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The National CORS Network and Surveying Productivity in Vietnam: A Techno-Economic Assessment of VNGEONET

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Abstract
Vietnam completed its national satellite positioning network, VNGEONET, at the end of 2019, and in September 2024 moved the service from free trial access to a priced public utility. Both steps were justified on productivity grounds, yet no published study has quantified how much surveying productivity the network can plausibly deliver, or under what conditions the new access charges leave users better off. This paper builds a transparent techno-economic model to answer those questions. Network geometry is assessed against the tessellation implied by the published station spacing; workflow effort is decomposed into mobilisation, control establishment, detail observation and office processing; and the resulting crew-hour requirements are compared across three technology configurations under two counterfactuals, a fully conventional workflow and single-base real-time kinematic surveying. Parameters are declared explicitly and stress-tested through a grid of break-even calculations, a 200,000-draw Monte Carlo simulation and a tornado analysis. Four findings stand out. The forty-one network-RTK stations cover between 26.8 and 68.6 per cent of the national land area depending on the spacing assumed, so the binding constraint on realised productivity is geographic rather than financial. The annual access charge of 6,750,000 VND per receiver is recovered after roughly twenty-three field-days against the single-base counterfactual and about five against the conventional one, and avoiding the purchase of a base receiver is worth several times the annual fee on its own. Crew reorganisation, not correction quality, determines whether the investment pays. Finally, the statutory labour norms consolidated in 2025 price photo control identically whether performed by total station or by GNSS, despite a 4.88-fold difference in the equipment norm, and establish no norm for real-time kinematic methods at all, so the productivity quantified here is invisible in the settlement of publicly funded work. Pricing reform is therefore second-order next to densification and norm revision, and the absence of published adoption statistics remains the main obstacle to evaluating the investment.

Keywords: Continuously Operating Reference Stations, Network RTK, Positioning Infrastructure, Surveying Productivity, Vietnam, Geospatial Policy

1. Introduction

National positioning infrastructure has quietly become one of the least visible and most widely used pieces of public capital. A network of continuously operating reference stations does nothing on its own. It transmits correction data that allows a satellite receiver in the field to resolve its position to a few centimetres in seconds rather than through hours of static observation followed by office computation. The economic consequence is that a task which once required a control traverse, a survey crew of three and a day of post-processing can be completed by one or two people in an afternoon, with the coordinates already in the national reference frame.

Vietnam made that investment between 2016 and 2019. The national satellite positioning system, VNGEONET, entered service on 27 December 2019 with sixty-five stations and a central processing facility in Hanoi. The stated purpose was explicit about productivity: the network was expected to modernise the surveying and mapping sector, accelerate the delivery of geospatial products, and raise labour productivity in a field where output had long been constrained by the pace of field observation. Five years later, in September 2024, the Ministry of Finance ended free access and introduced a schedule of user charges, converting an experimental facility into a priced public service.

Neither decision has been evaluated in the published literature. The technical performance of the network has attracted attention, with Vietnamese researchers testing positional accuracy under tree canopy, in urban settings and with low-cost receivers, but the economic question has not been addressed. How much surveying productivity can a network of this configuration actually deliver? Where does the answer depend on network geometry rather than on the technology itself? And does the 2024 fee schedule sit at a level that supports adoption or discourages it?

These questions matter beyond Vietnam. Many middle-income countries are at a similar point: the capital cost of a first-generation national network has been absorbed, densification is being debated, and finance ministries are asking whether users should pay. The evidence base they draw on comes overwhelmingly from high-income networks in Australia, Japan and western Europe, where station densities are an order of magnitude greater and the labour-cost structure is entirely different. A sparse network in a labour-abundant economy is a different economic object.

This paper offers an assessment built on what can actually be documented. Rather than claiming to measure realised productivity, which would require field records that are not in the public domain, it quantifies the conditions under which the network delivers net gains, and identifies which of those conditions currently bind. The approach is deliberately transparent. Every parameter is declared, its provenance stated, and its influence on the result tested. Where a parameter must be calibrated against operator records, that is said plainly rather than concealed behind a point estimate.

Three contributions follow. The first is a geometric assessment of coverage. Published descriptions of VNGEONET report a nominal station spacing of fifty to eighty kilometres in the three densified regions, but the forty-one network-RTK stations are concentrated in those regions rather than spread across the country. Translating station counts into serviceable area shows a gap between the network as described and the network as experienced by a surveyor working outside the delta and coastal corridors.

The second is a workflow-level productivity model that separates two counterfactuals which the policy debate routinely conflates. For a district land-registry office still working with a total station and static observation, network RTK is transformative. For a private survey firm that already owns a base-and-rover pair, the marginal gain is the elimination of base-station setup, the release of one crew member, and freedom from the baseline-length constraint. These are different magnitudes and they justify different policies.

The third is an evaluation of the 2024 fee schedule against those gains. Expressing the annual charge in crew-days rather than in dong makes its size immediately legible and shows that the fee is not what is holding adoption back.

The fourth uses the statutory technical-economic norms as evidence in their own right. These instruments state in binding form how much labour each survey operation is deemed to require, and reading them against the workflow model shows both what control establishment actually costs across terrain classes and where the norm system fails to register the technology it is meant to price.

The remainder of the paper proceeds as follows. Section 2 describes the network and the regulatory architecture around it. Section 3 reviews the relevant literature and sets out the conceptual framework. Section 4 presents the data and the analytical model. Section 5 reports results, Section 6 discusses them, and Section 7 draws out policy implications. Section 8 states the limitations and Section 9 concludes.

2. Vietnam's national positioning infrastructure

2.1 Network design and configuration

VNGEONET was designed as a two-layer network, and the distinction between the layers is central to everything that follows. Twenty-four geodetic stations are distributed across the whole country at average separations of 150 to 200 kilometres. Their function is to realise and maintain the national reference frame, to connect Vietnam to the International GNSS Service and to support geodynamic monitoring. They are built on deeply anchored concrete monuments for long-term positional stability, and they are not intended to support centimetre-level real-time work.

The forty-one remaining stations form the network-RTK layer. These are densified into three regions, the northern delta together with Thanh Hoa, the central region and central highlands, and the southern region, at average separations of fifty to eighty kilometres. This is the layer that delivers real-time positioning to field users. Correction streams are provided in the VN-2000 national coordinate and height system through virtual reference station and iMAX network solutions as well as conventional single-base RTK, with the network solution recommended because it draws on at least three stations and is therefore more stable than a single-base link. Static observation data are also published in RINEX format at one-second, fifteen-second and thirty-second intervals for post-processing.

All stations transmit to a control and processing centre in Hanoi over the public internet, and corrections reach field users over mobile data. Station hardware is standardised, using Leica AR25 antennas with GR50 receivers and Met 4A meteorological sensors, which matters for data homogeneity across the network. Table 1 summarises the configuration.

Table 1: Configuration of the VNGEONET national satellite positioning network

Attribute	Geodetic CORS layer	Network RTK (NRTK) layer
Number of stations	24	41
Spatial arrangement	Nationwide	Three densified regions: northern delta and Thanh Hoa; central region and central highlands; southern region
Average station spacing	150–200 km	50–80 km
Primary function	Realisation of the national reference frame; linkage to IGS; geodynamic monitoring	Real-time centimetre positioning for field survey
Monumentation	Deep-anchored concrete monuments for long-term stability	Standard CORS installation
Services delivered	24-hour static GNSS data in RINEX (1 s, 15 s, 30 s)	Network RTK (VRS, iMAX) and single-base RTK in VN-2000
Common infrastructure	Leica AR25 antenna, GR50 receiver, Met 4A meteorological sensor; central processing centre in Hanoi	Same
Construction period	2016–2019; launched 27 December 2019	Same

2.2 The regulatory architecture

The network did not arrive in a legal vacuum. The Law on Surveying and Mapping No. 27/2018/QH14, passed in June 2018 and detailed by Decree No. 27/2019/ND-CP, established surveying and mapping data as public property and set the framework for its management and exploitation. That characterisation is what later made a fee schedule legally possible, because public property carries an entitlement to charge for access.

Technical-economic norms followed. Circular No. 14/2019/TT-BTNMT set labour, materials and equipment norms for direct survey work supporting topographic mapping at 1:500 and 1:1,000 and national topographic mapping at 1:2,000 and 1:5,000. These norms are not merely administrative. They define the labour time deemed necessary to produce a unit of output, and they are the basis on which cost estimates and final settlements for publicly funded survey contracts are calculated. A technology that reduces field time delivers a measurable benefit to the operator only if the norm regime recognises that reduction, and this is a point the discussion returns to.

In March 2023 the Government approved Resolution No. 40/NQ-CP, the strategy for the surveying and mapping sector and the national spatial data infrastructure to 2030 with a vision to 2045. The strategy commits to modernising the national survey networks, mastering eighty per cent of advanced technologies by 2045, and integrating Vietnam into the global spatial data infrastructure. Norm-setting was subsequently consolidated: Circular No. 20/2024/TT-BTNMT repealed the earlier cadastral norms from the start of 2025, and Circular No. 70/2025/TT-BNNMT issued a consolidated set of technical-economic norms for surveying and mapping under the reorganised Ministry of Agriculture and Environment. Fig 1 places these instruments on a common timeline.

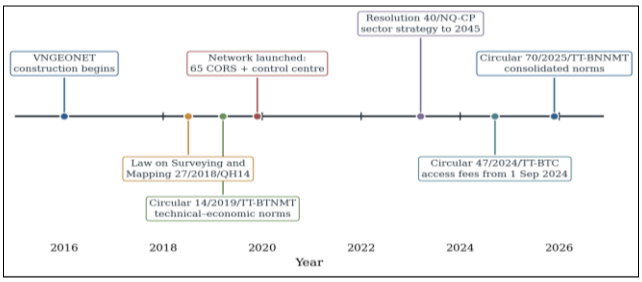

Fig 1: Development of Vietnam's national positioning infrastructure and its regulatory framework, 2016–2026

2.3 From free trial access to a priced service

For almost five years, access to VNGEONET correction streams was free. Registration was open, and at the time of the launch about six hundred accounts had been issued, used mainly for land management and map production, with Hanoi, Thai Nguyen, Quang Ninh and Ho Chi Minh City accounting for the largest shares. The stated rationale for free access was trial operation.

Circular No. 47/2024/TT-BTC, issued by the Ministry of Finance on 10 July 2024 and effective from 1 September 2024, ended that arrangement. Accounts issued under the previous regime ceased to operate on the effective date, and users were required to register and pay under the new schedule. Real-time correction data are charged per receiver on a monthly, six-monthly or annual basis, and 24-hour static GNSS data are charged per station per day. The charges apply in provinces and centrally governed cities where the national network has been densified, which is a further reminder that the network-RTK layer, not the geodetic layer, is the commercial product.

Two features of the schedule are worth noting before the analysis. The annual package is priced at a twenty-five per cent discount to twelve monthly purchases, whereas the six-month package offers only a 4.9 per cent discount, so the tariff is shaped to encourage long-term subscription by continuously operating firms rather than project-by-project use. Concessions exist for defence and security purposes at sixty per cent of the standard rate, and full exemption applies where data are required for defence, security or disaster response in declared emergencies. Table 2 sets out the schedule.

Table 2: Access charges for national positioning data under Circular No. 47/2024/TT-BTC, effective 1 September 2024

Data product	Unit	Charge (VND)	Effective monthly cost (VND)	Discount vs monthly purchase
Real-time kinematic correction data	1 month per receiver	750,000	750,000	—
Real-time kinematic correction data	6 months per receiver	4,280,000	713,333	4.9%
Real-time kinematic correction data	12 months per receiver	6,750,000	562,500	25.0%
24-hour static GNSS data	Per station per day	220,000	n.a.	n.a.

3. Literature and conceptual framework

3.1 Positioning infrastructure as an economic input

The economic literature on satellite positioning treats it as a general-purpose input whose value is realised in downstream sectors rather than in the positioning industry itself. Estimates of that value are large. Work for the United States economy attributed annual productivity gains and input-cost reductions of between 68 and 122 billion dollars to commercial use of satellite positioning, equivalent to roughly half to nine-tenths of one per cent of gross domestic product. Australian modelling reached a similar conclusion in a smaller economy, estimating that construction sector output in 2012 was between 440 and 710 million Australian dollars higher because of augmented positioning technologies used in site survey and machine guidance.

Two features of this literature are relevant here. It is dominated by computable general equilibrium modelling that aggregates across sectors, which is informative for a finance ministry weighing a national investment but of little help to an agency deciding how many stations to add or what to charge for access. And the productivity mechanism it invokes, in the surveying application at least, is almost entirely a reduction in labour input. That observation is what makes a workflow-level decomposition the natural unit of analysis, and it is the approach adopted below.

A later assessment of Australia's National Positioning Infrastructure Capability programme extended the framework to the infrastructure itself rather than the technology in general, valuing benefits net of user costs and modelling regional distribution. That study is the closest methodological precedent for what follows, although the Australian context differs sharply: the network draws on data-sharing agreements covering more than five hundred stations across a continent, and the labour costs that dominate the Vietnamese calculation are an order of magnitude higher.

3.2 Evidence on network RTK performance and productivity

The technical literature on network RTK is mature and consistent on two points. Network solutions outperform single-base RTK because distance-dependent errors are modelled across several reference stations rather than extrapolated from one, and performance degrades as inter-station distances grow. Testing of the Australian CORSnet-NSW network outside the Sydney metropolitan area, where inter-station distances exceed the twenty-five kilometre metropolitan average, documented that degradation directly and also showed that the quality indicators reported by rover equipment tend to be optimistic, a caution that matters for any productivity claim resting on first-fix times.

Performance in obstructed environments has been examined repeatedly, including forest boundary determination under canopy, where network RTK was compared against both static observation and total station work. The general finding is that centimetre accuracy cannot be guaranteed in all conditions, and that the technology substitutes for rather than wholly replaces optical instruments where satellite visibility is poor.

Productivity evidence, by contrast, is thinner and comes largely from industry rather than peer-reviewed sources. Reported gains cluster around a small number of mechanisms. Eliminating daily base-station establishment, which involves siting, tripod setup, power, initialisation and radio-link verification, is commonly reported to save between thirty and sixty minutes per job. Removing the base also removes the need for a second person to attend it, so a two-person crew can become a single operator. Accounts of boundary survey work describe a multi-day two-person total station task completed in one day by a single operator after the switch, and corridor work is reported to benefit particularly because positional error does not accumulate across repeated instrument setups. Integration of inertial sensors, which removes the need to level the pole, has been reported to add nearly fifty per cent to point-collection rates.

These figures are useful as orders of magnitude and unusable as parameters. They are drawn from vendor and practitioner sources with no common definition of the baseline, no control for job type, and an obvious selection toward favourable cases. The response adopted here is to treat them as bounds on a declared parameter range rather than as estimates, and to report results across that range.

3.3 Vietnamese research on CORS applications

Vietnamese work on CORS predates the national network. Research on virtual reference station solutions was completed in 2014 with the explicit aim of diversifying CORS applications, and subsequent studies examined the achievable accuracy of multi-station CORS positioning across terrain of varying complexity, including the effect of mobile network coverage on service availability. That last variable is easily overlooked and is a genuine constraint in mountainous provinces.

Since the network entered service, published work has concentrated on technical validation and on specific applications. Studies have addressed fixed virtual reference station solutions built on the national network, river cross-section survey using GNSS-RTK, survey and data processing for super-tall building construction, and the pairing of low-cost dual-frequency multi-constellation receivers with the national network, the last of which is directly relevant to the cost question because receiver price is a substantial barrier for small operators. Displacement across Vietnamese territory has also been determined from VNGEONET observations collected between August 2019 and March 2022, with results consistent with earlier published estimates.

What is absent from this body of work is any economic evaluation. No published study reports adoption rates, the composition of the user base, realised time savings, or the effect of the 2024 fee schedule. The six hundred accounts recorded around the launch remain the only publicly available adoption figure, and no comparable statistic has been published since. This is itself a finding, and Section 7 returns to it.

3.4 Conceptual framework

The framework used here treats surveying productivity as the outcome of a chain rather than a direct consequence of infrastructure. Physical infrastructure, meaning stations, their spacing and the reference frame they realise, determines what is technically available. Effective access, meaning fees, licensing, account administration and mobile connectivity, determines what is usable. Firm-level adoption, meaning equipment, skills and the reorganisation of crews, determines what is actually used. Only at the end of that chain does productivity change, measured as crew-hours per unit of output.

Each link is conditioned by a moderator. Network geometry governs the first, because a station that exists two hundred kilometres away is not available in any practical sense. Regulatory friction governs the second, since fee design and the norm regime jointly determine whether a technically accessible service is worth subscribing to. Absorptive capacity governs the third, because the labour-saving benefit is captured only by operators who reorganise crews rather than retaining a three-person team with better equipment. A feedback loop runs from demonstrated productivity back to investment, since densification decisions rest on evidence of use. Fig 2 sets out the framework, and the empirical sections address the first two links, where documentary evidence exists, while treating the third through declared parameters.

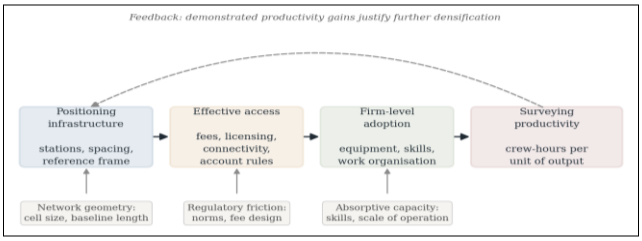

Fig 2: Conceptual framework linking positioning infrastructure to surveying productivity

4. Data and Methods

4.1 Analytical strategy

Measuring realised productivity would require field records from survey operators that are not in the public domain, and inventing them would be worse than not having them. The strategy adopted instead is conditional evaluation. The model quantifies the productivity gain and the net benefit that follow from a given set of technical and organisational parameters, then examines how far the conclusions survive as those parameters vary across their plausible range. Where a conclusion holds across the whole range, it can be stated without knowing the true parameter value. Where it does not, the paper says which parameter would have to be measured to settle the question.

Two counterfactuals are evaluated separately throughout, because merging them produces misleading averages. Configuration C0 is a fully conventional workflow using traverse or static GNSS control with a total station for detail. Configuration C1 is single-base RTK in which the operator establishes and maintains a base station. Configuration C2 is network RTK delivered through VNGEONET. Comparing C2 with C0 answers the question facing an under-equipped public survey unit. Comparing C2 with C1 answers the question facing a private firm that already owns GNSS equipment, and it is this incremental comparison against which the 2024 access fee must be judged.

4.2 Network geometry

Coverage is assessed by translating station counts into serviceable area. For a set of stations arranged with nearest-neighbour separation d, the natural service cell is the Voronoi hexagon, whose area is given by:

$$A(d) = (\sqrt{3} / 2) \cdot d^2 \approx 0.866\, d^2$$

The serviceable area of a layer with n stations is then $n \cdot A(d)$, which is compared against the national land area of 331,212 km². The exercise is deliberately generous to the network. It assumes every cell falls on land, ignores the loss of service where mobile data coverage is absent, and takes no account of the accuracy degradation documented at longer baselines. The resulting coverage share should therefore be read as an upper bound on the area over which network RTK is available at design performance.

The same relation inverted gives the nationally averaged spacing implied by a station count, which is useful for comparing networks whose stations are distributed differently:

$$\bar{d} = \sqrt{(A_{tot} / (0.866 \cdot n))}$$

International comparators are drawn from published network descriptions. Japan's GEONET comprises more than 1,300 stations at average intervals of roughly twenty kilometres. Malaysia operates MyRTKnet with 97 stations under the national survey department together with 21 stations in the Sarawak network. Australia's National Positioning Infrastructure Capability draws on data-sharing agreements covering more than five hundred stations. Station counts are matched to national land areas to produce comparable densities.

4.3 Workflow decomposition

A survey job is decomposed into four effort components: mobilisation and reconnaissance, control establishment, detail observation, and office processing. Under the conventional configuration these components take shares w of total crew-hours summing to unity. Each alternative configuration is characterised by three technology parameters and a crew size. The control elimination rate γ is the proportion of control-establishment effort removed. The detail-observation speed ratio κ is the rate at which detail points are collected relative to conventional work. The office-processing reduction δ is the proportion of post-processing effort removed, reflecting that real-time coordinates arrive in the national frame and require no baseline computation. Elapsed job time under configuration j is therefore:

$$T_j = w_{mob} + w_{ctl}(1 - \gamma_j) + w_{det} / \kappa_j + w_{off}(1 - \delta_j)$$

And crew-hours per unit of output follow as:

$$H_j = T_j \cdot n_j$$

Where n_j is field crew size. Two productivity ratios follow from this. The elapsed ratio T_0 / T_j measures schedule compression, which is what a client experiences. The labour ratio H_0 / H_j measures labour productivity, which is what determines cost. The two diverge whenever crew size changes, and that divergence is the main reason infrastructure benefits are understated when only elapsed time is reported.

Crew size under C2 is set at 1.6 persons rather than an integer, representing a mix of single-operator and two-person deployment across job types. This is a modelling convenience and is tested directly in the sensitivity analysis, where crew size proves to be the single most influential parameter.

Two sources are used to bound the effort parameters. The technical-economic norms issued under Circular No. 70/2025/TT-BNNMT provide legally binding labour requirements per unit of output, together with prescribed crew establishments and an explicit apportionment of effort across work steps within a photo-control job. These are used to anchor the control-establishment component and are reported in Section 5.3. The remaining parameters are bounded by the magnitudes reported in the practitioner literature reviewed in Section 3.2, which are treated as ranges rather than estimates.

4.4 Cost, break-even and capital avoidance

Against a counterfactual in which crew-hours per unit of output fall by a proportion s, a subscribing operator recovers the annual access charge F once annual productive field-days N satisfy:

$$N^* = F / (s \cdot C)$$

Where C is the fully loaded cost of one crew-day. Expressing the result in field-days rather than in dong is deliberate, because it makes the size of the fee legible without requiring agreement on the wage level. The annual charge F is 6,750,000 VND per receiver, taken directly from Circular No. 47/2024/TT-BTC. Break-even is computed across a grid of crew-day costs from 1.5 to 3.5 million VND and saving rates spanning the ranges appropriate to each counterfactual.

A second cost channel operates independently of time saving. Network RTK removes the requirement to own a base receiver, since corrections arrive from the network. Annualising the avoided purchase over a seven-year service life gives a benefit that does not depend on how many days the equipment is used, and for capital-constrained operators this is frequently the decisive consideration.

4.5 Simulation and sensitivity

Deterministic results are supplemented by a Monte Carlo simulation of 200,000 draws. Effort shares and the three technology parameters are drawn from triangular distributions over their declared ranges, shares are renormalised to sum to unity, and crew size under C2 is drawn as one or two persons with probabilities of 0.40 and 0.60. Productive field-days and crew-day cost are drawn independently. The simulation reports the distribution of crew-hour savings, benefit-cost ratios and net benefit per receiver-year under each counterfactual, together with the probability that the saving is negative, which is the outcome an operator would most want to know about.

A tornado analysis then varies each parameter individually across its full range while holding the others at baseline, applied to the incremental case against single-base RTK, since that is where the fee decision is actually made. Table 3 lists every parameter, its range, and its provenance.

Table 3: Model parameters, ranges and provenance

Parameter	Symbol	Baseline	Range	Provenance
National land area	A	331,212 km²	fixed	Official national statistics
NRTK stations	n	41	fixed	Network documentation
Design station spacing	d	65 km	50–80 km	Network documentation
Annual access charge	F	6,750,000 VND	fixed	Circular No. 47/2024/TT-BTC
Mobilisation share	w_mob	0.15	0.10–0.22	Model parameter
Control share	w_ctl	0.30	0.20–0.40	Bounded by norm-based control shares (Table 6)
Detail share	w_det	0.40	0.30–0.50	Model parameter
Office share	w_off	0.15	0.10–0.22	Model parameter
Control elimination, single-base	γ_1	0.55	0.40–0.70	Norm structure of control effort (Table 6); reported base-setup savings
Control elimination, NRTK	γ_2	0.80	0.65–0.92	Norm structure of control effort (Table 6); reported base-setup savings
Detail speed ratio, single-base	κ_1	2.20	1.80–2.60	Bounded by reported collection-rate gains
Detail speed ratio, NRTK	κ_2	2.35	1.90–2.90	Bounded by reported collection-rate gains
Office reduction, single-base	δ_1	0.45	0.30–0.60	Model parameter
Office reduction, NRTK	δ_2	0.55	0.40–0.70	Adjustment step is 3.2% of control effort (Table 6)
Field crew size, C0	n_0	3.0	fixed	Conventional crew; norms prescribe 4–5 (Table 6)
Field crew size, C1	n_1	2.0	fixed	Base plus rover operation
Field crew size, C2	n_2	1.6	1.0–2.0	Model parameter
Productive field-days per year	N	140	80–200	Model parameter
Crew-day cost	C	2,400,000 VND	1.5–3.4 million VND	Model parameter
Base receiver purchase price	P	220,000,000 VND	150–320 million VND	Model parameter
Equipment service life	L	7 years	fixed	Model parameter

4.6 What the method can and cannot establish

The model is an engineering-economic construction, not an econometric estimate, and it should be read accordingly. It cannot establish that Vietnamese surveying productivity rose after 2019, because that would require output and input data by operator over time, which have not been published. It can establish the sign and approximate magnitude of the gain implied by the network's technical characteristics, identify which parameters the conclusion is sensitive to, and determine whether the fee schedule is large or small relative to the benefit. Those are the questions the policy debate actually turns on, and they can be answered with documented inputs.

5. Results

5.1 Coverage of the network RTK layer

The forty-one network-RTK stations generate a serviceable envelope that depends strongly on the spacing assumed. At the lower bound of the design range, fifty kilometres, each station serves 2,165 km² and the layer covers 88,768 km², or 26.8 per cent of national land area. At the upper bound of eighty kilometres, coverage rises to 227,245 km², or 68.6 per cent. Taking the midpoint of sixty-five kilometres gives 150,017 km², or 45.3 per cent. Table 4 sets out the calculation and Fig 3 plots it.

The geodetic layer presents the opposite picture. At 150 kilometre spacing its twenty-four stations generate a nominal envelope of 467,654 km², and at 200 kilometres, 831,384 km², in both cases exceeding national land area. The reference-frame function is therefore comfortably served across the whole territory, while the real-time positioning function is not. This asymmetry is by design, but its practical consequence deserves emphasis: a surveyor in a province outside the three densified regions has a national reference frame available and no network RTK service, which from a productivity standpoint is close to having nothing.

The nationally averaged spacing makes the same point in a different unit. Spreading forty-one stations evenly across the country would imply a mean separation of 96.6 kilometres, well beyond the fifty to eighty kilometre design range. The design figure describes conditions inside the densified regions; the national average describes the country as a whole. Both are correct, and conflating them overstates what the network delivers.

Planned densification changes the arithmetic substantially. Adding the ninety to one hundred network-RTK stations reported as planned would bring the layer to 131 or 141 stations. At fifty kilometre spacing that produces coverage of 85.6 to 92.2 per cent, and at sixty-five kilometres or above the layer saturates national land area. Expansion on this scale converts a regional service into a national one, which is a materially different proposition from incremental addition.

Table 4: Theoretical service coverage of the VNGEONET network RTK layer

Station spacing d (km)	Service cell area (km²)	Coverage, 41 stations (km²)	Share of land area (%)	Share with +90 stations (%)	Share with +100 stations (%)
50	2,165	88,768	26.8	85.6	92.2
65	3,659	150,017	45.3	100.0	100.0
80	5,543	227,245	68.6	100.0	100.0

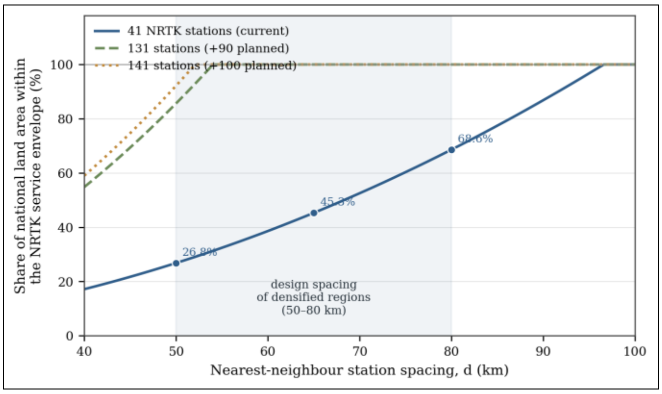

Fig 3: Share of national land area within the network RTK service envelope, by station spacing and station count

5.2 International benchmarking

Placing VNGEONET alongside comparable national networks clarifies where it sits. The network-RTK layer delivers 1.24 stations per 10,000 km², and counting all sixty-five stations gives 1.96. Malaysia, a country of almost identical land area, operates 118 stations across its national and Sarawak networks, a density of 3.57, roughly three times the Vietnamese network-RTK figure. Japan is in a different category altogether at 34.39 stations per 10,000 km², an implied mean spacing of about eighteen kilometres, consistent with the twenty to thirty kilometre interval reported for GEONET.

Australia appears to be the sparsest network in the comparison at 0.65 stations per 10,000 km², but that figure is an artefact of continental scale and a population distribution concentrated on the coastal fringe, and it should not be read as evidence that low density is unproblematic. The relevant comparators for Vietnam are Malaysia and, as an aspiration, Japan.

Planned densification would lift Vietnam to 4.83 stations per 10,000 km², placing it above Malaysia and implying a mean spacing near forty-nine kilometres. That is a credible target for a middle-income country and would bring the whole national territory inside the service envelope at the lower end of the design spacing. Table 5 and Fig 4 present the comparison.

Table 5: International comparison of national CORS network density

Network	Stations	Land area (km²)	Stations per 10,000 km²	Implied mean spacing (km)
Vietnam, VNGEONET network RTK layer	41	331,212	1.24	97
Vietnam, VNGEONET all stations	65	331,212	1.96	77
Vietnam, planned post-expansion	160	331,212	4.83	49
Malaysia, MyRTKnet and SGeDNet	118	330,803	3.57	57
Japan, GEONET	1,300	377,975	34.39	18
Australia, NPIC shared streams	500	7,692,024	0.65	133

Notes: Station counts from published network descriptions; Malaysian figures are as at 2021. Implied mean spacing computed as $\sqrt{A / 0.866n}$ and represents even distribution, which none of these networks achieves exactly. Australia's low density reflects continental scale rather than service inadequacy in populated areas. Source: author's calculation from the sources cited in Section 4.2.

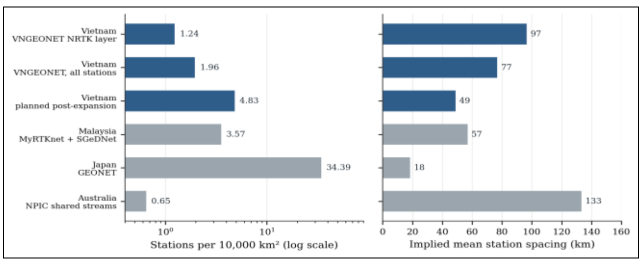

Fig 4: National CORS network density and implied mean station spacing, selected countries

5.3 Evidence from the statutory norm system

The technical-economic norms carry information that has not previously been used to assess the network, because they state in legally binding form how much labour each survey operation is deemed to require. Circular No. 70/2025/TT-BNNMT, issued on 28 November 2025 and effective from 15 January 2026, consolidates these norms and supersedes five earlier instruments. Its provisions on the class III national coordinate network and on photo control are directly comparable with the workflow model, and they allow several parameters to be replaced by documented values.

Establishing one class III coordinate point is normed at 2.73 group-workdays for site selection, 4.65 for monumentation and enclosure construction, 2.08 for static GNSS observation and 0.71 for network adjustment under difficulty class 2. Multiplying by the prescribed crew establishments of five, four, five and two persons respectively gives 44.1 person-days per point. The equivalent totals run from 39.3 person-days in the easiest terrain to 72.2 in the most difficult, a gradient of 1.84. Table 6 sets out the calculation and Fig 5 plots it.

That gradient deserves emphasis because it interacts with the coverage result. The norm system itself records that control establishment costs almost twice as much in mountainous, remote and island terrain as in the delta. Those are precisely the areas lying outside the network RTK envelope mapped in Section 5.1. The infrastructure is densest where the statutory cost of doing without it is lowest.

Three further provisions bear on the productivity question. The observation norm is defined for a session of three to four hours per point, equivalent to half a group-workday, with additional time charged by an explicit formula, and the adjustment norm rises by a factor of 1.20 for sessions between four and twenty-four hours and 1.50 beyond that. The equipment norm for observation specifies a set of two multi-frequency GNSS receivers at 0.54 machine-shifts per point, which is the base-and-rover pair that network RTK makes unnecessary. Taken together, the observation and adjustment steps account for 26.8 per cent of the person-days attributed to a class III point, and it is this portion, rather than the 42.2 per cent absorbed by monumentation, that a correction service can collapse.

The photo-control provisions are more striking still. Effort within a GNSS photo-control job is apportioned by published coefficients of 0.60 to site selection, 0.35 to observation and 0.05 to computation, which supplies a documented decomposition for the control component of the workflow model. Yet the accompanying note specifies that the labour norm for photo control by electronic total station is identical to the norm for photo control by GNSS, even though the equipment norm differs by a factor of 4.88, at 2.49 machine-shifts per sheet for the total station against 0.51 for the GNSS receiver set.

A norm system that recognises a fivefold difference in equipment utilisation between two methods while treating their labour requirements as equal is not a neutral accounting convention. It means that an operator switching from optical to satellite methods is credited with no labour saving at all in the settlement of publicly funded work. No provision anywhere in these chapters establishes a separate norm for real-time kinematic or network RTK methods, although the abbreviation schedule defines the term. The productivity that Section 5.4 goes on to quantify is, for work settled against these norms, currently invisible.

Table 6: Statutory labour norms for establishing one class III national coordinate point, by difficulty class

Work step	Crew (persons)	KK1	KK2	KK3	KK4	KK5
Site selection, group-workdays	5	2.38	2.73	3.32	3.91	4.51
Monumentation and enclosure, group-workdays	4	4.28	4.65	5.53	6.43	7.51
Static GNSS observation, group-workdays	5	1.78	2.08	2.53	3.03	3.64
Network adjustment, group-workdays	2	0.71	0.71	0.71	0.71	0.71
Site selection, person-days		11.90	13.65	16.60	19.55	22.55
Monumentation and enclosure, person-days		17.12	18.60	22.12	25.72	30.04
Static GNSS observation, person-days		8.90	10.40	12.65	15.15	18.20
Network adjustment, person-days		1.42	1.42	1.42	1.42	1.42
Total person-days per point		39.34	44.07	52.79	61.84	72.21
Index (KK1 = 100)		100	112	134	157	184

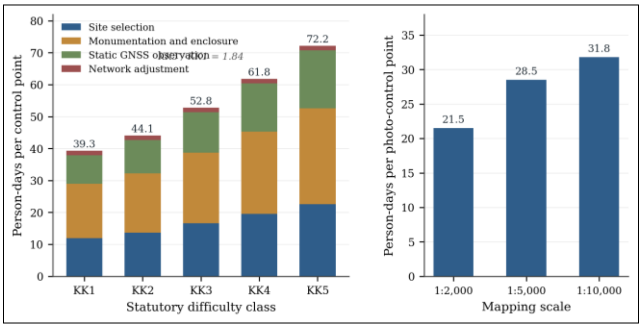

Fig 5: Statutory labour requirement for control establishment: class III coordinate points by difficulty class, and photo-control points by mapping scale

5.4 Workflow productivity

Under the baseline parameters, single-base RTK reduces elapsed job time to 54.9 per cent of the conventional workflow and crew-hours per unit of output to 36.6 per cent, the larger reduction reflecting the move from a three-person to a two-person crew. Network RTK reduces elapsed time further to 44.8 per cent and crew-hours to 23.9 per cent.

Expressed as ratios, network RTK compresses the schedule by a factor of 2.23 relative to conventional work and raises labour productivity by a factor of 4.19, a crew-hour saving of 76.1 per cent. Against single-base RTK the corresponding figures are considerably more modest: a schedule compression factor of 1.23 and a labour productivity ratio of 1.53, a crew-hour saving of 34.8 per cent.

The gap between those two comparisons is the analytical centre of this paper. A public survey unit moving directly from conventional methods to network RTK sees its labour requirement fall by roughly three-quarters. A private firm already operating a base-and-rover pair sees perhaps a third, and the greater part of even that comes from releasing a crew member rather than from faster observation. Policies that assume the larger number will overstate the return to subscription among exactly the operators most likely to subscribe. Table 7 and Fig 6 present the decomposition.

Table 7: Workflow decomposition and productivity ratios by technology configuration

Effort component and indicator	C0 Conventional	C1 Single-base RTK	C2 Network RTK (VNGEONET)
Mobilisation and reconnaissance	0.150	0.150	0.150
Control establishment	0.300	0.135	0.060
Detail observation	0.400	0.182	0.170
Office processing	0.150	0.083	0.068
Elapsed time index (C0 = 100)	100.0	54.9	44.8
Field crew size (persons)	3.0	2.0	1.6
Crew-hours index (C0 = 100)	100.0	36.6	23.9
Elapsed ratio vs C0	1.00	1.82	2.23
Labour productivity ratio vs C0	1.00	2.73	4.19
Labour productivity ratio vs C1	—	1.00	1.53
Crew-hour saving vs C0 (%)	—	63.4	76.1
Crew-hour saving vs C1 (%)	—	—	34.8

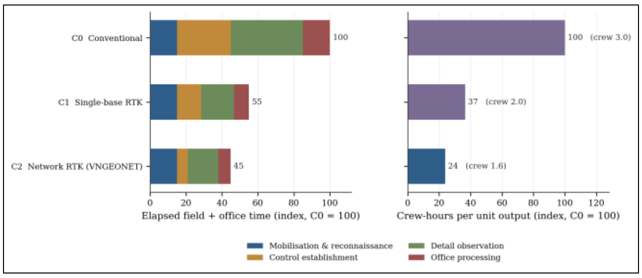

Fig 6: Workflow effort decomposition and crew-hour requirements by technology configuration

5.5 Where the incremental gain comes from

Because the incremental comparison drives the fee decision, it is worth examining how the gain behaves as the two technology parameters move. Fig 7 maps the crew-hour saving against single-base RTK across the full range of the control elimination rate and the detail-observation speed ratio, separately for two-person and single-operator deployment.

The two panels look almost nothing alike, and that is the result. With a two-person crew retained, the saving spans roughly minus seven to thirty-five per cent across the entire parameter space, turning negative in the lower-left corner where network RTK offers little advantage in control elimination or observation speed. With a single operator, the saving ranges from about forty-six to sixty-eight per cent and never approaches zero at any point in the space. Crew reorganisation, not technical performance, separates a marginal investment from a clearly profitable one.

This has an immediate practical reading. An operator who subscribes to the network, keeps the same three-person or two-person crew and simply works faster will capture a modest gain. An operator who restructures deployment around single-operator work will capture several times as much, from identical technology and an identical subscription.

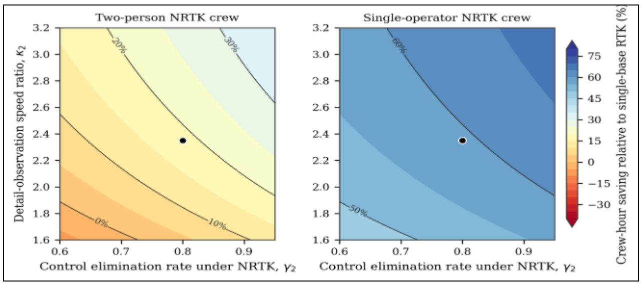

Fig 7: Crew-hour saving relative to single-base RTK across the technology parameter space, by crew size

5.6 Is the access charge material?

At the baseline crew-day cost of 2.4 million VND, the annual charge of 6,750,000 VND is equivalent to 2.8 crew-days of labour. That framing already suggests the answer, and the break-even calculation confirms it.

Against the conventional counterfactual, at a saving rate of fifty-five per cent and a crew-day cost of 2.4 million VND, the charge is recovered after 5.1 productive field-days. Against single-base RTK the requirement is higher but still modest. At a twelve per cent saving rate and the same crew-day cost, break-even arrives after 23.4 field-days. Across the full grid of saving rates from five to twenty-five per cent and crew-day costs from 1.5 to 3.5 million VND, break-even ranges from 7.7 to 90 field-days per receiver-year. Even the most pessimistic corner of that grid, in which a low-wage operator captures only a five per cent saving, is reached within a normal working year. Table 8 and Fig 8 report the grid.

Capital avoidance reinforces the conclusion through an entirely separate channel. Annualising the avoided purchase of a base receiver over seven years yields between 21.4 and 45.7 million VND per year depending on the purchase price assumed, with a central value of 31.4 million. That is 4.7 times the annual access charge, and unlike the labour saving it accrues whether or not the equipment is intensively used. For a small operator deciding whether to buy a second receiver or subscribe to the network, the arithmetic is not close.

Table 8: Break-even field-days per receiver-year, incremental case against single-base RTK

Crew-hour saving	C = 1.5M VND	C = 2.0M VND	C = 2.5M VND	C = 3.0M VND	C = 3.5M VND
5%	90.0	67.5	54.0	45.0	38.6
10%	45.0	33.8	27.0	22.5	19.3
15%	30.0	22.5	18.0	15.0	12.9
20%	22.5	16.9	13.5	11.2	9.6
25%	18.0	13.5	10.8	9.0	7.7

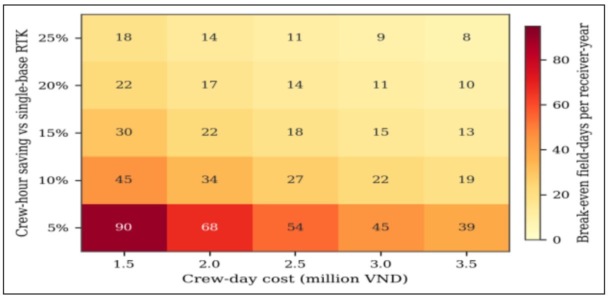

Fig 8: Break-even field-days per receiver-year under the 2024 access charge, incremental case

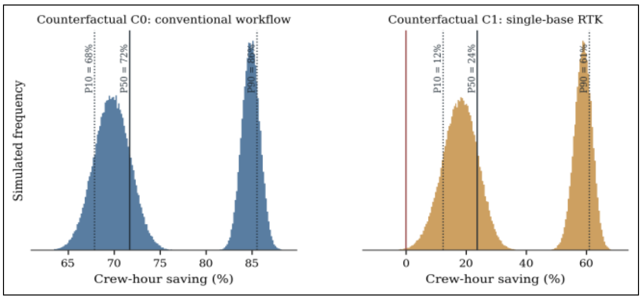

Fig 9: Simulated distribution of crew-hour savings under both counterfactuals

5.7 Simulation results

The Monte Carlo simulation confirms the deterministic pattern and adds information about dispersion. Against the conventional counterfactual the median crew-hour saving is 71.7 per cent, with a tenth percentile of 67.9 and a ninetieth of 85.6, corresponding to a median labour productivity ratio of 3.53. Median gross benefit per receiver-year is 251.8 million VND and the probability of positive net benefit is essentially unity.

The incremental comparison behaves quite differently, and its dispersion is the more informative result. The median crew-hour saving against single-base RTK is 23.7 per cent, but the tenth percentile falls to 12.3 and the ninetieth rises to 61.0, a spread of nearly fifty percentage points. Median gross benefit is 85.2 million VND per receiver-year and median net benefit 78.4 million, giving a benefit-cost ratio with a median of 12.6 and a tenth percentile of 5.5. The probability of net benefit being positive is 99.74 per cent, and the probability that crew-hours actually increase is 0.09 per cent.

Two readings follow. The subscription decision is not close under any plausible configuration, which is a reassuring result for an operator. But the wide dispersion of the incremental saving means the aggregate productivity effect of the network across the sector cannot be predicted from technology alone, since it depends on how many operators reorganise their crews. Fig 9 shows both distributions and Table 9 reports the summary statistics.

Table 9: Monte Carlo simulation results, 200,000 draws

Indicator	C0: P10	C0: P50	C0: P90	C1: P10	C1: P50	C1: P90
Crew-hour saving (%)	67.9	71.7	85.6	12.3	23.7	61.0
Labour productivity ratio	3.11	3.53	6.92	1.14	1.31	2.56
Gross benefit (million VND)	176.7	251.8	348.6	37.3	85.2	232.8
Net benefit (million VND)	169.9	245.1	341.9	30.6	78.4	226.1
Benefit-cost ratio	26.2	37.3	51.6	5.5	12.6	34.5
Probability of positive net benefit (%)	-	100.00	-	-	99.74	-
Probability of negative crew-hour saving (%)	-	0.00	-	-	0.09	-

5.8 Sensitivity

The tornado analysis, applied to the incremental case with a baseline net benefit of 110.2 million VND per receiver-year, ranks the parameters unambiguously. Field crew size under network RTK produces the widest swing at 136.9 million VND, followed by productive field-days at 100.2 million and crew-day cost at 92.6 million. The three technology parameters, which are the ones most often debated, produce swings of 22 to 40 million VND, an order of magnitude smaller than crew size.

The ordering carries a clear message. Whether the investment pays is governed by how work is organised and how intensively the equipment is used, not by how well the correction service performs within its normal operating envelope. Improving network performance from the lower to the upper end of its plausible range moves net benefit by roughly a third. Moving from two-person to single-operator deployment more than triples it. Fig 10 presents the ranking.

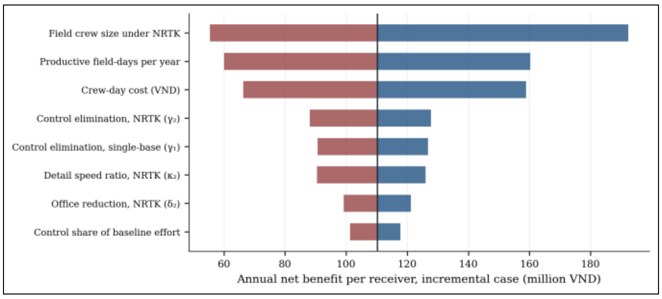

Fig 10: Tornado sensitivity of annual net benefit per receiver, incremental case against single-base RTK

6. Discussion

6.1 A coverage problem, not a pricing problem

The debate that followed the introduction of access charges in September 2024 focused almost entirely on the charges themselves. The results here suggest that focus was misplaced. An annual subscription of 6,750,000 VND per receiver is recovered within twenty-three field-days against the most conservative realistic counterfactual and within about five against the conventional one. Measured against a working year of well over a hundred productive days, the charge is a rounding error in an operator's cost structure, and the avoided purchase of a base receiver is worth several times more than the subscription costs.

What does constrain realised productivity is geography. Between 31 and 73 per cent of national land area sits outside the network RTK envelope even on assumptions generous to the network, and the shortfall is concentrated in exactly the terrain where conventional survey is slowest and most expensive: mountainous and remote districts where traverse work is laborious and where the productivity gain would consequently be largest. The network delivers its benefit most abundantly where survey was already easiest.

This is not a criticism of the original design, which allocated a fixed budget sensibly by densifying where economic activity and cadastral demand were greatest. It does mean that the next increment of investment has a different economic character from the first. The first sixty-five stations bought reference frame plus service in the high-demand regions. The next ninety to one hundred would buy service in regions where the per-station benefit may be lower in volume but higher in intensity, and where the alternative is not single-base RTK but conventional survey.

A qualification belongs here. Correction data reach users over mobile networks, so network RTK coverage cannot exceed mobile data coverage, and earlier Vietnamese research identified this explicitly as a determinant of achievable performance. In the mountainous provinces where densification would deliver the largest per-job gain, mobile coverage is also weakest. Station construction alone may not deliver service, and a densification programme that does not account for connectivity risks building stations whose corrections cannot be received.

6.2 The organisational condition

The finding that crew size dominates every technical parameter is consistent with a long-standing pattern in the productivity literature, in which the returns to a general-purpose technology depend on complementary organisational change rather than on the technology itself. Network RTK is an unusually clean instance. The technology's central capability is that it removes the need for anyone to attend a base station, and an operator who continues to field a two-person crew has purchased that capability and declined to use it.

Vietnamese conditions make the failure to reorganise more likely than elsewhere. Public survey units operate under staffing establishments that are not easily reduced, and contracts priced under technical-economic norms are settled against normed labour inputs rather than actual ones. If the norm regime assumes a crew of a given size, a unit that deploys fewer people may find the saving accrues to the budget rather than to itself, which removes the incentive to reorganise. The productivity potential quantified in Section 5 is then technically available and institutionally locked.

Safety and quality assurance also bear on this. Single-operator field work in remote terrain raises genuine occupational risk, and the case for retaining a second person is not purely inertial. The point is not that every crew should be reduced, but that the economic case for the network is far stronger where reduction is feasible, and that this is where deployment should be prioritised.

6.3 Norms, settlement and the transmission of technical change

The technical-economic norm system is the transmission mechanism between a technology that saves time and an operator that benefits from saving it, and the evidence in Section 5.3 shows that the mechanism is currently open-circuit. Norms define the labour deemed necessary per unit of output and thereby determine what publicly funded survey work costs and what it is settled at. If the norm does not move, the saving does not reach anyone.

Two provisions of Circular No. 70/2025/TT-BNNMT make this concrete. The labour norm for photo control is identical whether the work is done by electronic total station or by GNSS, while the equipment norm differs by a factor of 4.88. And no norm anywhere in the consolidated instrument distinguishes real-time kinematic or network RTK methods from static observation, although the abbreviation schedule defines the term and the observation norm is explicitly built around a three to four hour session using a pair of receivers. An operator who completes the same work in minutes with a single receiver connected to VNGEONET is settled at the norm for a method it no longer uses.

The consequences run in both directions and neither is benign. Where contracts are settled at normed labour inputs, the operator captures the saving as margin and the state pays for efficiency it is not receiving, which is a fiscal problem. Where a public survey unit is staffed to the prescribed establishment of four or five persons, the unit cannot convert the saving into anything at all, because the crew size that Section 5.8 identifies as the dominant determinant of net benefit is fixed by the same instrument that fixes the norm. The technology is adopted, the capability exists, and the productivity remains on paper.

That the consolidation took effect in January 2026, six years after the network entered service and more than a year after access was priced, indicates how far norm revision has lagged the infrastructure. Whether to norm network RTK separately, and how any saving should be shared between the state and operators during a transition, is a decision that can be made deliberately or allowed to emerge from the timing of successive circulars. It has so far emerged.

6.4 Comparison with other national programmes

Set against Japan and Malaysia, the Vietnamese network is a first-generation facility that has not yet been densified to service standard. Japan's GEONET, with more than 1,300 stations at twenty to thirty kilometre intervals, is a different class of infrastructure supporting continuous deformation monitoring alongside survey. Malaysia, with almost identical land area and population density patterns, operates roughly three times the Vietnamese station density. The planned expansion would close that gap and place Vietnam ahead of Malaysia, which is a reasonable regional benchmark.

The Australian experience is instructive for a different reason. Its economic assessments were commissioned as part of the investment case and were designed to value benefits net of user costs and to model regional distribution, which produced evidence usable in subsequent funding decisions. Vietnam has made an investment of comparable strategic significance without an equivalent evaluation framework. Building one need not be elaborate, and Section 7 sets out what a minimum version would require.

7. Policy implications

Four implications follow directly from the results, and they are ordered by the size of the effect the analysis attributes to them.

Densification should take priority over pricing reform. Coverage of the network RTK layer is between 26.8 and 68.6 per cent of national land area, while the access charge is recovered within a few weeks of field work. Effort spent adjusting the tariff will move realised productivity far less than effort spent extending the service envelope. The planned addition of ninety to one hundred stations would bring the whole territory inside the envelope at fifty kilometre spacing and should be treated as the central productivity measure of the strategy adopted under Resolution No. 40/NQ-CP rather than as a technical follow-on.

Station siting should be planned jointly with mobile data coverage. Corrections that cannot be received deliver nothing. A joint siting exercise between the surveying and mapping authority and telecommunications operators would identify districts where a station must be accompanied by connectivity investment, and would avoid building capacity that cannot be used.

Network RTK should be separately normed. The consolidated norms price photo control identically whether performed by total station or by GNSS, differentiate the two only in equipment utilisation, and make no provision for real-time kinematic methods, so no saving from the network reaches the settlement of publicly funded work. Establishing a distinct norm, and stating explicitly how the saving is shared between the state and operators during a transition, would convert technical capability into either lower public cost or stronger adoption incentives. Leaving the question to the timing of successive circulars produces neither.

Adoption statistics should be published as a routine series. The six hundred accounts reported around the launch remain the only public adoption figure, and no series has been published since the move to paid access, which means the effect of the 2024 charges on take-up is unknown. A quarterly series reporting active subscriptions by province and package type, correction sessions served, and the mix between real-time and static products would cost almost nothing to produce, since the data are already generated by the billing system. Without it, neither this analysis nor any other can move from conditional to measured evaluation, and the next densification decision will be made on the same evidence base as the last. Table 10 maps each constraint identified in the analysis to the instrument that addresses it.

Table 10: Identified constraints and corresponding policy instruments

Constraint identified	Evidence in this study	Policy instrument	Responsible body
Network RTK service envelope covers only part of national territory	Coverage of 26.8–68.6% of land area (Table 4)	Construct the planned 90–100 additional NRTK stations, prioritising districts outside the three densified regions	Surveying and mapping authority
Correction delivery depends on mobile data coverage	Identified in prior Vietnamese research; concentrated in mountainous provinces	Joint station siting and connectivity planning with telecommunications operators	Surveying and mapping authority with telecommunications regulator
Benefit is conditional on crew reorganisation	Crew size produces the largest sensitivity swing (Fig 10)	Revise staffing and deployment guidance for public survey units; address occupational safety in single-operator work	Provincial land and survey agencies
Norm system does not register the technology	Identical labour norm for total station and GNSS photo control despite a 4.88-fold equipment-norm difference; no norm for RTK methods (Table 6)	Establish a distinct network RTK norm and publish the transitional sharing rule	Ministry responsible for surveying and mapping norms
Adoption is unobserved after the move to paid access	No published series since the launch-period account figure	Quarterly publication of active subscriptions, sessions served and product mix from billing records	Network operating centre
No evaluation framework for the investment	Absence of any published economic assessment (Section 3.3)	Commission a benefit assessment net of user costs, with regional disaggregation	Ministry responsible for surveying and mapping

Source: Compiled by the author from the analysis in Sections 5 and 6.

8. Limitations

The principal limitation is that this is a conditional assessment rather than a measurement. The control-establishment parameters are anchored in the statutory norms reported in Section 5.3, which are documented and binding, but the remaining effort parameters are bounded by magnitudes reported in the practitioner literature rather than estimated from primary observation. Readers should treat the direction and approximate magnitude of the findings as robust, since they survive across the full parameter space, and treat the point estimates as illustrative until calibrated against operator records. The parameters still requiring calibration are identified individually in Table 3.

The coverage calculation is geometric and generous. It assumes regular tessellation, places every service cell on land, and ignores both terrain obstruction and the accuracy degradation that testing of comparable networks has documented at longer baselines. Actual service coverage will be lower than the figures in Table 4, which strengthens rather than weakens the paper's central argument about densification.

The analysis is confined to the surveying and mapping application. Precise positioning also supports agriculture, machine guidance in construction, transport and disaster monitoring, and in several national assessments those sectors account for the larger share of aggregate benefit. A full economic evaluation of VNGEONET would need to extend beyond the survey workflow modelled here.

Finally, the comparison of station densities across countries treats networks as if their stations were interchangeable, which they are not. Ownership, access model, correction quality and service guarantees differ substantially between the networks compared, and density is only a first approximation to service availability.

Three extensions would address these limitations directly. A field time-and-motion study across matched job types would convert the declared parameters into measured ones. A survey of licensed operators would establish the composition of the user base and the extent of crew reorganisation. And a spatial analysis combining station locations with mobile coverage and terrain would replace the geometric coverage estimate with a modelled service map, which is the single most useful input to the densification decision.

9. Conclusion

Vietnam built a national positioning network on the expectation that it would raise surveying productivity, and then began charging for access on the same expectation. This paper has assessed both decisions against what can be documented, and reaches a conclusion that inverts the terms of the usual debate.

The productivity potential is real and large. Relative to a conventional workflow, network RTK reduces crew-hours per unit of output by roughly three-quarters under baseline parameters, with a simulated median saving of 71.7 per cent. Relative to single-base RTK, which is the realistic counterfactual for most equipped firms, the median saving is 23.7 per cent, still substantial but an order of magnitude less dramatic than the headline figure, and dependent almost entirely on whether crews are reorganised.

The access charge introduced in 2024 is not a meaningful constraint on that potential. It is recovered within twenty-three field-days on conservative assumptions and within five against the conventional counterfactual, and the avoided purchase of a base receiver is worth about 4.7 times the annual charge on its own. Arguments that the fee obstructs adoption are not supported by the arithmetic.

What does constrain the network is its extent. Forty-one network RTK stations cover between a quarter and two-thirds of national land area on assumptions that favour the network, and the uncovered remainder is concentrated in the terrain where the productivity gain would be greatest. Densification, planned jointly with mobile connectivity, is the measure that would convert technical capability into national productivity.

A second constraint is institutional and was not anticipated at the outset of this study. The norms that govern how publicly funded survey work is costed and settled price photo control identically whether it is performed by total station or by satellite methods, and establish no norm for real-time kinematic work at all. Whatever the network delivers technically, none of it is registered where public survey contracts are priced.

One further conclusion concerns evidence rather than infrastructure. Six years after the network entered service and two years after access was priced, the only public adoption figure remains the account count recorded at the launch. The billing system introduced in 2024 generates precisely the data needed to evaluate the investment, and publishing it as a routine series would allow the next densification decision to rest on measurement rather than, as here, on conditional inference from declared parameters. That is a low-cost reform with a high return, and it is the one this paper most firmly recommends.

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