

D2D Market Evolution

The Case Beyond Consumer Demand

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Idea in Brief

Reaching a phone by satellite is not new. For decades it required a specialized satellite handset, the separate, expensive devices carried by mariners, remote crews, and emergency responders, which kept the market small. The reason direct-to-device (D2D) connectivity is suddenly everywhere is that the capability has moved into the phones people already own: a standard smartphone connecting straight to a satellite, with no special hardware and no dish, distinct from fixed services like Starlink's home internet. What began as emergency messaging on mainstream smartphones has become a consumer retail product sold by major carriers, and that progression has accelerated sharply in the past year. A maturing market changes the strategic question for the players involved: mobile operators, satellite operators, and the investors backing both. In a nascent market, the choice is close to binary, whether to place the bet at all. In a market maturing this quickly, D2D has separated into distinct submarkets and succeeding in it depends on a more specific set of choices: which segment to target, how the capability fits the business model, and on what timeline the return arrives.

Consumers have made their preference clear. In a survey of more than 12,000 smartphone users across 12 markets, 60% said they would pay more for satellite-enabled service and nearly half would switch providers to get outdoor coverage in their plan.¹ The expectation that a phone should work everywhere has moved from aspiration to something closer to a consumer right.

If demand is that clear, why is there so much disagreement about whether D2D is a good investment? Part of the answer is that demand and revenue are not the same thing. Willingness to pay for an occasional backup runs well below what people pay for a primary connection, and it is lowest in the regions with the largest coverage gaps, where mobile ARPU are a fraction of developed-market levels. Telecom investors see that gap and a long, capital-heavy path to profit. Others look to the value pools that matter most to satellite businesses — defense procurement, government communications, and industrial IoT — which carry far higher per-unit economics but have barely reached revenue, held back by multi-year certification and procurement. Each side is right about the part of the market it sees. Or perhaps the disagreement misses the point, and the investment is not about direct consumer revenue at all: D2D is becoming a baseline capability operators will provide because customers expect it and competitors offer it, whatever it earns on its own.

¹ The Great Connectivity Convergence: NTN in Consumer Mobile, GSMA Intelligence, December 2025. Survey of 12,000+ smartphone users across 12 markets.

Each of these views leads somewhere different, which is why the decision comes down to three questions of positioning:

01 Which use cases are you targeting, and how contested are they?

Consumer connectivity already has entrenched players with real head starts, and the competitive landscape is evolving quickly, with incumbent and emerging D2D providers forming partnerships, commercial agreements, and ownership links with terrestrial mobile operators. Beyond the smartphone, defense, sovereign connectivity, and industrial IoT look different: no dominant player, no settled architecture, and real upside for those who move early and position well. The device changes — a soldier's standard handset, a purpose-built terminal, an embedded IoT module — but each still rides the same constellation and spectrum consumer D2D already funds.

02 Where does D2D fit in your revenue model?

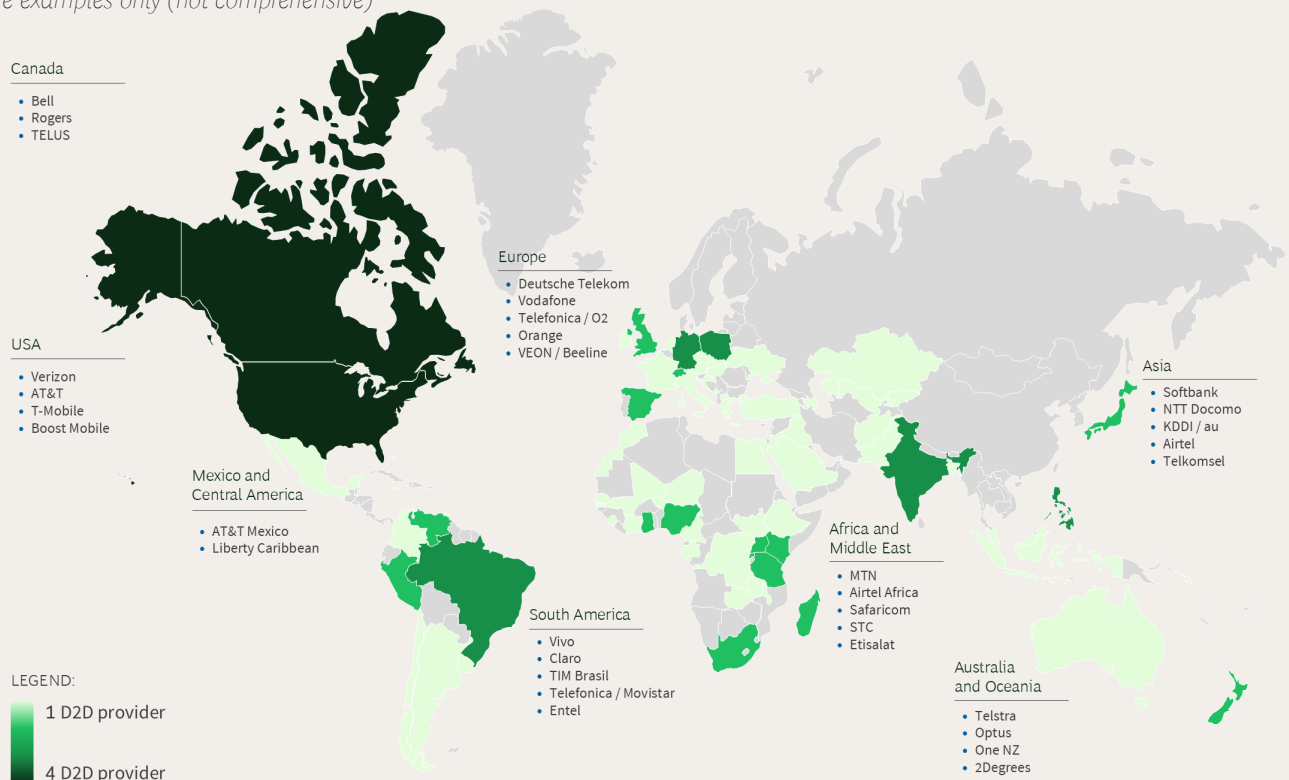
For some operators it is a consumer product with its own P&L; for others a network-resilience investment, a competitive differentiator, or a capability they must offer whatever it earns directly. The answer determines the business case, the partnerships, and which threats warrant a response.

03 What is your expected return timeline?

Consumer economics can be measured today, while government, defense, and industrial IoT mature over years. The segments are real, but they pay back on very different schedules.

EXHIBIT 01 Concentration of Direct-to-Device partnerships around the world

Telcos listed are examples only (not comprehensive)



Note: Country-level operator counts reflect the number of satellite operators (Starlink, AST SpaceMobile, Lynk Global, Skylo) with at least one confirmed or announced partnership with any MNO in that country. MNOs logos displayed represent the top mobile operators by revenue in each region with at least one active D2D partnership.

01 | What's changed since last year: D2D's move from proof of concept to operational reality

The old constraint on D2D was as much commercial as technical: with the market limited to specialized-handset users, there was little reason to invest heavily in it. What has changed over the past year is the volume of real-world evidence. Satellite connectivity is now something subscribers expect a mobile plan to include, and real-world use is beginning to show what it can do.

Two kinds of orbit matter here. Traditional satellites sit in geostationary orbit roughly 36,000 km up, where a single craft can cover an entire region but the distance adds latency that makes interactive use difficult. D2D instead runs on low Earth orbit constellations, a few hundred kilometers up, where each satellite covers a small footprint and global service takes hundreds or thousands of them, an architecture that only became affordable as launch costs fell. The low orbit is what makes a direct link to an ordinary handset possible.

A mass consumer market changes the investment calculus. Demonstrated demand across tens of millions of handsets justifies the capital that voice and video require, and everyday use across live networks has replaced modeled predictions with performance data from the field. Field data is defining what D2D can realistically deliver: two-way video calls reach further up the service stack than emergency messaging, though the demonstrations to date have run in lightly loaded beams, and per-user throughput falls as more users share one. Voice has held up through tree cover, terrain, and partial obstruction, with service running in national parks and other areas terrestrial networks never covered. None of this overturns earlier assessments of where the physics dictates D2D will struggle, but it lets operators validate their business cases against operating evidence rather than conjecture.

1.1 | Operational deployments have provided a more granular view of where D2D performs

D2D's performance depends heavily on the operating environment. Open sky can support the highest data rates, while heavy canopy and dense urban canyons fall back to messaging and emergency use, with a gradient of partial obstruction in between, where most real-world use sits. The granularity now available from live deployments lets operators plan against the service levels each environment actually delivers rather than a single theoretical peak.

One limit is fundamental: D2D barely works indoors. The D2D spectrum's propagation characteristics and transmit power limitations mean the link cannot punch through walls the way a nearby cell tower does, so D2D reaches a phone with a view of the sky, not one deep inside a building. It extends coverage; it does not replace the terrestrial network.

D2D service quality by operating environment

Environment	Typical conditions	Likely service level	Representative throughput (per beam, shared)
Open sky, rural	Clear view of the sky, light beam loading	Data, voice, and messaging	~3–15 Mbps
Partial obstruction	Trees, terrain, intermittent blockage	Messaging and voice where the link stays stable	~1–3 Mbps
Near-window	Clear sky path through a window, in a building or vehicle	Basic messaging and light data	<1 Mbps
Heavy canopy	Dense foliage, limited sky view	Messaging and emergency use	~100 kbps
Dense urban canyon	Significant blockage and interference	Fallback / intermittent	Intermittent

Note: Figures are per-beam capacity, shared across users in a beam, not single-user rates, and scale with allocated spectrum. The low end reflects the ~2×5 MHz used in current US deployments (T-Mobile PCS spectrum leased to Starlink), where independent measurements put per-beam capacity near 3 Mbps; the high end assumes the additional spectrum operators are now acquiring. Throughput also requires a clear path to the sky: D2D performs poorly through foliage or in urban canyons and does not reach deep indoors, and voice depends on link stability rather than peak speed.

1.2 | Spectrum is becoming a strategic asset

Alongside signal propagation, spectrum availability is the other hard constraint on D2D's long-term potential. Spectrum is finite, and LEO satellite connectivity is a scale business — operators who secure spectrum position early hold a structural advantage that is difficult to close later. The transaction activity of the past eighteen months reflects exactly that logic: more than \$30 billion in spectrum-related deals have been announced or closed, as satellite operators, hyperscalers, and mobile carriers move to lock in access rather than depend on partnerships that could be renegotiated. For governments, the calculus has also changed: spectrum allocation is increasingly linked to sovereignty, critical infrastructure resilience, and national connectivity objectives, creating political momentum for reallocation toward non-terrestrial network (NTN) use cases that would have been difficult to justify a few years ago.

Recent spectrum transactions relevant to D2D

Transaction	Spectrum	Geography	Value	Why it matters for D2D
COMPLETED				
SpaceX acquires EchoStar spectrum assets (AWS-3, AWS-4, H-block)	Multiple nationwide holdings	US	~\$20B	Satellite operators controlling spectrum directly rather than through MNO partnership access
Amazon acquires Globalstar	MSS licenses, satellite network, D2D assets	Global	~\$11.6B	Secures global MSS spectrum and D2D assets for Amazon's own satellite ambitions and shortcuts years of regulatory queuing
AST acquires Ligado L-band portfolio	40 MHz L-band	North America	\$550M + warrants + \$80M/yr lease + 17.5% rev. share	Prime mid-band L-band with strong NTN propagation characteristics and a favorable position for mobile connectivity
AST acquires Sky & Space Global S-band rights	60 MHz global NGSO S-band	Global	\$64.5M	Lower-priority NGSO S-band; equatorial orbit profile limits AST compatibility, but secures a spectrum position ahead of potential regulatory upside
PROPOSED				
Lynk + Omnispace merger	60 MHz global NGSO S-band	Global	Undisclosed	Value contingent on regulatory clearance in North America and EU
Viasat / Space42: Equatys JV	100+ MHz pooled L-/S-band (Inmarsat + Thuraya)	Global	Undisclosed	Announced Sep. 2025; venture formation underway, pending definitive agreements and regulatory approvals; commercial rollout targeted within 3 years
AT&T, T-Mobile, and Verizon D2D JV	Shared spectrum (details pending)	US	Undisclosed	MNO-level commitment to coordinated D2D spectrum; structural shift in how US operators approach NTN

Note: most satellite spectrum is shared rather than exclusively licensed, allocated on a first-come, first-protected basis, so these holdings do not confer the exclusive control a mobile operator has over its licensed bands.

The scale of spectrum investment stands out against the modest revenue D2D has generated so far. Even as operators grow more realistic about which use cases it will and will not serve, they are placing a substantial bet on its long-term potential.

02 | Where D2D creates sustainable economic value first: The consumer opportunity

Consumer connectivity is the natural starting point for any D2D assessment: it is the segment that is operational today, the one most people have direct experience with, and the one that produces the largest headline numbers. The full consumer business case, however, extends beyond direct subscriber revenue to the broader ways D2D creates value for a telco.

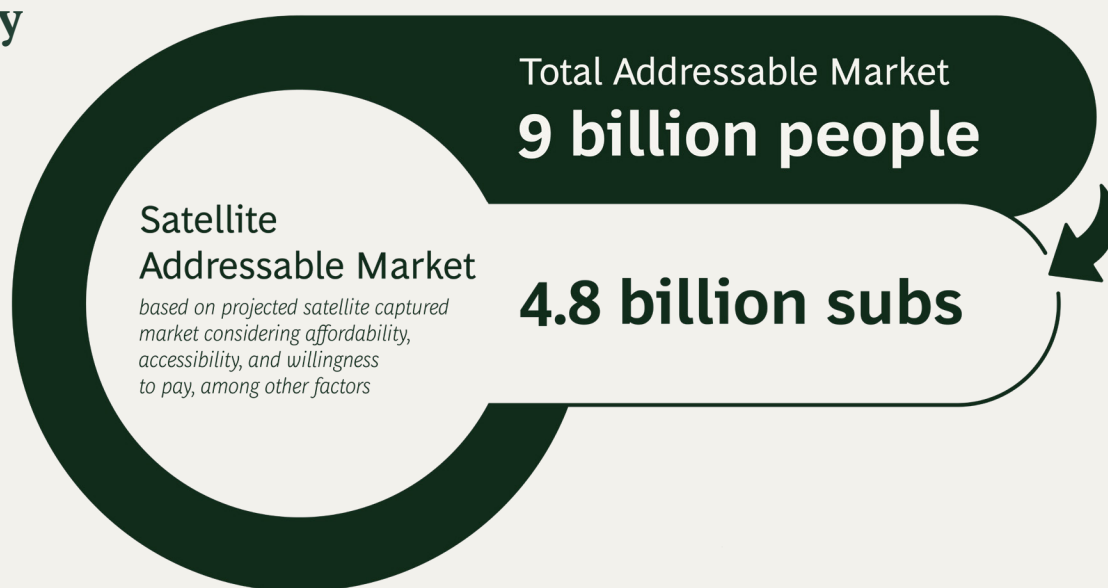
2.1 | The direct revenue opportunity: large in population, but concentrated in value

The addressable population for D2D is enormous: mobile subscribers who periodically lose coverage, plus the billions still underserved by terrestrial networks. Of a total mobile base of roughly 9 billion, Novaspace estimates that around 4.8 billion fall within D2D's satellite-addressable market (see Exhibit 4). Forecasts built on that base arrive at very large long-term opportunities, which explains at least part of the capital and attention flowing into the sector.

EXHIBIT 04

Total and satellite addressable market (2025)

Market Addressability



The challenge in translating this into revenue is that commercial potential is not equally distributed across that subscriber base. Regions with the greatest connectivity needs tend to have the lowest mobile ARPU, while high-value subscribers in developed markets are already well served by terrestrial networks and are likely to adopt D2D primarily as a continuity layer. Willingness to pay for backup connectivity is lower than for a primary service, which means the revenue opportunity is distributed very differently from the subscriber opportunity, a gap that becomes concrete against regional ARPU data.

EXHIBIT 05

Regional mobile ARPU vs. satellite service pricing (2025)

Region	Terrestrial mobile ARPU (\$/mo)	Satellite retail ARPU — voice & LDR (\$/mo)	Satellite retail ARPU — broadband (\$/mo)
North America	\$57	\$10	\$15
Latin America	\$8	\$1.50	\$2.00
Europe	\$17	\$5	\$7
Russia & C. Asia	\$5	\$0.90	\$1.30
Middle East & Africa	\$5	\$0.90	\$1.30
Asia Pacific	\$7	\$1.25	\$1.70

Note: Satellite retail ARPU figures are modeled estimates, derived from announced rates where available or from regional ARPU benchmarks in regions where pricing has not yet been released.

On a 50/50 satellite revenue split, where the satellite operator and mobile carrier share subscriber revenue evenly, a North American subscriber generates 5–10 times more revenue than one in a developing market. The first wave of D2D commercial revenue will therefore concentrate in North America, Europe, Australia, New Zealand, Japan, and parts of Northeast Asia, markets combining high ARPUs with strong smartphone penetration and established operator distribution channels. Developing markets represent a large addressable population but are more likely a second-phase opportunity as device costs fall and service economics improve.

In most developed markets, D2D is being positioned as an extension of existing mobile service, providing coverage continuity when terrestrial networks are unavailable. The strength of that proposition varies sharply by geography. In much of Europe, terrestrial networks cover upward of 95% of land area, so D2D adds little where a cellular signal already reaches; in the U.S., Australia, Canada, and Brazil, large areas have no terrestrial coverage at all, and D2D fills a genuine gap. Adoption there will hinge on how operators package satellite-enabled services into existing plans, and whether that proposition drives meaningful incremental ARPU. Geographic expansion is a real part of the D2D story, but on its own it does not explain the scale of operator ambition or investment in the sector.

2.2 | Beyond the direct revenue line: how else D2D creates value for telcos

Satellite operators have collectively committed billions of dollars to constellation deployment, launch, ground infrastructure, and spectrum acquisition — capital that is difficult to recover through retail consumer subscriptions alone, even under favorable assumptions around pricing and revenue sharing.

EXHIBIT 06

Illustrative subscriber thresholds to recover announced D2D investments

	AST SpaceMobile	SpaceX Starlink Mobile	Lynk Global
Est. D2D capex 2026–2030 (\$M)	\$7,000	\$10,500	\$4,125
Annual revenue required assuming 5-yr payback (\$M)	\$1,400	\$2,100	\$825
Developed-market ARPU to operator (50/50 split, \$10 retail)	\$5	\$5	\$5
Developed-market breakeven subscribers	23.3M	35.0M	13.8M
As % of Developed-market subs (~1.2B)	2.0%	3.0%	1.2%
Developing-market ARPU to operator (50/50 split, \$1.50 retail)	\$0.75	\$0.75	\$0.75
Developing-market breakeven subscribers	155.6M	233.3M	91.7M
As % of rest-of-world mobile subs (~4.5B)	3.4%	5.1%	2.0%

Note: CapEx covers manufacturing and launch only; spectrum acquisitions excluded. Five-year payback period used for illustrative purposes. Developed market refers to North America, Europe, and OECD Asia-Pacific members (Australia, New Zealand, Japan, and the Republic of Korea); developing markets include all other regions.

These penetration rates are achievable in principle, but they leave little room for the strategic and network-economic logic operators are evidently applying. The pace of investment, set against the subscriber math, points to a rationale beyond direct consumer revenue.

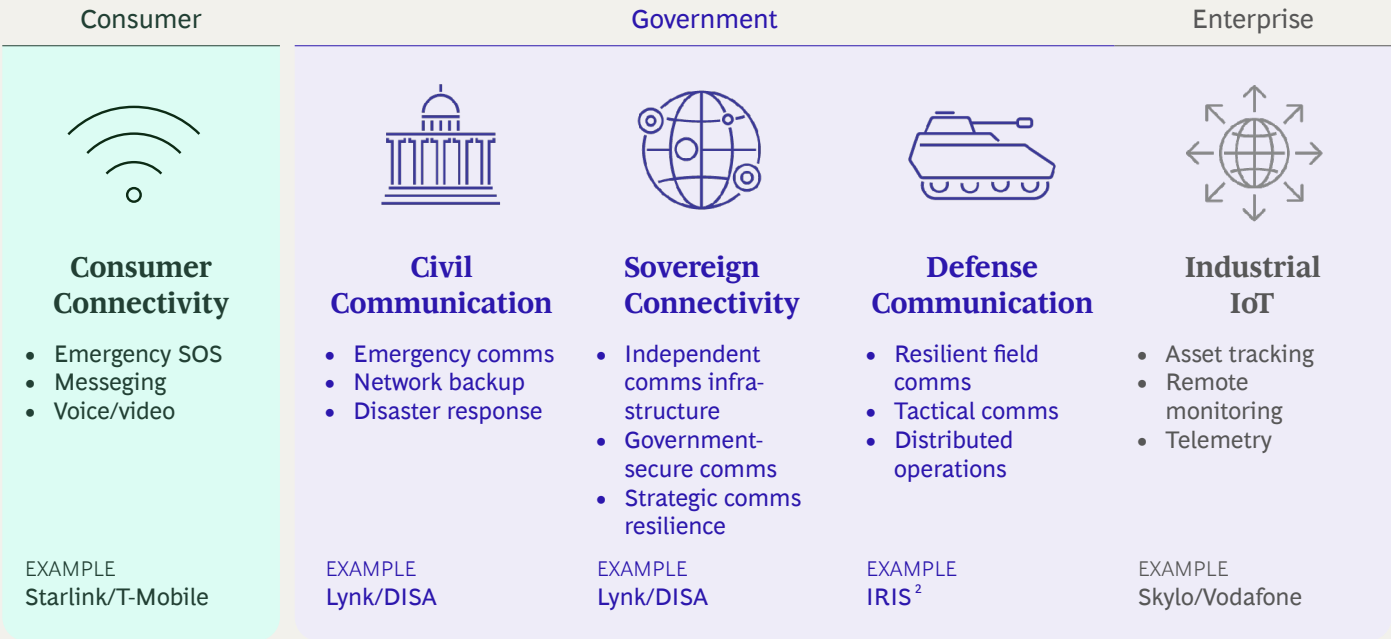
For many operators, D2D may ultimately become part of the cost of doing business: a capability they must offer because customers will expect it and competitors will provide it, whatever revenue it generates on its own. The precedent is in-flight Wi-Fi: JetBlue’s early bet paid off in retention and differentiation, and eventually in the competitive cost of not offering it once connectivity became a standard passenger expectation. The Wi-Fi fees themselves were never the point. The parallel for telcos is direct: as satellite-enabled coverage spreads, the question moves from what D2D earns to what it costs to be the operator that does not offer it. Mobile operators are already acting on that logic: the D2D joint venture formed by AT&T, T-Mobile, and Verizon is widely seen as a step to preserve the carriers’ bargaining power as satellite connectivity becomes a larger part of the mobile market.

03 | Beyond consumer connectivity: Emerging B2G and B2B value pools

Even granting the full weight of the consumer case, the larger long-term opportunity in D2D may lie elsewhere. Consumer connectivity is the right place to start, and it remains the most defensible near-term revenue, but for a satellite operator the consumer market is a question about the device, while the larger question is what the constellation behind it can serve once the satellites and spectrum are in place. Government communications, defense, and industrial IoT each command higher perunit economics, and although their use cases span purpose-built terminals, standard handsets, and embedded IoT modules, all draw on the same orbital infrastructure consumer D2D already justifies. Because none requires a dedicated constellation of its own, each adds demand that improves the economics of an asset being built anyway, and that improvement reaches all three parties: for satellite operators it is the difference between a marginal consumer case and a viable one, for mobile

EXHIBIT 07

Recent D2D activity spans consumer, government, and enterprise markets



 Operational deployment  Contract, funded program, or strategic partnership

operators it lowers the shared cost base behind a D2D offering, and for investors it turns D2D from a single-market bet into something closer to a portfolio. The pattern is structural: in the satellite sector, hardware volume and economic value do not scale together. Defense accounts for 48% of satellite manufacturing and launch spend on 9% of satellite volume, while five mega-constellations will account for 66% of all satellites launched through 2034 but only 11% of total market value. Consumer D2D, by design, sits at the high-volume, lower-margin end of that range, which is exactly why the smallervolume segments deserve a closer look.

3.1 | Government opportunity: a structural shift toward 3GPP-based connectivity

Government demand for satellite communications has nearly doubled in five years, reaching \$11.8B globally in 2025 from \$6.4B in 2020, and is projected to hit \$14.6B by 2030. It is smaller in absolute terms than the consumer addressable market, but more concentrated, more predictable, and higher-margin per unit: a single defense contract can outweigh hundreds of thousands of consumer subscriptions.

Civil security is the most operational government use today. Public-safety networks such as FirstNet already run mission-critical communications over commercial standards, and satellite connectivity extends that coverage to responders working beyond the reach of terrestrial networks. It is the segment where standards-based non-terrestrial connectivity is closest to live deployment, and a leading indicator for the defense demand forming behind it.

Defense is the larger prize, and a change in procurement philosophy is opening it to standardsbased systems. Military procurement reached \$7.5B in 2025, 64% of global government satellite communications spend, and militaries increasingly mandate 3GPP-based standards for new programs instead of commissioning bespoke proprietary systems, prizing lower cost, interoperability across allied forces, and coverage where fixed infrastructure is absent or vulnerable. The move toward commercial standards runs across satellite connectivity broadly, from broadband constellations like IRIS² to D2D, so it is a tailwind D2D shares rather than owns. What is specific to D2D is the device: it reaches the standard handset a soldier already carries, connecting dismounted troops and forward units without the dedicated terminals traditional MSS requires, at lower cost and far wider reach.

Defense establishments around the globe are already acting on this, with programs underway across multiple geographies:

The US Department of War has committed \$1B to military 5G connectivity deployment, with a long-term goal of integrating all Pentagon military assets via 5G NTN

NATO is running 5G pilots on military bases in Latvia and Germany, including dedicated defense network slices

The British Army is deploying private 5G across 162 bases as a first step toward broader broadband connectivity

Certification, not demand, sets the pace of revenue in this segment. A system demonstrated commercially in 2025 typically needs 3–5 years of qualification before generating meaningful defense revenue, so networks operational today are unlikely to begin defense service until the tail end of the decade. A parallel from the launch side of the industry shows how long that qualification curve runs: SpaceX’s Falcon 9 flew its first commercial missions in 2010, but defense customers require extensive certification before entrusting national-security payloads to a new vehicle, and most of those missions did not follow until the back half of the 2010s.

3.2 | Enterprise opportunity: unlocking hybrid connectivity through industrial IoT

Satellite IoT has been available for years, but its cost has historically confined it to a narrow set of high-value assets. Legacy plans ran \$40–\$70 per device per month, nearly 15 times the cost of cellular IoT, which is why in 2024 satellite accounted for just 7.5 million of the 18.8 billion IoT connections worldwide.

The value of satellite-enabled industrial connectivity is already well understood by the enterprises that would buy it. Integrated deployments in mining and long-haul trucking, where companies like John Deere have used satellite links to keep equipment running beyond terrestrial coverage, have improved gross margins on the affected operations by 10–15% and 8–12% respectively, through fleet-management efficiency, predictive maintenance, and reduced downtime. Cost and the absence of standardization were the only barriers, and D2D removes both by building satellite fallback into standard NB-IoT and LTE-M chipsets, extending those gains to the far larger base of assets satellite economics never reached. A February 2026 survey of 600 IoT decision-makers across agriculture, energy, transport, mining, and utilities suggests buyers are ready to move: 91% plan to adopt D2D IoT devices within 18 months, and 34% within six.

Enterprise adoption tends to arrive as a step change rather than a gradual ramp. Consumer growth is a slow drip of individual decisions, each subscriber adding at the margin, while enterprise demand stays flat until a business case closes and then commits an entire fleet at once. Reliability is what closes that business case, and every additional commercial deployment supplies more evidence of it. Enterprise D2D could therefore scale faster than the current momentum case suggests, which is calibrated to the drip rather than the cliff.

04 | Sizing up the opportunity: How value pools map to investment horizons

Every participant in the D2D market is making a bet on timing as much as on technology or market size, and the timeline embedded in that bet determines almost everything else about how the opportunity should be evaluated. The same set of facts looks very different to an operator expecting returns in three years than to one underwriting a ten-year thesis. Near-term skeptics are not misreading the consumer economics; those economics are demanding. Long-term optimists are not ignoring them; they are weighing them against a different set of value pools that mature on a slower schedule.

Illustrative evolution of D2D value pools

Value pool	Near term (2025–2028)	Medium term (2029–2035)	Long term (2035+)
Consumer connectivity — developed markets	Primary source of adoption and monetization; Starlink established first-mover position	Established; competitive pressure intensifying	Mature; commoditizing
Consumer connectivity — developing markets	Limited; device economics and affordability constrain near-term adoption	Growing as D2D compatibility expands to more affordable devices	Large addressable population; long-cycle opportunity
Operator economics (retention, differentiation, coverage floor)	Increasingly recognized; difficult to quantify directly	Embedded in operator strategy and network planning	Baseline capability; cost of doing business
Civil and sovereign communications	Early deployments and procurement; landscape still forming	Scaling; sovereign mandates driving adoption	Established value pool; government ARPU structurally above consumer
Defense communications	Pilots and certification programs; limited revenue; no clear leader yet	Growing deployment as 3GPP-based standards clear military certification	Mature procurement; highest per-unit value
Industrial IoT (hybrid satellite-cellular)	Early deployments; chipset integration progressing; landscape open	Scaling; hybrid model unlocking new verticals	Large volume at lower per-unit economics

The value pools do not arrive together, and that staggering is the whole of the investment question. Consumer connectivity and operator economics drive near-term returns, while government, defense, and industrial IoT are real and well-evidenced opportunities that will not show up meaningfully in revenue on a two-to-three-year timeline. In a market this early, the gap between those horizons matters more than it would in a mature sector: the opportunity that exists in 2030 will look substantially different from what is visible today, and a participant who evaluates D2D against its current revenue profile alone is anchoring on the least informative moment in its development.

Conclusion

D2D is here to stay. It has become an expectation baked into consumer devices, operator strategies, and government procurement, and the question has moved from whether to engage to how to do so with enough precision to win. Across satellite cellular IoT and D2D, the addressable market is expected to exceed \$10 billion annually by 2030 — satellite cellular IoT growing at nearly 20% a year, consumer D2D reaching hundreds of millions of subscribers — with government satellite communications adding another \$14.6 billion in annual revenue. The scale of the opportunity is clear. What is far less settled is who captures which part of it, and the answer looks different depending on where you sit.

For mobile operators, D2D is closer than it appears and more accessible than it looks: much of the heavy infrastructure sits on the satellite side, so the near-term investment is modest. The harder questions are commercial. How much margin to concede to a satellite partner, whether to treat D2D as a product with its own P&L or a retention and coverage play, and what it costs to be the operator that does not offer it once customers expect it. The competitive move already underway among the largest US carriers suggests the answer is not to wait.

For satellite operators, the consumer line alone rarely justifies the capital. The stronger case runs through the adjacent markets the same constellations can serve: government, defense, and industrial IoT carry higher per-unit economics and longer contracts, and because they ride infrastructure consumer D2D already funds, the incremental cost of serving them is modest. The discipline is sequencing, earning consumer revenue now while positioning for higher-value demand that certification and procurement will gate until the back half of the decade.

For investors, the discipline is matching capital to the right segment and the right horizon. Consumer economics can be underwritten today on familiar terms; defense, government, and industrial IoT are larger and higher-margin but arrive on procurement timelines that a consumer-style model will misprice. The value pools are real; the question is which one a given thesis is actually buying.

D2D's future isn't in doubt. What's still open is who captures it — and that will be decided not by who moves first, but by who is clearest about which part of it is theirs.



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