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Tracking India's infrastructure development near the Line of Actual Control

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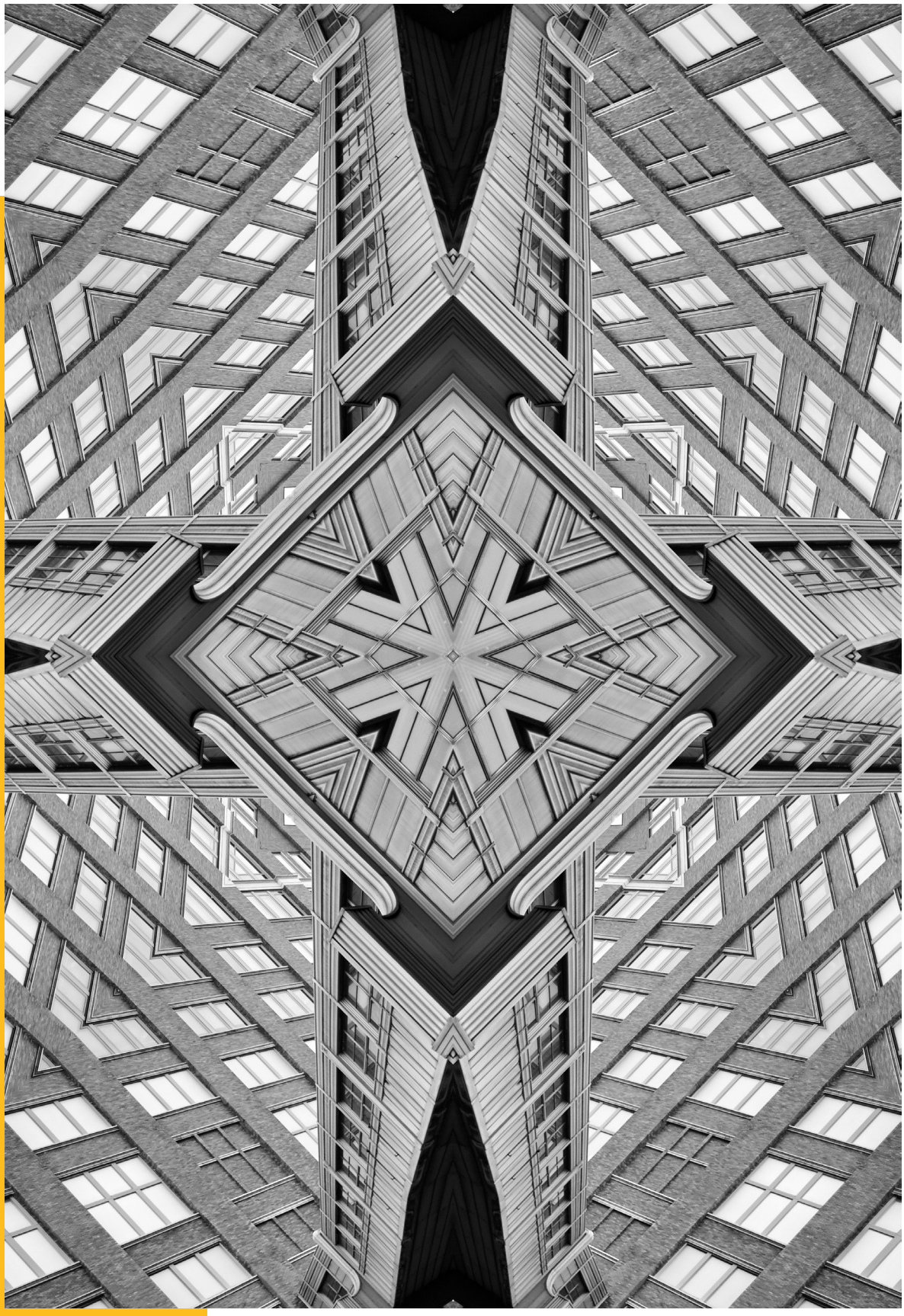

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Tracking India's Infrastructure Development Near the Line of Actual Control

John Swartz

Abstract

The pace of Indian infrastructure building along the Line of Actual Control (LAC) bordering China has historically been slow due to financial and doctrinal constraints, but has accelerated in the past 20 years. Construction has become more efficient owing to bureaucratic changes and the infusion of greater financial resources. This paper attributes these changes to strategic compulsions brought about by Chinese actions—both diplomatic and on-the-ground—related to the LAC. Overall, the Indian government has responded well to the changes in its strategic environment by improving the preparedness, resiliency, and capacity of its road and air infrastructure in the region. The paper notes, at the same time, that rail infrastructure continues to lag behind.

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Introduction

The pace of Indian infrastructure build-up along its border with China has increased dramatically in the last two decades. This has been caused largely by China's actions around the border dispute. India put specific mechanisms in place, and made available larger amounts of financing to facilitate the recent constructions.

Overall, the Indian government has managed to expand infrastructure networks to improve coverage of the Line of Actual Control (LAC) in the last 10 to 15 years. There have been vast improvements to the road network, in spite of doctrinal, natural, bureaucratic, and financial difficulties. The increased number of tunnels and bridges also signals far more investment, operational capacity, and technical capability, while independently adding to the quality of the road system. Regarding the air domain, India has maintained a strategic advantage—in some respects, and despite a smaller budget—by leveraging its topography (allowing India to launch aircraft at full capacity).[1] The picture is less bright, however, in terms of rail connectivity, where there is a large asymmetry. Nonetheless, India is in an overall better position today along the LAC, infrastructurally speaking, than it was 20 years ago.[a,b,2]

Prior to this period of growth, the Indian Government had been constrained by its own doctrine that prohibited building infrastructure. This changed, owing to strategic pressures and internal changes, largely stemming from the Chinese military's actions on the border and, diplomatically, from prolonged deadlocked negotiations with China regarding disputed territory.[3]

This paper briefly discusses the strategic importance of various types of infrastructure; describes the crucial hindrances to Indian infrastructure development along the LAC, starting in the 1950s and continuing to the present; and outlines the mechanisms and changes in environment that occurred which sped up infrastructure expansion. It also highlights air and rail infrastructure development, as these two have their own unique dynamics that need focused attention.

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a This paper will not make much mention of specific road quality around the LAC as there has been virtually no credible scholarship on the subject.

b Both the Ministry of Defence and BRO were reached out to for inquiry, however, neither organisation responded to the request.

Introduction

The author used secondary sources for background. For the rest of the data, the paper relied on primary sources (mostly government documents), along with interviews with domain experts.[c] News and scholarly articles were also used, where appropriate.

> "The Indian government has managed to expand infrastructure networks to improve coverage of the LAC in the last 10 to 15 years."

c These include Dr Manoj Joshi, Ambassador Ashok Kantha, Jayadeva Ranade, Dinakar Peri, Snehesh Alex Phillip, Rezaul Hasan Laskar, Kalpit Mankikar, Trisha Ray, and others who wished to remain anonymous.

Strategic Importance of Infrastructure

The LAC is the *de facto* border between India and China; it is distinct from the *de jure* legal boundaries that are not agreed upon. That said, especially in the past, it was often argued by China that the LAC was indeterminate and that therefore their incursions were accidental or not incursions at all.[4] The LAC came into existence around the time that China and India became independent following the Second World War, and when, in 1962, they fought a war over the border. After this war, the two sides had a somewhat agreed upon line that they would patrol up to or, in the case of incursions, pass—and this would be known as the LAC.[5] However, the nature of this mutually patrolled border would change after 2020, when the Chinese People's Liberation Army (PLA) launched a number of simultaneous incursions along the LAC, including one that turned violent, killing troops on both sides.[d] Some of these incursions would be quickly repelled or settled; however, to this day, two Chinese incursion points remain entrenched. These incidents changed the way the two countries patrol the LAC: they no longer stay far away from the border, patrolling the areas infrequently. Today, it is far more common to have very frequent patrols, with troops of both countries residing close to one another.[6]

Road and rail network

Given the kinds of rough terrains present along the Indian hinterlands, the proliferation of road infrastructure is critical for allowing a steady supply chain of fresh troops, adequate force induction speed, materiel movement, and cross deployments to support positions in a time of war. Given how brutal the environment is around the LAC, being cut off from supplies might not just lead to a serious tactical disadvantage; it could, even without enemy intervention, prove deadly. There are incidents where it has been clear that it was not the enemy that killed soldiers, but the environment itself.[7] Additionally, if there is a prolonged kinetic conflict in the future, the more road connections there are around the border, both longitudinal and lateral, the more resilient these supply chains will be to enemy interdiction.

d The ramifications of this incident will be a recurring theme in this paper.

Strategic Importance of Infrastructure

To elaborate, among these highly fragile mountains a single or couple of well-placed munitions—the kind which China has plenty of—can turn a critical road into a critical roadblock requiring time-consuming repairs, and severely hampering defensive or offensive action. However, if there are alternate routes within a short distance of a critical roadblock, supplies could be rerouted and moved with only minor delays.[8] The new surge in tunnelling not only provides faster routes, but also all-weather access—critical for the wetter months—and enemy fire resiliency.

The typical strategic strength of rail infrastructure is that massive volumes of materials and people can be moved rapidly. Rail also complements road and air. While road and air infrastructure excel at speed and resiliency, rail is important due to its efficiency. The weakness of rail is that it is more vulnerable to attacks, sabotage, and natural earth movement, thus making it unreliable in a larger conflict. Additionally, in this mountainous terrain it requires a high level of tunnelling and bridge making—the Jammu–Baramulla line being a testimony to this—which makes it highly costly and complex. For India, its importance has been debated given the current orientation of Indian forces and the difficulties it faces in construction and financing.[9]

In recent years, China has moved its forces closer to the front, and therefore, their force-induction-time is likely to be much faster. The Indian forces, however, largely reside farther from the border itself, and because of, in large part, the lack of rail transport, their force-induction-time would be much slower.[10] This makes rail transport indeed critical, but India must assess if it would be worth the cost.

Air power-related infrastructure

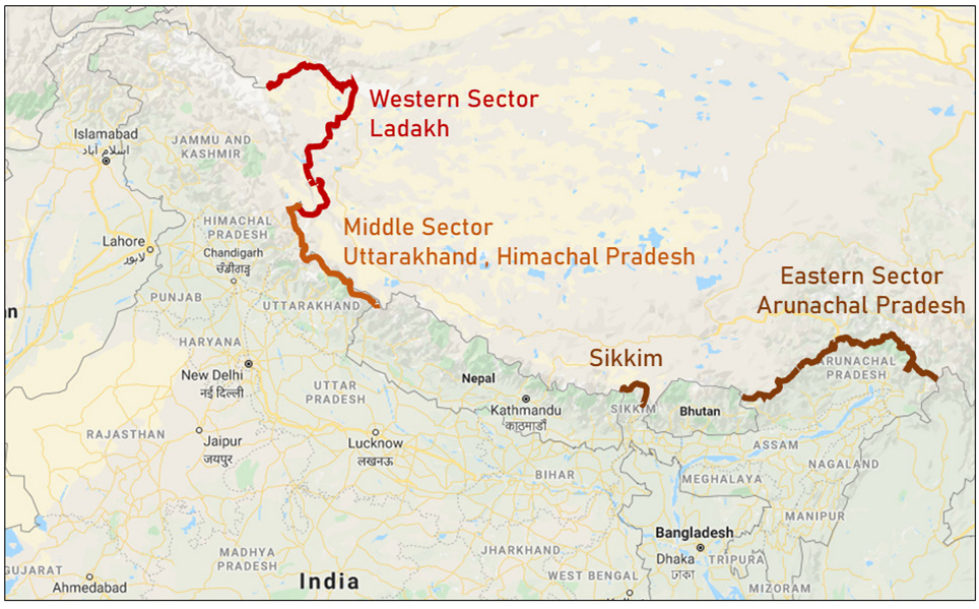
In the modern military age, air power-related infrastructure is crucial in securing the defence of or maintaining deterrence in key areas. The Indian military already has some natural advantage due to the topography along its side of the border.[11] Despite this advantage, India must seriously consider expanding its air power, as China has been massively, and multidimensionally, expanding theirs in the border region.[12] Additionally, given the fragility of the road infrastructure, it may be prudent to increase the availability of heavy lift and logistics focused helicopters, as they could prove crucial in resupplying military installations that have been heavily damaged or cut off.

Timelines

The real start of the infrastructure projects in the northern Indian hinterland has been rather piecemeal. There were efforts to build a road in Ladakh in 1965, Tawang got its first road in 1962, and Walong was only connected in the 1990s.[13] In 1960, the Border Roads Organisation (BRO) was formed for maintaining, managing, and constructing border roads. However, the largest infrastructure push started around the early 2000s with the United Progressive Alliance (UPA) government, largely prompted by China's aggression and border intrusions. The hostility produced an effective top-down effort from around 2014, though its intensity and effectiveness has oscillated.

The question is why India failed to initially create a significant infrastructure system near the LAC, despite the frequent face-offs and a war with China. The short answer is doctrine and terrain. To the other question of why India had such a slow construction pace, the answer is bureaucracy and finances.[14]

Figure 1. Map of the Line of Actual Control[15]



Source: Google Maps

Historical Hindrances and Impediments

Doctrine

Experts interviewed for this paper agree that up until the early 2000s, India's strategic doctrine prescribed very limited roads around the LAC and virtually none that go right up to it, defining the speed of infrastructure at the time and creating long-term ramifications.[16] The actual supplies up to the LAC at this point were often provided by specially-bred mule/yak trains or aircraft. The roots of this defensive doctrine likely stem from the failure of the Indian Army in the month-long 1962 war. In that war the Indian military, despite valiant efforts, failed to defend the LAC effectively. It was only when China called a unilateral ceasefire that their army stopped advancing, and soon afterward withdrew from most of the invaded area but retained control of about 38,000 sq km of territory in Aksai Chin. The military leadership, after this point, reasoned that if the first line of defence failed, it would be prudent to make the Chinese army's job more difficult by forcing them to trudge through the far tougher Indian terrain, show their cards (where they intended to attack), and allow the Indian military to mount a counter attack.[17] While this was the prevailing approach at the time, it would later bear poison fruit and force India to start building infrastructure well after the Chinese did.[e,f,18]

Environment

Apart from the doctrinal reasons, it was topography and climate that hugely influenced the Indian infrastructural position along the LAC. The terrain has been a definitive factor regarding the nature of the conflict contemporarily and historically.[g,19] The terrain of the Himalayas and their foothills are particularly precarious to build upon for a number of reasons: the mountain's drastic elevation changes and youthful fragility, and the climate.[20]

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e This thinking would later change later after the Indian military gained more technological capabilities, stemming largely from its increased rocket, and artillery capabilities.

f More recently, another change that occurred in the military establishment had to do with perceptions of Pakistan. A number of experts (Hasan Rezaul Laskar, interview with author, New Delhi, June 15, 2023; Snehesh Alex Phillip, interview with author, New Delhi, June 16, 2023) noted that strategic thinking used to be centered on Pakistan, but with that country currently in hot water, India has been allowed to focus its energies towards China.

g Specifically, the Himalayas creates a tactical environment where it is very difficult for either side to advance rapidly without stretching their supply lines and/or facing serious attrition.

Historical Hindrances and Impediments

First, the Himalayas have huge variation in elevation—from valley troughs to mountain zeniths. This means that any road constructed must travel along ridgelines, and if the roads require movement traversing ridges, technically complicated and expensive bridges or tunnels must be built. Additionally, movement without these tools—in the absence of bridges and tunnels—is glacial. When there are only roads along the mountain ridges, any damage to the road forces one to go all the way back down to the foot of the mountain, to start moving forward all over again.[21]

Second, due to the geologically young age of the mountain range, landslides and other forms of earth movement are very common.[22] This, and the third factor of climate—compound the cost of upkeep. As has been extensively recorded, often whole sections of road wash away during the rains, snows, and landslides, requiring annual repairs and vast maintenance budgets.[23] These problems influence rail infrastructure build up. Due to the already enormous construction expense of rail infrastructure, it may never make financial sense to build rail tracks that, in some areas, will inevitably be shaken or swept away.[24]

Finally, the climate makes construction more difficult in a multitude of ways. In the Himalayas, there are torrential downpours during the monsoon and snowfall of similar proportion during the winter. This means that in addition to the washing away of roads, any road construction that is ongoing must stop, as neither concrete nor asphalt can harden in these conditions. Therefore, work is limited to the drier half of the year. On top of this, many areas are routinely cut off during the winter and wetter months, as narrow passes fill with snow, making them impassable. Conditions for workers are also brutal because of the weather and elevation. Even machines struggle with the environment so the only equipment that is used is of medium and indigenous type, and is not state-of-the-art.[25]

Bureaucratic and Financial

The final broad reason why infrastructure took so long to develop near the LAC has to do with the government, primarily with regards to bureaucracy and finance. Starting around 2006, the Government of India, under then Prime Minister Manmohan Singh's UPA, came out with sweeping plans for LAC infrastructure expansion, including 73 planned roads.[h,i,26] However, little work was completed from 2006 to 2014.[27] What were the bureaucratic and financial problems that caused this lapse?

Analyst Jayadeva Ranade attributes it to the lengthy processes in a democracy, unlike in the Chinese system of government. "There they just draw a line and the PLA gets it done."[28] In India the line of command is ponderous: the army communicates what they want to the engineers; the engineers talk to the financiers; the financiers find the land and money required to compensate those owning it, and pay for it; then the environmental agencies, state governments, and interest groups have their say to make sure that the infrastructure will not interfere with the environment—and only then can construction begin. Crucially in this process, according to BRO sources, a large part of the problem was specifically getting forest clearance and land acquisition approvals.[29] These alone would often take at least three years.[30] Due to this slow, arduous process, the top-down push in 2006 failed to materialise.

For example, former Indian Ambassador to China, Ashok Kantha, says that during his tenure, one of the roads they had planned suffered serious delay because it crossed a protected elephant corridor.[31] These corridors are legally safeguarded in India, making it difficult to get approval to cross them.[32] This specific conflict could only be resolved when higher officials pushed the project through the bureaucratic mire.[33]

h Some scholars note that Vajapayee did also sanction 13 border roads to be constructed in 1999, however, most are unaware of this because it was not acted upon and is not mentioned in most public records.

i It would also be prudent to note that, while much of the Indian infrastructure development along the LAC is strategic, some part of the effort is 'innocent' in nature. These efforts towards increasing connectivity with its hinterlands generally, and increasing their level of development, are done in a very similar fashion to China's own efforts in their hinterlands.

Historical Hindrances and Impediments

Though financial matters were less publicly catalogued, it is clear that, according to BRO internal documents, the lack of funding before and around 2017 was a critical factor.[34] To emphasise the historical capacity constraints, according to Policy Guidelines for Changes in Construction Philosophy in BRO, during 2016—and before the advent of mass outsourcing and greater funding—out of a budget of INR 35.2 billion (US$429.7 million) about INR 5 billion (US$60.9 million) was spent on maintenance—a figure that increased in later years.[35]

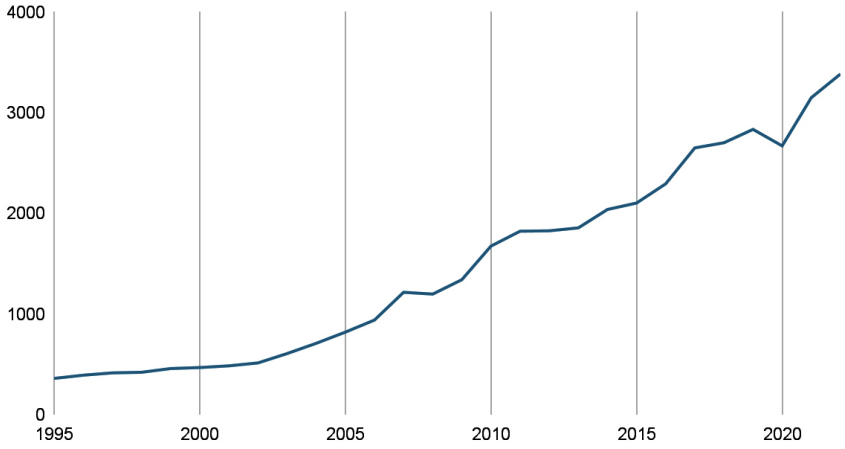
After the maintenance, salaries of ground establishment, and work charged establishment were paid for, only about INR 15 billion (US$ 182.8 million) or 42.5 percent of the total budget was left for actual construction.[36] Given these budgetary constraints it is no wonder that the BRO struggled to move rapidly. The result was that infrastructure building took a long time, and the BRO was stretched thin. At this time, the BRO had more projects than they could efficiently handle, both fiscally and administratively.[37]

The specific time when these matters were largely resolved is debated, though it is commonly accepted to be from around 2014 to 2017.[38] What specifically changed that led to an increased pace in construction from this point? The answer lies in three key factors—financial, doctrinal, and strategic. The factors that caused the physical changes are financial and doctrinal, while the impetus for these changes was strategic.[j]

Finance

After 2014, one of the key factors that increased the pace of Indian infrastructure development was the country's economic growth, with increased funding being allocated to the BRO. India's GDP has grown from US$360.2 billion in 1995 to US$820.3 billion in 2005, to US$2.1 trillion in 2015, and, finally US$3.7 trillion in 2023 (see Figure 2).[39] This remarkable economic growth in the last five to 10 years has translated to greater discretionary capital for infrastructure along the LAC.

Figure 2. Indian GDP over Time, in US$ billion[40]



Sources: "India GDP 1960-2023," MacroTrends;[41] "Report for Selected Countries and Subjects," IMF[42]

j It should be noted that India, as Dr. Manoj Joshi described it, due to its asymmetric terrain will always be at an infrastructural disadvantage to China on the Tibetan plateau. Due to the myriad and multidimensional factors previously mentioned, including climate, elevation change, and earth movement, India will always have slower and more expensive infrastructure projects as compared to China. China also has a remarkably easier infrastructure challenge as it relates to the environment. The Tibetan plateau is a distinctly flat and dry piece of land that, if properly resourced (as has been accomplished) is fairly simple to build upon. As Dr. Joshi put it, if a road is destroyed in Tibet, China can find another road nearby, cross it and keep moving towards the front. However, in India, if a longitudinal road is destroyed then India either needs to move from the ridge back to flat ground and take another road there, or have already built a bridge or tunnel traversing adjacent mountains (Manoj Joshi, New Delhi, June 2023).

The Pieces Come Together

What suggests that these funds were channelled to border infrastructure?

First, experts agree that the increase in the BRO's efficiency and capacity strongly indicate greater fiscal resources.[43] Second, according to the Ministry of Defence, in the last five years, INR 154.7 billion (approx. US$1.877 billion) have been spent on Indo-Chinese border roads alone, with some 2,088.57 km of new roads built using this money.[44] This juxtaposes figures from 2011 to 2016: in that period, according to the BRO, only INR 144 billion (approx. US$1.73 billion) were spent on 'general strategic' roads, which include all roads that are deemed primarily for military use, including those on other borders.[45] Thus, the current Indo-Chinese Border Road spending exceeds all border road spending between 2011 and 2016.[46] Additionally, according to BRO Director General Lt. Gen. Rajeev Chaudhary, there has been a 100-percent increase in the BRO's budget in the last two years.[47] The BRO's capital budget also increased by around 40 percent in the 2022–23 financial year.[48]

Third, the increase in tunnelling and bridge construction indicates that a large budget, and focus, has indeed been allocated toward LAC infrastructure. According to Lt. Gen. Chaudhary, in the year after the Galwan incident (2021), 87 bridges were constructed, and another 67 were built the next year (2022)— stark increases over previous years.[49] Tunnelling too, has seen growth, with a number of ambitious projects in the works.[50] Specifically, the Zoji-La Tunnel is close to completion after its deadline was pushed closer to the present by three years, the Shinku La Tunnel is about to begin construction, and the Se La Tunnel is undergoing construction.[51]

Overall, these large increases in the BRO's budget have unlocked possibilities and increased the capacity of the BRO. Before the 2014–2017 period, the financial capacity of the BRO was far too small for its expanding mission. With increased funding in recent years, those capacity hindrances seem to have been ameliorated.[52]

Bureaucracy

One of the first clear indications of doctrinal change was the Indian government's China Study Group (CSG), which in 1999 identified strategically important roads along the LAC. As illustrated by *The Statesman*, "The CSG identified 73 strategically important roads along the border as Indo-China Border Roads (ICBRs). The Cabinet Committee on Security (CCS) in 1999 had approved the construction of these roads … and set a tentative target of work between 2003 and 2006. The target was later extended from 2006 to 2012. But till now [2017] the work is far from over."[53] Though there had been a push from the government in the early 2000s, these did not propel construction. It was possible that such critical articles during the 2010s, and, certainly, Chinese incursions like Doklam (2017) or the Galwan incident (2020) finally pushed the rhetoric into action.[54]

The effect of these changes can be seen empirically in the sharp increase, especially since 2020, in kilometres of road laid, and the number of bridges constructed by the BRO.[55] According to *The Tribune*, from 2017 to 2022 the BRO completed 3,595 km of new roads.[56] Before this, according to an NDTV report, the BRO, as of 2015, had completed only 626 km since they started in 2006–2007.[57]

What caused this increase in efficiency, bureaucratically, is clear. Besides funding, a number of mechanisms were put in place from 2014 to 2017 that sped up the bureaucratic process and increased construction efficiency. These mechanisms included, but were not limited to the following:

- The Ministry of Environment and Forests giving "general approval for diversion of forest land required to allow the BRO to quickly construct the roads."[58] This reduced a large number of environmental stumbling blocks that hampered the building process.[59]

- The states, where the projects were often bureaucratically mired, were pushed by the Central government to give the BRO 'Empowered Committees' status to be in a position to rapidly resolve "issues related to land acquisition, wildlife clearance, allotment of quarries etc."[60] The specific mechanism change was that high state-level leaders

now comprised the committees tasked with resolving these disputes, as opposed to lower level leaders with less discretion. This allowed projects to be fast-tracked through a number of bureaucratic mazes.[61]

- Projects were allowed to be fully outsourced, greatly expanding the capacity of the BRO. Before 2017, outsourcing was only allowed and used in specific small areas, like the supply of finishing materials. This meant that large, high-capacity, construction businesses would not be attracted and only smaller, local contractors would take the projects.[62] After 2017, however, all projects worth over INR 1 billion (US$12.1 million) had to be outsourced under the new 'Engineering Contract Procurement Model'.[63] Also, smaller projects could be contracted as a package, again attracting bids from larger companies.[64] This meant that with large businesses taking up projects, the BRO was freed up to take a more managerial role, and could focus on the Sisyphean task of keeping the roads already built, open.

- At the ground level, the creation of an advanced stockpile of construction materials like aggregate was made, preventing shortages from causing slowdowns.[65]

At the top level, the leadership of the BRO were given "enhanced financial and administrative powers."[66] This meant that the BRO leadership (chief engineers, Assistant Director General of Border Roads, Director General of Border Roads) were allowed to approve the contracts of far larger projects, and procure more expensive equipment unilaterally. Before this policy, these BRO leaders would have had to go higher up to the Ministry of Defence for approval.[67]

Strategic Environment

The shifts in strategic environment along the border, gradual at first, were accelerated by key incidents, both diplomatic and kinetic, beginning in 2000. These incidents brought about a dramatic shift in how India saw the state of the border and kickstarted significant infrastructural development in the area.

The Pieces Come Together

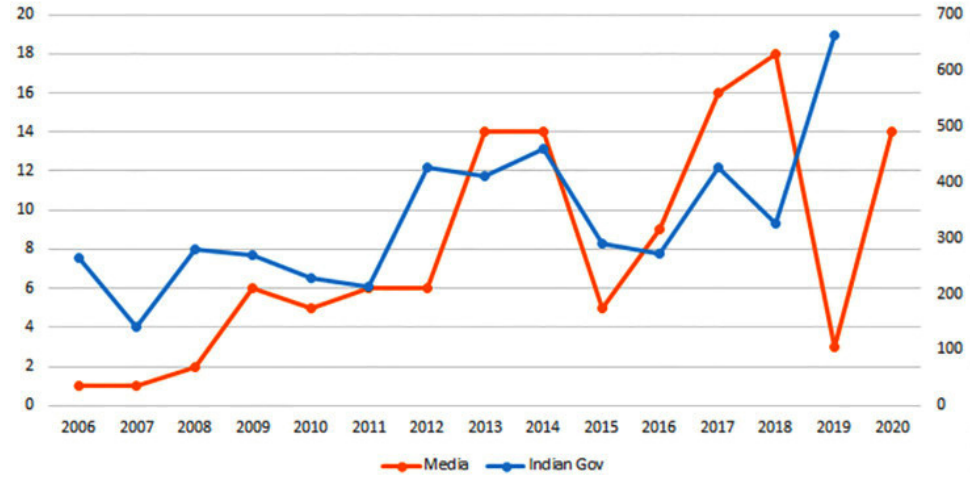
The likely starting point of the change within the government was the failure of the border negotiations in the late 1990s and early 2000s. Experts believe that after numerous sessions with the Chinese officials, Indian negotiators felt they had reached an impasse.[68] China seemed uninterested in fully settling the border problem, as they were adamant that Tawang, a large and crucial city located in Arunachal Pradesh, belonged to China. This was, and is, a point that India will not accept and China knew this, thereby ensuring that negotiations were indefinitely stalled.[69]

This realisation solidified over time, and negotiations stagnated. This timeline matches some of the first large pushes towards Indian infrastructure development. First, and as previously mentioned, in 1999 the China Study Group was organised and they identified a number of crucial strategic roads. Later, in 2006, the UPA government announced the construction of 73 roads along the LAC.

After the growing realisation that China was entrenched in its position, India started growing closer to the United States around 2005 under then PM Singh. The two countries' relationship warmed, with India voting with the US at the International Atomic Energy Agency (IAEA) twice, in 2005 and 2006; they held joint military exercises in 2005 and, most pivotally, agreed on a civil nuclear deal in 2008. These moves, especially the nuclear deal, according to experts, shifted how China saw India.[70] Ambassador Kantha put this shift most aptly when he said that in 2008, China started to see India through the prism of their competition with the US, and that this perception would further solidify after Xi Jinping took office in 2012.[71]

This period from 1999 to 2012 can be seen largely as a time for perceptual shifts, with some reports claiming that the number of border transgressions increased after 2008 (Figure 3). However, from 2013 to the present, there were more physical face-offs along the border, border transgressions, and heightened mutual negative perceptions.[72]

Figure 3. Number of Chinese Incursions, by Year[73]



Note: Independent data is listed in orange using the left scale, the Indian Government's data is in blue using the right scale

To summarise this period—largely excluding smaller incidents—the start was at Depsang in 2013 where Indian and Chinese troops had a stand-off for three weeks. The following year, there was a 16-day stand-off in Chumar.[74] A week-long stand-off in Burtse occurred in 2015.[75] In 2017, there was the crucial Doklam incident for 73 days, in Bhutan, and a far smaller incident near Pangong Tso.[76] Additionally, according to experts this was the year that marked far greater Chinese infrastructure investment.[77] In 2019, there was another face-off at Pangong Tso.[78] However, the most important incident, according to experts interviewed for this paper, that paradigmatically shifted the Indian perception of China, was the Galwan incident of 2020. This likely unintended escalation paired with numerous other, likely intended, incursions occurring simultaneously, tarnished an already poor Indo-Chinese relation. After this point, according to Jayadeva Ranade, there was "zero trust," given how China violated all norms, and earlier 1993 and 1996 agreements on conduct.[79] These incidents, paired with continued diplomatic stasis, forced the Indian leadership across the government and military to rethink their approach on the border, and put more emphasis on border infrastructure, both monetarily and organisationally.

Air Infrastructure

This section discusses the unique dynamics in the other two key areas of infrastructure—air and rail.

Air infrastructure has largely followed the pace of road infrastructure, and was largely prompted, like the proliferation of the road infrastructure, by shifting perceptions of Chinese intentions and on-the-ground strategic environment.

It was in 2008 that significant efforts to improve air infrastructure were undertaken. It started with the reopening of the strategically important Daulat Beg Oldi (DBO) airfield,[k] which was done by the Air Force despite the Central government not giving permission.[80] Regarding the opening of the airfield, Vice Chief Air Marshal (Retd) Pranab Kumar Barbora was quoted by *Times Now*, in early June 2020, as saying that "43 years had gone by, and there was no clearance to re-operate from there because of so many reasons and every time there was no no no ... ." The Indian Air Force responded to inquiries by saying that "it is the Air Force's responsibility to maintain troop's logistics."[81] The importance of this action in 2008 is that it shows a clear unilateral move by the Indian Air Force to increase their operational readiness, in stark contrast to 43 years of passivity. This was likely in reaction to increased Chinese border incursions.

Around the same time that the DBO airfield reopened, the Fukche and Nyoma airfields, in Ladakh, also reopened in 2008 and 2009. Both were either closed or had fallen into disuse after the 1962 war, so their reopening showed a continued breaking of strategic norms. The Nyoma airfield, after the 2017 Doklam crisis, would be sited for and is now undergoing upgrades to its advanced landing grounds. These new runways will allow fighter aircraft to use them, and, according to Lt. Gen. Chaudhary, will add further military resiliency in the area.[82] Additionally, the BRO claims that the new runways are likely be completed within two working seasons—from August 2023.

k This airfield is critical because it is exceedingly close (around 10 km) to the Chinese side and therefore is in a very high-threat area. It is also one of India's only pieces of controlled territory that lies in the flat Tibetan plateau, making it a uniquely suited piece of land to mount offensive action. See: https://theprint.in/opinion/new-road-to-dbo-not-enough-to-stop-pla-tunnel-under-saser-la-pass-is-the-solution/1626931/.

If this was achieved, it would underscore the greater efficiency of the modern BRO. However, according to ORF analyst, Dr Manoj Joshi, due to the proximity of these landing grounds to the border, they could be rapidly rendered inoperable by enemy fire during a conflict.[83]

Like the upgrades to Nyoma, after Doklam in 2017, India also decided to upgrade another seven advanced landing grounds in Arunachal Pradesh.[84] These landing grounds should allow for more mobility and resilience in the Eastern Sector, which has generally received less attention.[85]

The BRO reports that two new helipads were completed in 2022 at Hanle and Thankung, both in Eastern Ladakh. The Air Dispatch Sub Unit in Chandigarh began undergoing upgrades to "ensure efficient and uninterrupted delivery of essential stores and equipment for execution of works on ground."[86] As reported in 2021, the government planned four new airports and 37 new helipads for Ladakh alone.[87] In 2022 it was widely reported that the Indian Army was undergoing notable upgrades, fortifying and expanding its rocket force.[88] This action is likely in response to China's own rocket force expansion, and the ongoing initiative to build an offensive deterrent.[89] In addition to these openings, upgrades, and reopenings, the military also innovated after Galwan, requesting the development of 'portable helipads.' When completed and proliferated, these could further raise the reliability of supply chains in contested areas, and enhance the offensive and defensive capabilities of the forces currently in place.[90]

The Indian air infrastructure in the Himalayas is placed so that, unlike the roads, the terrain lends itself to a tactical advantage over China. The reason for this is the vast and rapid elevation change, whereas the Chinese Air Force is forced to have its relevant bases at a high altitude on the vast Tibetan Plateau. India has the advantage of having nearby valleys and foothills to put their runways and helipads. The key effect of the territorial asymmetry is that India's lower infrastructure allows aircraft to take off in denser air, allowing them to carry their full load. Chinese air forces, on other hand, must carry significantly (often quoted at 50 percent) reduced fuel and material loads.[91] This topographical difference lends great advantage to India in air.

Rail Infrastructure

The Indian government, despite enormous rail growth in other areas of the country, has historically neglected rail infrastructure near the LAC. Following Galwan, plans are being drawn to dramatically increase rail infrastructure. The reason for this neglect has been the expense involved in the laying and maintenance of these rail lines, and the doctrine of limited infrastructure along the LAC. At present, there is no strategically relevant rail near the LAC.[92]

The largest rail project near the LAC is the 338-km Jammu–Baramulla line (also known as the Udhampur–Srinagar–Baramulla Rail Link). This project was announced in 1994, but due to hindrances—including terrorism, lack of funding, inhospitable terrain, it is yet to be completed. The project is expected to cost some INR 350 billion (US$4.26 billion). While expensive and long overdue, this project showcases India's newfound capabilities in tunnelling and bridge building, as it has required an unprecedented amount of both.[93]

The other notable rail line lies in the eastern sector of the LAC and was made in 2014. It is the 22-km Harmuti–Naharlagun line which was the first rail line to connect the strategically critical Arunachal Pradesh with the rest of the country. Before this line, there was only "1.26 kilometres of railway line inside its [Arunachal Pradesh's] border."[94]

In the aftermath of Galwan, there has been a seemingly large increase in the number of plans for railway lines. However, given the limited number of border rail projects, and delays in construction (Jammu–Baramulla line) the projected pace of these plans has drawn skepticism. In addition to the Jammu–Baramulla line, which should be completed by 2024, the bulk of the new rail plans lie in the Eastern Sector, where there are a number of strategic rail lines in the works. According to the *Print*'s Snehesh Alex Phillip, a "200 km broad gauge line between Bhalukpong to Tawang (Arunachal Pradesh), 87 km line between Silapathar (Assam) to Along via Bame (Arunachal Pradesh), and 217 km line between Rupai (Assam) to Pasighat (Arunachal Pradesh) which also has an advanced landing ground of the Indian Air Force" are all planned, along with a line from Nathu La to Rangpo.[95] These lines, when completed, will massively increase the Indian Army's capability to move heavy cargo and troops to strategic areas at a low cost.

Conclusion

The picture of Indian infrastructure today is far better than it was only 10 or 15 years ago. While the overall pace and level of Indian infrastructure certainly does not match that of China, it has picked up in recent years, and the proliferation of tunnels and bridges independently signal a holistic increase in capability.[96]

In the past, infrastructure build-up was hampered by a defensive military doctrine and later was mired in bureaucracy compounded by funding constraints.[97] Then and now, India battles the brutal landscape of the high Himalayas, which slows efforts to build and maintain positions.[98] The key factors that have pushed infrastructure improvements near the LAC are increases in budget and a plethora of bureaucratic changes.[99] In turn, these shifts can be attributed to the changes in the strategic environment along the LAC, which started to be recognised in the early 2000s, following diplomatic stasis, and grew far more salient from the mid- to late 2010s. As Ambassador Kantha recounted to this author, around 2008 China started to see India through the prism of their competition with the US, and their actions after this change grew only more incendiary.[100]

Air infrastructure development has followed a similar trajectory to that of the roads, with most upgrades occurring in the late 2000s, following Doklam and Galwan. Regarding rail infrastructure, there is a massive asymmetry, and what has been built has taken very long. The silver lining is that there are more plans in the works, which should lead to a brighter picture overall.[101] Strategically, all elements of infrastructure—road, air, and rail—have important roles to play in improving the supply chain resiliency, supply chain bandwidth, force induction time, and general preparedness. With this in mind, it has been prudent of the Indian government to more quickly improve infrastructure near the LAC in the last 15 years. It is a crucial question for researchers to analyse whether or not this Indian infrastructure build-up will have a deterrent effect on Chinese aggression.

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