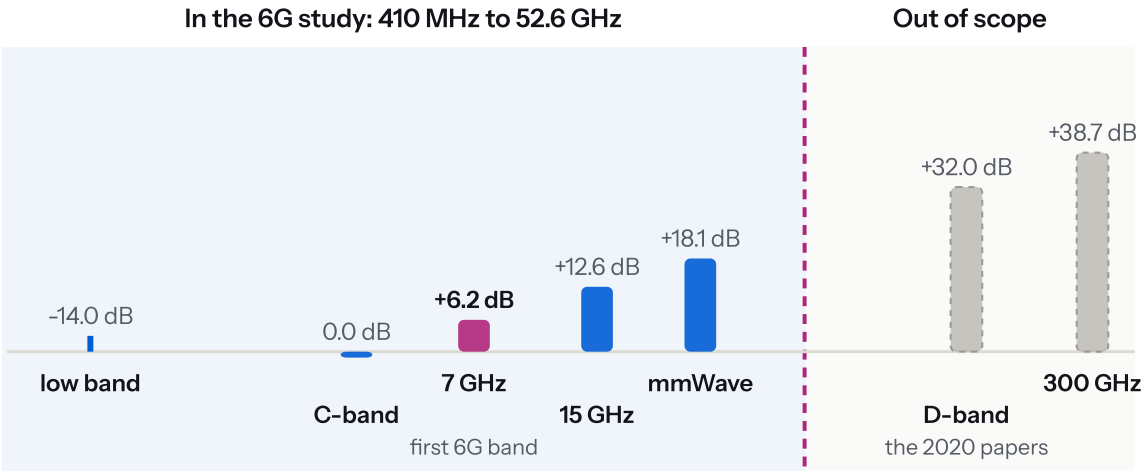
The new band adds capacity by using spectrum not previously used for mobile, around 7 GHz, in channels two to four times wider than today's. Higher frequencies lose more signal, and the industry has moved its ambition from frequency to antennas (Exhibit 4).

The loss between a tower and a phone rises with the square of the frequency, as part 2 sets out, so doubling the frequency costs about 6 dB. Against the 3.5 GHz the 5G build was priced on, 7.125 GHz costs 6.2 dB and 15.35 GHz costs 12.8 dB. The D-band at 140 GHz, which the first 6G papers were written around, costs 32 dB. The remedy is an antenna that is larger in wavelengths, which narrows the beam. A typical 5G panel has 64 transceivers behind 192 elements; the 7 GHz prototypes of 2026 have 256 ports behind 1,024, more than five times the elements. 3GPP has drawn its line at 52.6 GHz, and sub-terahertz was never proposed.

EXHIBIT 4

The first 6G band costs 6 dB against the C-band; the terahertz bands of the 2020 papers cost 32 dB and are out of scope

Frequency, logarithmic. Bars: extra free-space loss against 3.5 GHz, 20 log(f/3.5).



The antenna answer: 64 transceivers and 192 elements at 3.5 GHz; 256 ports and 1,024 elements in the 7 GHz prototypes of 2026. Sub-terahertz, 90 to 300 GHz, was never proposed for the study.

Source: 3GPP RP-251881 and TR 38.914; Rec. ITU-R P.525-5, loss calculated as 20 log(f/3.5); Samsung, Qualcomm and ZTE releases of 2026 for the antenna counts (Filed and Calculated).

The retreat can be measured, and Samsung recorded both ends of it. Its 2020 white paper called terahertz inevitable and set a peak rate of 1,000 gigabits a second. In February 2026 the same company called 7 GHz X-MIMO a core 6G technology and reported a peak of 3 gigabits a second outdoors with KT in Seoul. The draft minimum requirement in part 3 is 36 gigabits a second in 600 MHz, a twenty-eighth of the 2020 figure. No vendor has said it was wrong about terahertz; the 2026 papers leave it out. For a carrier, one claim matters more than any peak rate: Ericsson's head of networks says 6 and 7 GHz can be matched in the downlink from the existing 3.5 GHz grid, and no operator has confirmed it.

- **For the band.** All seven equipment and chip vendors; GSMA, for up to three times today's spectrum; NGMN, for 6 to 15 GHz. The European regulators' group names 540 MHz of upper 6 GHz as the primary 6G band by 2030, and the American executive branch backs 7.125 to 7.4 GHz.
- **Against it, or sharing it.** Apple, Broadcom, the cable industry and the Wi-Fi industry on 6 and 7 GHz, with NCTA citing Wi-Fi "carrying nearly 90% of mobile data". Ofcom shares upper 6 GHz between Wi-Fi and mobile and supports only 7.125 to 7.25 GHz at WRC-27. Aviation opposes 4.4 to 4.8 GHz.
- **Paying today.** No one pays for 7 GHz. For mid-band capacity in general, 8.45 million T-Mobile 5G broadband customers and 6.2 million Verizon fixed wireless subscribers pay $35 to $70 a month.

> The first 6G band costs 6 dB and a thousand-element antenna, a price the industry can pay where 32 dB was not. Whether it is cheap depends on one unconfirmed claim, that it fits the existing site grid, and whether it is available depends on regulators who have given the same frequencies to Wi-Fi in the United States and split them in Britain.

The standard needs none of the three things called AI

The phrase AI-native covers three different things. One uses a trained model to run part of the radio better. The second puts half a model in the phone and half in the network, and the third replaces the radio's computer with a graphics processor. They have different owners, different standards and different critics (Exhibit 5).

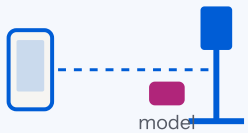
The first is settled and small. Release 19's work item, RP-240774, made normative a framework for one-sided models, which live wholly in the phone or the network. The second is the hard one. A phone describes the radio channel to the network in compressed form. A two-sided model puts the compressor in the phone and the decompressor in the base station, and the two halves have to be trained together, so a phone from one company and a base station from another must share a trained model. The Release 20 work item, RP-251870, lists three ways: a fully specified reference model, a standardised encoder structure with parameters exchanged, or a standardised dataset format. The third, running the base station's signal processing on graphics processors, is not a 3GPP matter.

EXHIBIT 5

Three different things are called AI, and 3GPP has decided that 6G must also work without any of them

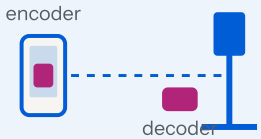
AI in the radio: one-sided

A model lives wholly in the phone or wholly in the network. Rel-19 normative: beam prediction, positioning. Everyone agrees.



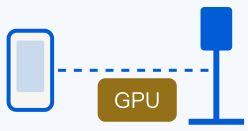
AI across the link: two-sided

Half the model in the phone, half in the base station, trained together. Rel-20 work item; three interoperability routes still open. Qualcomm for; Ericsson cool.



AI as the radio's computer: AI-RAN

The base station's software runs on general-purpose GPUs. Not a 3GPP matter. Nokia, NVIDIA and SoftBank for; Ericsson, Samsung and most operators against, on cost.



Decided (RP-251881): the 6G System can also operate without AI/ML

Source: 3GPP RP-240774 (Release 19), RP-251870 (Release 20) and RP-251881 (6G study); vendor and operator statements as cited in the text (Filed and Reported).

The 6G study's own decision is a sentence the marketing never quotes: the 6G radio and RAN design shall ensure that the 6G system can also operate without AI/ML. AI is therefore optional by design, and "AI-native" describes products built on it. The claims continue regardless. Nokia Bell Labs says a learning radio could set up bespoke waveforms, constellations and pilot signals. Its trial with NTT DOCOMO and SK Telecom at 4.8 GHz in November 2025 reported throughput gains of up to 100%. Qualcomm says 6G will be the first AI-native wireless system. Ericsson's researchers say a non-AI fallback will always be there and that one-sided uses should come first.

The third dispute is about money and microseconds. NVIDIA paid $1.0 billion for 2.9% of Nokia at $6.01 a share, and Nokia claims 1.5 times the capacity and twice the spectral efficiency on its own testing, with a commercial release in 2027. Ericsson says GPUs are one option for 6G and AI RAN and not the only one. Its technical objection is that a million-parameter model cannot run in the 500 microseconds a base station has to process each slot. Samsung does not believe GPUs are a prerequisite for 6G. Verizon's chief technology officer said that if you divide performance by cost, one day it makes sense, and today it does not. Light Reading reports one GPU card at 300 W against one custom accelerator at 40 W, more than seven times the power.

> The standard has answered the question the slogans ask. 6G must work without AI, so AI-native is a property of products rather than of the specification. The decision to watch is the two-sided model, because 3GPP's three routes are three answers to who pays for the training and who owns the result. The GPU argument lies outside the standard and inside the capex line of part 4.

Energy is the condition every operator has put on buying anything else

Energy is a condition of sale rather than a feature a customer sees. A network spends most of its life nearly idle, and the saving on offer is in what it does then (Exhibit 6).

The operators have said the same thing for three years. NGMN's 2023 position statement asks for absolute energy reduction, and Orange lists energy efficiency as a core requirement of 6G. The filings explain why. Vodafone used 6,006 GWh in its 2025 financial year, and 94% of it went on networks and technology centres.

EXHIBIT 6

Operators use thousands of gigawatt-hours a year, vendors promise savings on idle capacity, and 3GPP has fixed a method rather than a number

WHO	WHAT THE RECORD SAYS	BASIS
Vodafone	6,006 GWh in FY2025; 94% in networks and technology centres	ESG methodology 2025
Telefónica	4,993 GWh in 2025	ESG data book 2025
AT&T	15.0 million MWh of energy in 2025, 12.9 million of it electricity	Corporate responsibility KPIs
BT	Nearly 1% of UK electricity; over 90% of it in networks	Company newsroom
Ericsson	Idle energy cut by a factor of four against 5G by stretching the beacon interval from 20 to 160 ms	Live networks at about 20% utilisation on 4G and 6% on 5G; white papers of 2024 and 2026
Nokia	Average power halved while supporting ten times the peak capacity	November 2022; no stated basis
3GPP TR 38.914	Efficiency defined relative to a fully loaded reference case; evaluated at zero load and at one load below 30%; no numeric target	Approved June 2026; evaluated against 5G NR

Operator figures are as each company reports them and are not on one definition.

Source: Vodafone, Telefónica, AT&T and BT as named in the table; Ericsson white papers of 6 November 2024 and 12 June 2026; Nokia blog, 1 November 2022; 3GPP TR 38.914 section 5.1.15 (Filed and Published).

> Energy is the only one of the eight on which operators and vendors say the same thing, and the only one on which the standard has fixed a method rather than a figure. The vendors' savings, however, are savings on capacity a 5G site is not using, which at 6% utilisation is most of it. None of them says what a loaded 6G site will draw.

The December 2026 migration decision is the capex decision

A 5G phone, a 5G site and a 5G core have to reach 6G without a second network, and how they get there is the most argued question in 3GPP this year. It comes to a head at the two plenaries of 7 to 11 December 2026, the first hinge on the watch-list in part 7 (Exhibit 7).

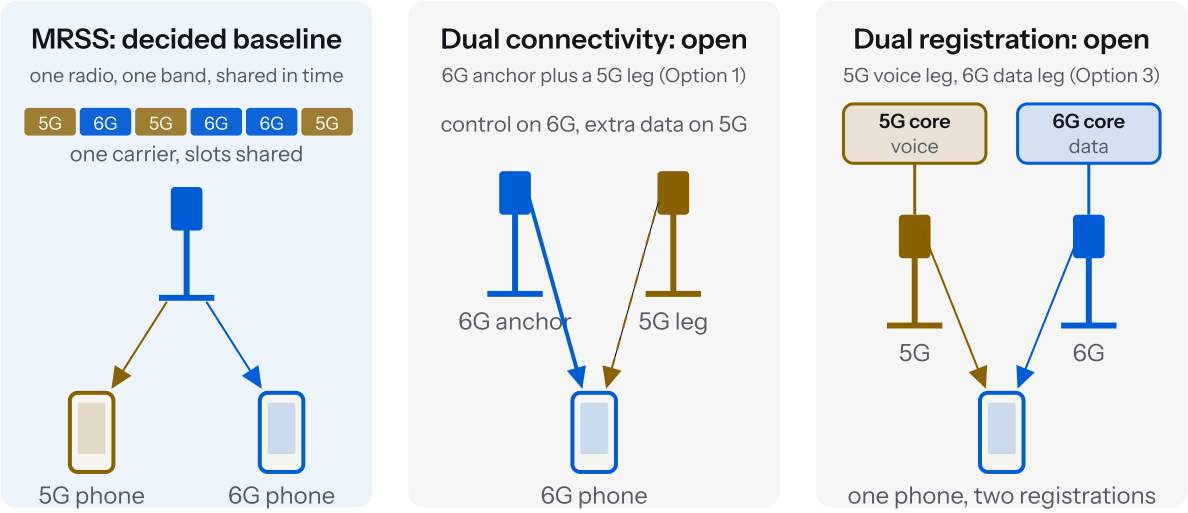
The decided part is that 6G stands alone. TR 38.914 requires a standalone RAN architecture and, in the baseline, no aggregation of any kind between 5G and 6G, the opposite of how 5G launched on its 4G anchor. What makes standalone affordable is multi-RAT spectrum sharing, MRSS. One carrier in a band the

operator holds is served to 5G and 6G phones from one radio, so 6G can start before any new band is bought. RAN#113 added that the two must share the downlink control channel efficiently, because two separate control channels in a 10 MHz carrier cost over 14% and up to 23% in overhead.

The open part is whether anything beyond MRSS is allowed. The options are a 6G-anchored dual connectivity that adds a 5G leg, a 5G-anchored one, and a dual registration that splits 5G voice from 6G data. RAN#113 postponed the question to RAN#114 on 7 to 11 December 2026 and asked the architecture group to rule on dual registration by SA#114 the same week. The core has a deadline of its own. The SA plenary set SA2#178 in November as the last date for an architecture decision, and its chair minuted that the timeline would be in danger without one.

EXHIBIT 7

Spectrum sharing from one radio is the decided path from 5G to 6G, and the two alternatives wait on the plenaries of 7 to 11 December 2026



Decision: RAN#114 and SA#114, 7 to 11 December 2026

NGMN: MRSS only · 12 operators at RAN#113: Option 1 at most · Deutsche Telekom: none of the options

Source: 3GPP TR 38.914 and RP-262262 (RAN#113, 17 September 2026); NGMN guidance of 8 September 2026; 6G Futures on RAN#113 (Filed and Reported).

Here the operators have written the most and agreed the most. NGMN's 2023 statement said 6G must not inherently trigger a hardware refresh of 5G RAN infrastructure. Vodafone's Luke Ibbetson put it more directly: the fundamental rationale is to avoid the need to go and replace radio infrastructure. At RAN#113 Deutsche Telekom withdrew from a twelve-operator paper on the alternatives, on the grounds that none of the options are needed.

- **No forced hardware refresh in existing bands.** NGMN in 2023, 2025 and 2026; Vodafone, AT&T and Verizon. Ericsson says 6G will be software-upgradable on certain hardware, which it has not named; Nokia offers upgrades on new GPU hardware.

- **MRSS as the only baseline.** NGMN in June and September 2026; twelve operators at RAN#113. 3GPP has made it the baseline and left the alternatives open. Ericsson calls MRSS “highly efficient” and multi-vendor MRSS on one radio “complex to realize in practise”.

- **An evolved core, with connectivity independent of AI agents.** Seventeen operators at SA#113. 3GPP assumes the 5G core framework as the starting point, has three directions on the table and a decision due in November 2026. Ericsson wants an evolution of the 5G core, Nokia an AI-aware core, Huawei and ZTE an agentic core.

- **A business case before capex.** NGMN in 2025 and 2026; Orange; AT&T. This is not 3GPP’s to give. The vendors’ answer is the 5G record: 3.3 billion subscriptions, T-Mobile’s postpaid phone ARPU up from $46.04 to $50.37 in six years, AT&T’s down 0.3% in the last year.

The vendors agree in public and hedge in the detail. Ericsson’s chief executive calls 6G an evolution of 5G, while its RAN blog describes a standalone deployment without any form of aggregation. Qualcomm’s representative told MWC that 6G is not an evolution, it is a revolution. The hedge has a reason: Ericsson’s chief executive conceded, as reported, that softwarisation may structurally hurt the top line.

What did not make the list

Some of what the early roadmaps promised has gone. Reconfigurable intelligent surfaces were never proposed for the 6G study, sub-terahertz is out of scope above 52.6 GHz, and ambient IoT carries on in 5G-Advanced. Immersive communication is in the report as a composite target and in every vendor’s paper as a scene with glasses in it, but no operator has put it forward as the business case. Meta’s numbers suggest why: $2.2 billion of Reality Labs revenue against a $19.2 billion operating loss for 2025.

> In 5G every feature was supplied by the equipment vendor, licensed by the regulator and sold by the carrier. In 6G the three capabilities furthest along each depend on a party outside that triangle, and each of those parties can take the value without the carrier. The capabilities that stay inside the triangle are the ones the operators are fighting for in the standard. They are winning the written part of that fight; whether they win the hardware part is a December decision.

Terms used

- **NTN.** Non-terrestrial network: 3GPP’s term for satellites and high-altitude platforms in the mobile standard. Transparent means the satellite relays to a base station on the ground; regenerative means the base station is on board.

- **ISAC.** Integrated sensing and communication: using the network's own transmissions as radar. Monostatic sensing listens for its own echo; bistatic uses a second site as the receiver.
- **Upper mid-band, FR3, centimetre wave.** Industry names for roughly 7 to 24 GHz; 3GPP refers to "around 7 GHz". Giga-MIMO, X-MIMO and GigaMIMO are vendors' names for antennas of a thousand or more elements built for it.
- **MRSS.** Multi-RAT spectrum sharing: one carrier in one band served to 5G and 6G phones from one radio. The operators' chosen baseline.
- **Two-sided model.** A trained model split between the phone (encoder) and the base station (decoder), whose halves must be trained together. Interoperability between companies is the open question.
- **Standalone.** A 6G network with its own core and no 5G anchor. 5G launched the other way, riding on 4G.

Implications

CARRIER STRATEGIST	Score every 6G capability on five columns rather than three, and ask of each who outside your company it needs. Put 7 to 11 December 2026 in the calendar as the first hinge, because the migration decision there is the capex decision. For sensing, build the tender response before the product, because the first buyer will be a government.
INVESTOR	Model seven of the eight capabilities as cost lines until a price appears. The one line with a price is coverage insurance at $10 a month, and the one with a customer is a procurement business in China. Read the December plenary decisions for whether the 2028 to 2030 capex in part 4 is a software or a hardware number.
VENDOR	Build to the four demands the operators have written down: software on radios already installed, MRSS that works across vendors, a core they control and a business case first. Name the radios that qualify before a competitor does. For AI, lead with the Release 19 work item and the Release 20 interoperability route you support, rather than with the adjective.

Method and limits

HOW THIS WAS BUILT

Each capability is read from four layers of evidence. What 3GPP has decided and left open comes from the study description, the approved technical report and the plenary reports, with the trade press that attended as a second source. The vendors speak through their own papers and releases, quoted and dated, and the operators through the NGMN Alliance's board-approved position papers and named executives on the record. What has been sold comes from price pages and filings.

The dependency map scores each capability on five things: part 6's release, band and device, plus a partner outside the carrier and a regulator's permission that it cannot work without. Delay and resolution figures are our calculation from the speed of light and the stated altitude or bandwidth.

WHAT IT DOES NOT SHOW

A 3GPP agreement is a membership decision and can be revisited at the next plenary, so the open items listed here are the ones the plenaries have scheduled. Where a vendor claims a capacity or efficiency gain, its basis is given, and the text says when that is the vendor's own testing. An operator that has said nothing is not assumed to agree. The explanations of each mechanism are simplified. Nothing here ranks one vendor's product against another's.

Data as of: 3GPP, operator and vendor documents as read 2 Oct 2026; SpaceX's 800 MHz agreement as announced 8 Oct 2026, read 12 Oct 2026 · Method version 1.1 (fact-checked against second sources).

Sources. 3GPP: the 6G radio study description RP-251881, TR 38.914 v20.0.0 and the news of its approval, the RAN1 status report RP-261238, the RAN#113 decisions on migration and spectrum sharing and device types and 3GPP's note on the meeting, the ISAC work item RP-261566 and TS 23.137, the architecture study TR 23.801-01 and the SA#113 report, the NTN work item RP-240775 and the AI/ML work items RP-240774 and RP-251870; 6G Futures on RAN#113 and SA#113 and Light Reading on the core (1 October 2026) as second sources. Operators: NGMN's position statement (2023), key messages (June 2025), architecture and migration options and deployment timeframe papers (June 2026) and September 2026 guidance; Light Reading on AT&T, Verizon, Vodafone and the GPU dispute; TelecomTV on Verizon and sensing; Fierce on T-Mobile and AI-RAN cost; The Mobile Network on Orange; Qualcomm's coalition release (2 March 2026). Vendors: Ericsson on RAN decisions, architecture, energy, direct-to-device and sensing, and its researchers' AI air-interface talk; Nokia on the golden bands, the AI-native air interface, satellites and energy; Samsung on 7 GHz with KT, sensing with Verizon, its 2025 white paper, its 2020 white paper and energy; Huawei and ZTE at MWC 2026; MediaTek on satellites; NTT DOCOMO's AI air-interface trial; SoftBank's AITRAS release; NVIDIA's Nokia investment. Regulators and others: the RSPG opinion on a 6G spectrum roadmap, Ofcom's upper 6 GHz statement, NCTA's statement at the FCC, the NTIA's Mission 6G 28, the 5GAA and 5G-ACIA papers, Xinhua on China Mobile's sensing sites and Caixin on the ministry order. Prices and filings: T-Mobile's T-Satellite page and Home Internet plans, telecoms.com on its first-quarter call; Rogers and One NZ; Verizon's AST commitment and AT&T's AST agreement; Globalstar's 8-K on Apple; EchoStar's SpaceX release; Grain Management's release and SpaceX's update of 8 October 2026; T-Mobile's fourth-quarter 2025 and fourth-quarter 2019 releases, Verizon's second-quarter 2026 release and AT&T's fourth-quarter 2025 release; Meta's fourth-quarter 2025 release; Vodafone's ESG methodology, Telefónica's ESG data book, AT&T's responsibility KPIs, BT's energy note and GSMA Intelligence's energy note; the Ericsson Mobility Report (June 2026). Retrieved and cross-checked 2 Oct 2026.

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The first step is a one-day teardown. Each step stands on its own, has a fixed fee agreed before it starts, and you decide whether the next one is worth doing.

STEP 1

One-day teardown

A 90-minute working session on the decision in front of you, a written answer in two working days, and the model behind it, yours to keep.

STEP 2

Two-week assessment

Two working sessions, a 12 to 18 page memo with the working shown so your team can check every number, and a one-page board summary.

STEP 3

Project

Scoped to the engagement, with weekly checkpoints, until a first offering is in the market with your team running it. Every model and source is yours at the close.

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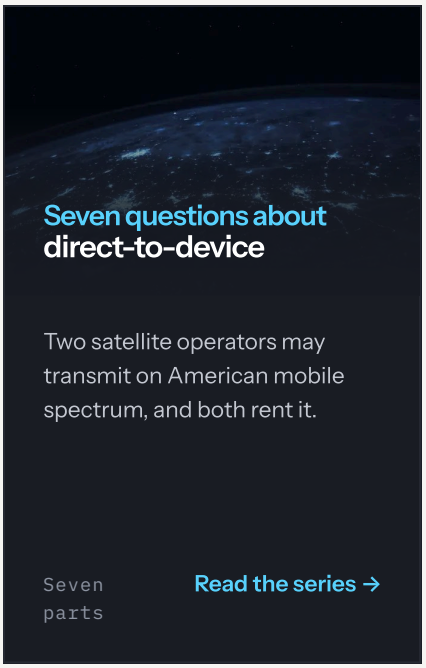
The other series

Each series takes one subject and answers five to eight questions about it from the primary record. All are free to read on the site or to download as ebooks.

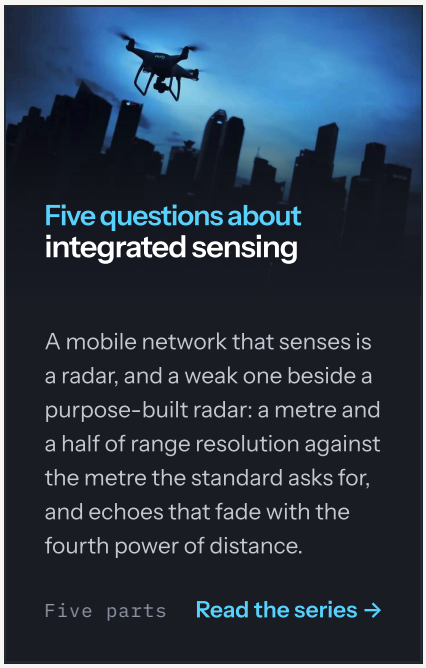


Seven questions about direct-to-device

Two satellite operators may transmit on American mobile spectrum, and both rent it.

Seven parts

Read the series →

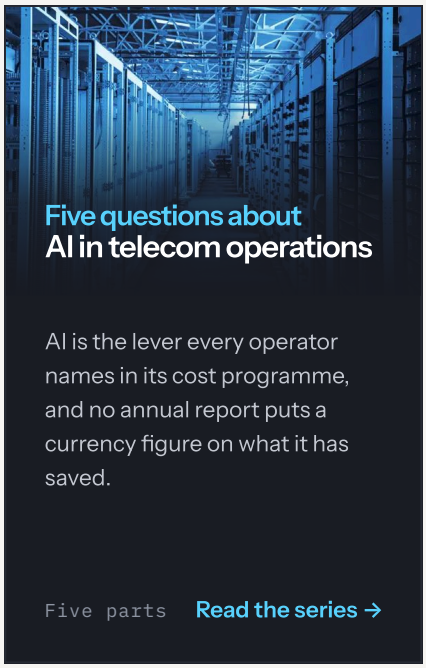


Five questions about integrated sensing

A mobile network that senses is a radar, and a weak one beside a purpose-built radar: a metre and a half of range resolution against the metre the standard asks for, and echoes that fade with the fourth power of distance.

Five parts

Read the series →

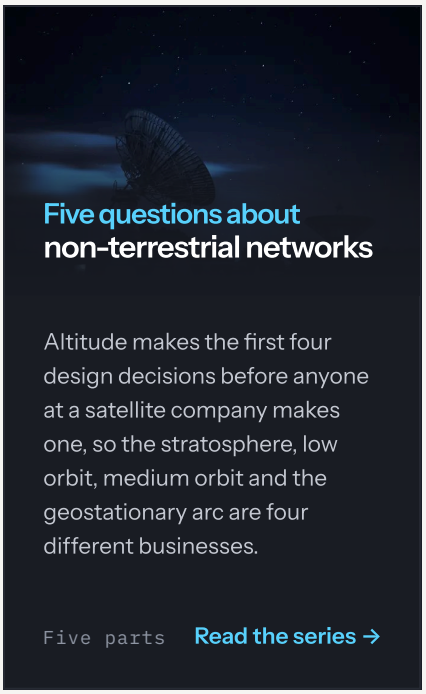


Five questions about AI in telecom operations

AI is the lever every operator names in its cost programme, and no annual report puts a currency figure on what it has saved.

Five parts

Read the series →

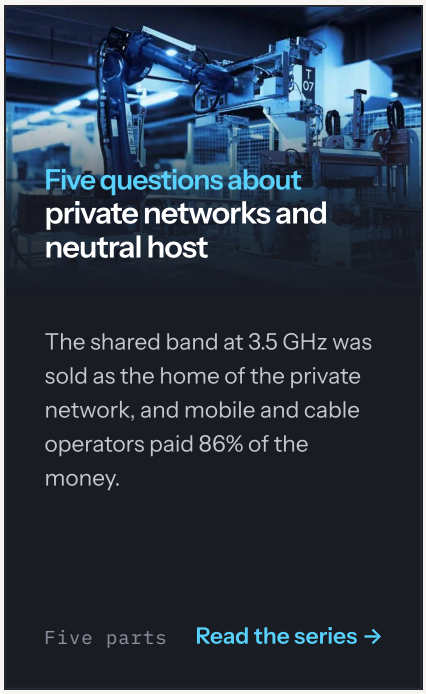


Five questions about non-terrestrial networks

Altitude makes the first four design decisions before anyone at a satellite company makes one, so the stratosphere, low orbit, medium orbit and the geostationary arc are four different businesses.

Five parts

Read the series →

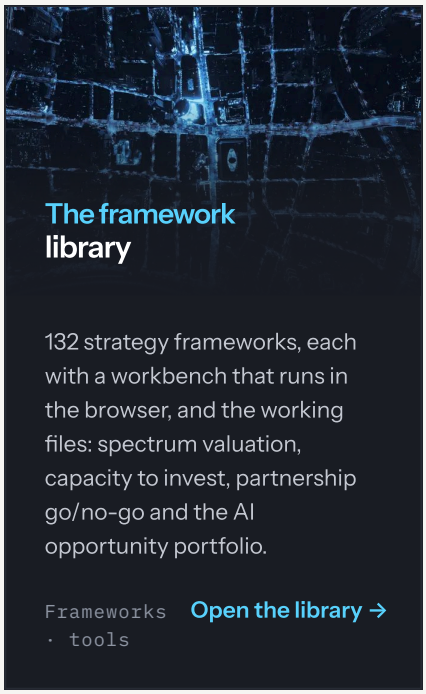


Five questions about private networks and neutral host

The shared band at 3.5 GHz was sold as the home of the private network, and mobile and cable operators paid 86% of the money.

Five parts

Read the series →



The framework library

132 strategy frameworks, each with a workbench that runs in the browser, and the working files: spectrum valuation, capacity to invest, partnership go/no-go and the AI opportunity portfolio.

Frameworks · tools

Open the library →

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