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This document was prepared by Gary Gereffi and Danny Hamrick, consultants with the International Trade and Productive Development Unit of the subregional headquarters in Mexico of the Economic Commission for Latin America and the Caribbean (ECLAC), under the supervision of Nahuel Oddone, Chief of the same Unit.

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Abstract

This report examines the development and upgrading prospects of the medical device and aerospace clusters in Baja California, Mexico within the context of global value chains (GVCs). Prepared for the Economic Commission for Latin America and the Caribbean (ECLAC) and the Government of Baja California, the study applies two complementary analytical frameworks: cluster development, which highlights the differentiated roles of firms within local production systems, and GVC analysis, which emphasizes how global lead firms, governance structures, and standards shape upgrading trajectories. The analysis finds that Baja California has experienced a marked process of industrial transformation over the past two decades. Building on capabilities developed in consumer electronics and other export-oriented industries, the region has consolidated its position as a strategic nearshoring platform for advanced manufacturing serving North American markets.

The medical devices cluster has reached significant scale, employing approximately 100,000 workers and hosting a dense concentration of multinational firms. While production remains focused on manufacturing and assembly, evidence of process, product, and functional upgrading is observed, particularly in areas such as sterilization services, automation, and selected design and engineering activities. The aerospace cluster follows a distinct development path. Rather than being organized around a few flagship firms, it is shaped by multiple Tier-1 and Tier-2 companies operating under stringent certification and quality regimes. This distributed structure has supported diversification but also underscores the need for strong coordination mechanisms, including industry associations, logistics platforms, and workforce certification systems. Drawing on comparative international experiences, the report highlights the role of targeted public policies in supporting upgrading through supplier development, skills formation, institutional coordination, and environmental performance. The findings emphasize that sustained competitiveness depends on aligning economic upgrading with social upgrading—through improved job quality and skill development—and environmental upgrading, particularly in regulation-intensive sectors. The study concludes that an integrated productive development approach is essential for strengthening local capabilities, increasing value capture, and supporting inclusive and sustainable industrial development in Baja California, Mexico.

Introduction

This report analyses the participation of Baja California's industrial sectors in global value chains (GVCs), with a focus on the aerospace and medical device clusters. It responds to the request of the United Nations, Economic Commission for Latin America and the Caribbean's (ECLAC) Subregional Headquarters in Mexico and the Secretaría de Economía e Innovación of Baja California, Mexico to provide an evidence-based assessment of how these two dynamic clusters contribute to regional development, and how their future upgrading can be supported through targeted policy. This report emphasizes the importance of identifying strategies for sustainable upgrading, with special attention to the incorporation of state-level economic activities and the articulation of firms, institutions, and policy actors.

In addition to economic upgrading, the report acknowledges the importance of social upgrading—defined as the improvement of workers' rights, job quality, and local capabilities—and the growing relevance of environmental upgrading, which refers to cleaner production processes, reduced emissions, and compliance with increasingly stringent environmental standards. While the analysis primarily focuses on economic dynamics, both dimensions serve as complementary goals in the long-term development of GVCs.

The report is organized in eight sections. Following the introduction, section I presents the two complementary theoretical lenses used in the study. First, the cluster development perspective highlights the role of firm heterogeneity and the dynamic hierarchy of roles—anchors, propellents, connectors, and enablers—that shape local development. Second, the GVC framework situates Baja California's clusters in international production networks, emphasizing the opportunities and constraints for upgrading in manufacturing, supply-chain, and knowledge dimensions. This dual lens allows us to link local firm-level dynamics with the governance of global industries, clarifying which upgrading trajectories are feasible. Subsequently, section II sets the stage with a discussion of Baja California's recent industrial history and the double transition that moved the region from consumer electronics into higher-value advanced manufacturing.

Sections III and IV present in-depth analyses of the two priority clusters: medical devices and aerospace. These sectors are analysed with a focus on key firms, workforce capabilities, and infrastructure, and key government policies that shape the growth of both sectors. Sections V and VI introduce comparative international case studies, showing how other countries and regions have pursued successful upgrading strategies in these industries. In medical devices, we look at Costa Rica, the Dominican Republic, and Ireland; and in aerospace, we focus on Phoenix, Arizona in the United States, Montreal in Canada, Querétaro in Mexico, and Morocco. These comparisons serve as benchmarks to assess Baja California's relative position in each GVC and to zero in on key policies used to promote each cluster and their main firms.

Section VII of the report offers integrated policy takeaways to advance economic growth, human talent development, innovation, and sustainability for Baja California policymakers. The conclusion summarizes insights from the two clusters and the comparative cases. The report shows that the two clusters differ in important ways. The medical devices sector in Baja California is anchored by a set of global flagship firms (like Medtronic, Cardinal Health and Becton Dickinson) which organizes the cluster and sets upgrading pathways for local suppliers. Aerospace, by contrast, has a distributed anchor structure, with multiple Tier-1 and Tier-2 firms—such as Collins, Honeywell, Safran, Eaton, Gulfstream—each exerting influence but none dominating. These structural differences imply that Baja California policymakers should pursue differentiated strategies: in medical devices, working closely with the global flagships; and in aerospace, building collective strength across multiple anchors and strengthening enabling institutions. Finally, section VIII offers a robust conclusion that synthesizes the findings of the report, highlighting how the combined lessons from the cluster analyses and international cases can shape Baja California's future upgrading trajectory.

I. Complementary frameworks for Baja California's industrial growth: cluster development and GVC analysis

The development of Baja California's industrial clusters can be understood through two complementary analytical lenses. On one hand, the cluster literature (Giblin and Ryan, 2012 and 2015; Ryan et al., 2020b and 2022) emphasizes the roles that multinational firms play in shaping cluster evolution. In the medical devices cluster, we will see that multinational enterprise (MNE) subsidiaries can act as instigators (early anchors like Medtronic that seed large-scale activity), propellents (firms such as Cardinal Health that broaden the technological base through automation and consumables), connectors (innovators like Össur that build global research and development (R&D) and supply linkages), and enablers (specialists such as Avantti that plug ecosystem gaps like sterilization). This role-based perspective highlights the importance of heterogeneity and resilience: clusters thrive when multiple types of firms bring different capabilities, preventing over-dependence on a single technological trajectory.

The cluster development approach is rooted in the nexus of economic geography and international business. It shows how leading subsidiaries of MNEs can anchor the evolution of local clusters, and how spin-out start-ups from these lead subsidiaries can strengthen the local entrepreneurial ecosystem. The literature by Ryan, Giblin, and colleagues on Medtronic in the Galway region of western Ireland is an excellent illustration of this approach. Their work has a clear narrative arc, based on the following elements:

- inward foreign direct investment (FDI) can start clusters via knowledge transfers and reputation effects (Giblin and Ryan, 2012);
- these anchor MNEs promote cluster evolution and connectivity in their roles as instigators, propellents, and connectors, and new knowledge flows help to diversity and upgrade the region (Giblin and Ryan, 2015);
- local spinouts drive resilience as former MNE employees inject technological heterogeneity into the entrepreneurial ecosystem (Ryan et al., 2020b); and

- subsidiary upgrading enables co-governance and solid crisis performance, as evidenced by the ability of Medtronic Galway to ramp up ventilator production by 40% early in COVID-19 (Ryan et al., 2020a and 2022).

The GVC framework, on the other hand, utilizes an external and global perspective to analyse how cluster upgrading occurs under different forms of GVC governance and how the resilience and innovation potential of clusters derives from the interaction of firms, GVCs, and state policies (Gereffi, 2018 and 2019; Gereffi and Lee, 2016; Gereffi et al., 2019). Economic upgrading can take the form of product, process, functional, or chain upgrading, while governance structures—hierarchical, captive, relational, modular, or market-based—determine which trajectories are feasible (Gereffi et al., 2005). In using GVCs as a lens to analyse the responses to supply-chain disruptions for four medical products during the COVID-19 crisis (rubber gloves, face masks, ventilators, and vaccines), resilience was viewed as a multi-dimensional concept with different meanings at the levels of the firm (operational efficiency), the industry (appropriate GVC governance), and the state (national security) (Gereffi et al., 2022).

For Baja California, vertical governance by global lead firms like Medtronic or Cardinal Health sets stringent quality and regulatory conditions, while horizontal governance through local associations and the Secretaría de Economía e Innovación enables joint action, workforce development, and supplier upgrading. This framework underscores the importance of governance dynamics and power relations in shaping the benefits that local firms and workers capture from integration into global chains.

Together, these perspectives suggest that Baja California's industrial policies can be further strengthened by pairing economic growth goals with complementary efforts to integrate economic, social, and environmental upgrading. The cluster roles framework stresses the need to cultivate a balanced ecosystem of anchors, propellants, connectors, and enablers, while the GVC governance framework highlights the external pressures and upgrading paths that condition how value is created and captured. By integrating these insights, policymakers can design strategies that both leverage the presence of global lead firms and ensure that local suppliers, institutions, and workers are positioned to upgrade within GVCs.

A. Useful typologies

In their cluster/entrepreneurial ecosystem, Ryan, Giblin, and colleagues (Ryan and Giblin, 2015; Ryan et al., 2020b; Ryan et al., 2022) emphasize how MNE subsidiaries and their local suppliers adopt different roles that shape local cluster trajectories. The key roles are:

- Instigators: Early anchor firms whose entry seeds the cluster. They trigger the initial agglomeration of suppliers, workforce skills, and supporting institutions.
- Propellents: Firms that broaden or diversify the cluster's capabilities, often by introducing new technologies, automation, or scale. They prevent the cluster from being "locked in" to a narrow specialization.
- Connectors: Subsidiaries that build international linkages, transfer knowledge, and create absorptive capacity. They may link local suppliers to global standards or bring in R&D/testing functions.
- Enablers (sometimes implicit): Actors (often specialized firms or service providers) that plug structural gaps, such as sterilization or logistics, allowing the cluster to function as a full ecosystem.

In contrast, the GVC framework focuses less on firm roles and more on pathways of upgrading and the types of governance that condition them. Various forms of upgrading are outlined in the GVC literature (Humphrey and Schmitz, 2002; Gereffi, 2019), including:

- Product upgrading: Moving into higher-value, more complex devices.
- Process upgrading: More efficient production (e.g., automation, lean, Six Sigma).
- Functional upgrading: Taking on new roles like design, R&D, and sterilization.
- Inter-chain upgrading: Moving into related industries (e.g., electronics, wearables).

The GVC literature has various typologies of GVC governance structures, which refer to how "lead firms" in GVCs exercise power over suppliers within the chain. One well-known typology outlines five types of GVC governance: hierarchy (vertically integrated firms); captive (a supplier is dependent on only one lead firm); relational (relies on trust and frequent interactions for complex or difficult to codify information between buyers and sellers); modular (simple, codifiable transactions, often leveraging information technology (IT) and standards for efficiency and flexibility); and markets (many buyers and sellers with competitive pricing) (Gereffi et al., 2005).

In Baja California, economic upgrading is visible by product, process, or functional shifts by key firms in the clusters. However, governance matters in a different way because original equipment manufacturers (OEMs) like Medtronic or Honeywell exercise hierarchical (vertical) control, but cluster associations and government authorities (like the Secretaría de Economía e Innovación) provide horizontal governance.

A further dimension relevant to both the cluster and GVC perspectives is the role of social upgrading—the improvement of job quality, worker capabilities, and inclusion within production networks. In Baja California, vertical governance by lead firms and horizontal governance through local institutions shape not only technological and economic trajectories but also the conditions under which workers participate in these industries. International experience shows that clusters are most resilient when economic and social upgrading reinforce one another: investments in workforce skills, occupational safety, gender inclusion, and career mobility expand the local absorptive capacity needed for more advanced functions. This report adopts an integrated view of upgrading in which productivity gains, technological modernization, and skill deepening occur in tandem with improved working conditions and greater opportunities for local talent to advance into engineering, regulatory, and supervisory roles.

In parallel, the GVC framework highlights that upgrading increasingly encompasses not only economic and social dimensions but also environmental upgrading—improvements in resource efficiency, emissions control, waste management, and compliance with global environmental standards. For Baja California, this is particularly relevant in sectors such as medical devices and aerospace, where lead firms face rising regulatory and market pressures to reduce environmental impact across their supply chains. Embedding environmental upgrading into local upgrading trajectories reinforces economic competitiveness: firms that adopt cleaner processes, reduce sterilization emissions, or improve materials efficiency are better positioned to meet evolving international requirements and to move into more advanced GVC roles.

In general, the cluster and GVC perspectives highlight different phenomena: the cluster approach helps us to understand who within the cluster drives its evolution (e.g., MNE subsidiary and supplier roles), while the GVC framework tells us what kind of upgrading is possible and under what governance conditions. Together, they show that upgrading pathways in Baja California depend both on the internal role-mix of firms (anchors, propellents, connectors, and enablers) and on the governance pressures from global lead firms and standards.

II. Precursors of contemporary clusters in Baja California

A. The transformation of Tijuana's television cluster (1990s-2010s)

Tijuana built one of the world's most important television (TV) manufacturing hubs in the 1990s–2000s, reaching very high output and a dense cluster of OEMs and suppliers. In the 1980s and 1990s, Japanese OEMs—including Sony, Panasonic, Sanyo, JVC, Hitachi, and Sharp—along with Korean (Samsung, LG) and Taiwanese firms (Delta, ADI Systems), established operations in Tijuana and Mexicali. These companies were drawn by Mexico's maquiladora program,[1] low-cost labour, and proximity to the United States market. By 1991, 65% of TVs sold in the United States were assembled in Mexico, most of them in Tijuana (Brito Laredo and Carrillo, 2019, p. 46). The North American Free Trade Agreement (NAFTA) adopted in 1994 strengthened Mexico's integration into United States-centred supply chains and boosted exports to the United States, encouraging Asian electronics firms to establish or expand operations in Baja California to serve the North American market. By the early 2000s, employment in Baja California's broad electronics cluster was estimated at around 90,000 workers, including over 10,000 engineers and technicians. Tijuana became "the TV capital of the world", exporting millions of sets annually to the United States.

As the TV cluster neared its peak in 2003, warning signs began to appear. According to ProduCen (2003), Baja California hosted 15 OEM plants that assembled about 19 million TV units annually, with 22,000 direct jobs and an additional 15,000 supplier jobs. Tijuana accounted for about 65% of this production. The employment structure was heavily weighted to low-skill positions, with 46% production line workers and 34% technicians, while only 0.2% were R&D or creative roles. Local value added was estimated at just 3% of export value in wages, plus another 3.0%–3.5% from indirect goods and services (e.g., packaging and wooden platforms) with limited local value capture (ProduCen, 2003, pp. 7-11).

[1] This is also known as the Industria Manufacturera, Maquiladora y de Servicios de Exportación (IMMEX) Program, an export-promotion scheme primarily based on fiscal incentives.

Technological change was a critical factor in the Tijuana TV cluster. As TV production in Tijuana was peaking, cathode ray tube (CRT) and projection TVs were in technological maturity or decline, while liquid crystal display (LCD) and plasma TVs were just being introduced in Tijuana. The ProduCen report warned that new flat-panel technologies could reduce direct assembly jobs by 25%–30% and undermine the CRT-focused supplier base in the Baja California cluster. It proposed a 10-year strategic vision to establish technology centres, foster local suppliers of strategic inputs, align universities and training programs with digital technologies, attract venture capital, and rebalance employment toward more specialized roles (ProduCen, 2003, pp. 12-14).

The transformation of Tijuana's TV cluster was a dramatic yet somewhat short-lived success story. However, it contains important lessons for our analysis of contemporary Baja California clusters like the medical device and aerospace GVCs. During the mid-2000s the technological shift from CRT to flat-panel (LCD, light emitting diode (LED), and plasma) TVs accelerated. Panels, printed circuit boards, and key components were overwhelmingly imported from Asia, reducing the comparative advantage of Tijuana as a production hub. While Tijuana's total production and exports rose, local value added fell. The structural fragility of the TV cluster derived from its heavy reliance on low-skill labour, low value-added assembly, and impending risks from the CRT-to-flat-panel transition. The lesson was clear: clusters cannot thrive on production scale alone. They need deliberate policies that: (i) anchor higher-value activities locally; (ii) cultivate competitive Mexican suppliers; (iii) build strong industry-education linkages; and (iv) ensure that new technologies support job quality.

The evolution of Tijuana's TV cluster also highlights the impact of emerging business models on cluster development. Consumer electronics in Baja California transitioned from OEM-driven production to contract manufacturers (CMs) and electronic manufacturing services (EMS) firms. This reflects fundamental changes in the governance structure of the electronics GVC (Sturgeon and Kawakami, 2011):

- OEMs are firms that design, develop, and manufacture their own branded products (e.g., Sony, Panasonic, Sharp). The TV plants in Tijuana were part of global corporate networks that carried out local assembly, but key decisions on product specifications and components were made at OEM headquarters in Japan, South Korea, or the United States.
- CMs produce goods-to-order (i.e., specification contracting) for another firm, the brand owner (OEM). The scope of a CM is primarily assembly and sometimes the procurement of parts.
- EMS firms have a broader business model than CMs, which expanded beyond assembly into end-to-end services (such as procurement and supply-chain management; testing, repair, and refurbishment; logistics; and after-sale services).

In theory, CMs have a narrow assembly role, while EMS firms are more comprehensive service providers. In practice, big firms like Foxconn can fulfil both roles. In the Tijuana TV cluster, for example, Foxconn acts as a CM when it assembles Sony-branded TVs strictly to Sony's specs, and it acts as an EMS when it provides diverse services (procurement, logistics, and customization) for multiple brands.

A more fundamental implication of the changing business models after 2003 is that Tijuana's TV cluster shifted from OEM-led industrial upgrading (export and employment growth, some local engineering, and supplier development) to a more concentrated CM/EMS-dominated growth model (assembly-only, low-value activities) (Brito Laredo and Carrillo, 2019). By 2013, production in Baja California had grown to 29 million units, but employment had fallen to 14,800 and the supplier base eroded. Global OEMs were replaced by a smaller set of CMs and EMS firms (Foxconn, TPV, Hisense); previously dominant Japanese OEMs exited the region (see Table 1).

Table 1
Baja California, Mexico: evolution of the television cluster, 2003-2013

	2003	2013
Technology[a]	CRT	LCD, Plasma, LED
Number of plants	13	19
Production *(Millions of units)*	14	29
Number of employees	22 000	14 800
Type of employees:		
Workers	46%	69%
Technicians	34%	10%
Administrators	12%	16%
Managers	8%	4%
Business model[b]	OEMs only	OEM, CM, and EMS
Ownership structure of firms:		
Japan	8 of 13 – Sony, Panasonic (Matsushita), Sanyo, JVC, Hitachi, Sharp, Toshiba, & Mitsubishi	3 of 10 – Panasonic, Sanyo, & Sharp
Taiwan Province of China	2 of 13 – Delta, ADI Systems	3 of 10 – Delta, ADI Systems, & Foxconn
Republic of Korea	2 of 13 – Samsung, LG	2 of 10 – Samsung, LG
United States	1 of 13 – Diamond Electronics	1 of 10 – Diamond Electronics
China		1 of 10 –Trend Smart/TPV

Source: Prepared by the authors, on the basis of Brito Laredo, J. and Carrillo, J. (2019). *Trayectoria de la industria de televisores en México: ¿Escalamiento o desescalamiento?* Universidad Autónoma de Baja California, p. 64.
[a] CRT: cathode ray tube; LCD: liquid crystal display; and LED: light-emitting diode.
[b] OEM: original equipment manufacturer; CM: contract manufacturer; and EMS: electronics manufacturing services.

The transformation of the OEM-led cluster did not mean the end of electronics in Baja California. Several Japanese OEMs exited or sold their plants: Sony sold its Tijuana plant to Foxconn in 2009; JVC closed its Tijuana plant in 2010; Hitachi sold to Trend Smart/TPV around 2011; and Sharp's Rosarito plant (just south of Tijuana) was acquired by Chinese-owned Hisense in 2015–2016. The TV cluster in Tijuana remains a high-volume assembly hub today, but its role in the TV GVC is limited. Foxconn, Hisense, Samsung, and TPV anchor mass assembly for the United States market, but panels and advanced components come from China, the Taiwan Province of China, and the Republic of Korea, leaving Mexico focused on final assembly and logistics.

While the post-2008 restructuring of the TV cluster in Tijuana represented a shift in GVC positioning and more concentrated production, its scale remains significant. For example, official data show that in 2024 the state of Baja California generated nearly US$ 8.5 billion in exports of monitors and projectors, not incorporating television reception apparatus (i.e., flat-panel displays) (National Institute of Statistics and Geography [INEGI] and Secretaría de Economía, 2025). Moreover, the broader electronics sector in the region still employs more than 120,000 direct workers, with a large component in the Tijuana area specializing in television/display assembly.

Tijuana's TV cluster demonstrates that scale alone is not sufficient for upgrading, but it can still be consequential for future upgrading. Although lead-OEM design and engineering functions largely migrated elsewhere, the region's TV/display assembly base remains a substantial manufacturing platform. That continuity provides a ready labour force, supply-chain infrastructure, and export orientation that underpins the more recent growth of adjacent higher-value manufacturing clusters such as medical devices and aerospace.

More generally, the evolution of Tijuana's TV cluster underscores the risks of development strategies that rely heavily on low-skill, low-mobility employment. Although the cluster achieved impressive scale, its limited investments in workforce upgrading and local capability development left it vulnerable during the transition to flat-panel technologies. Tijuana illustrates that MNE-dominated clusters using less complex technologies and activities not tied to the local territory are susceptible to value chain downgrading that generates lower levels of local value added.

As Baja California shifts into higher-value sectors such as medical devices and aerospace, these historical lessons carry renewed importance. The sustainability of the region's current industrial transformation hinges on pairing economic upgrading with meaningful social upgrading—expanding training pipelines, improving job quality, and enabling workers to transition into more technical and innovation-oriented roles. Without such measures, the region risks reproducing an assembly-centric profile that limits long-term competitiveness and social development.

B. Tijuana's double transition – from TVs and autos to medical devices and aerospace

Tijuana, Baja California has undergone a double transition over the past two decades. A first wave (1990s–2000s) consolidated large export clusters in TVs and, to a lesser extent, automotive assembly and parts. A second wave (post-2009) saw a shift of local suppliers, engineers, and technicians into medical devices and aerospace, while TV production reconfigured toward contract manufacturing under new Asian ownership. This transformation was driven by several converging events:

- In the television GVC, the CRT-to-flat-panel transition reached a tipping point around 2009. Japanese OEMs (Sony, Panasonic, Sharp and so on) were already scaling down or exiting, while Foxconn and Hisense consolidated operations through acquisitions. Thus, the business model shift from OEMs to CM/EMS changed the TV cluster's structure.
- The global financial crisis of 2008-2009 accelerated OEM retrenchment and forced regional suppliers to seek diversification. Many lower-tier suppliers and skilled workers began pivoting into medical devices and aerospace, sectors less exposed to the volatility of consumer-electronics.
- In the auto sector context, Mexico's central auto corridor (e.g., Guanajuato, San Luis Potosí, Aguascalientes) deepened with the construction of Toyota's Guanajuato (TMMGT) plant and seven OEMs plus about 500 suppliers (Carrillo et al., 2023, p. 12), while Tijuana remained a specialized outpost. The United States-Mexico-Canada Agreement (USMCA) further incentivized regional sourcing and wage thresholds, favouring sites with dense supplier bases.

The concerns raised in Baja California's regional development plans about technology risks and supplier thinness crystallized by 2009, which created both urgency and opportunity for cluster diversification into medical devices and aerospace. Capabilities that already existed in the region, such as the precision assembly, quality certification, lean practices, and technician talent developed in the TV boom translated well into the cleanroom (medical devices) and traceability (aerospace) production logics that pushed local suppliers and workers into these sectors. Thus, the legacy of electronics in Baja California did not vanish; it pivoted to supplier capabilities needed in the new sectors.

Contract manufacturers are critical players in Tijuana's double transition. In Tijuana the TV cluster's pivot reconfigured control in high-volume production lines to CM/EMS firms like Foxconn and Hisense, while business models shifted to contract production. That preserved a scalable, multi-client base that suppliers and skilled workers could leverage as they moved into medical devices and aerospace. CM/EMS firms are ready platforms (people, production lines, quality assurance, lean systems) that can be repurposed across sectors; during shocks, firms sell excess capacity via OEM/contract work—exactly the kind of flexibility that eases cross-sector shifts. In addition, these large firms become anchors that sustain demand for local services, including tooling, plastics, metal-mechanics, and testing, cushioning shocks while enabling suppliers to redeploy to emerging sectors like medical devices and aerospace.

While this double transition reflects the state's strategic shift toward hosting higher-value activities within advanced manufacturing, the legacy sectors of televisions and automotive have not lost importance. The electronics industry contains high-value added global segments, but they remain largely outside Mexico; in Baja California, the legacy TV and display segment continues to operate primarily in high-volume assembly. Even so, these activities still generate substantial output, employment, and supply-chain infrastructure for the region.

The TV and display cluster remains among the state's leading exporters, and the automotive segment—anchored by Kenworth and a small number of large suppliers of heavy trucks and components—continues to generate significant output and stable employment. In both cases, the sectors have consolidated around fewer and larger firms that maintain strong production volumes. By contrast, the newer clusters of medical devices and aerospace exhibit greater diversity of firms, technologies, and a high potential for functional upgrading within GVCs. This coexistence of mature and emerging clusters highlights Baja California's layered industrial structure, where legacy sectors provide scale and infrastructure, while newer ones drive innovation and knowledge-based growth.

A key question for the medical device and aerospace clusters in Baja California is whether they have the potential to lead the region into a new era of sustained economic growth and development. They both have adequate scale. Aerospace is Baja California's largest hub, with over 100 firms and around 45,000 jobs in Tijuana and Mexicali. Medical devices is also a robust cluster with more than 80 companies and about 74,000 jobs in the state, with Tijuana as the anchor. Both sectors have a significant number of OEMs and are strong in contract manufacturing. The innovation potential is improving but uneven. Constraints remain in terms of supplier depth, local R&D and design, and specialized test and validation capacity. Sections III and IV will take a much closer look at the performance of the medical device and aerospace clusters in Baja California.

III. The medical devices cluster in Baja California, Mexico

A. Overview

Baja California, Mexico has emerged as one of the most dynamic medical device manufacturing hubs in the Americas. Anchored in Tijuana, Mexicali, and Ensenada, the cluster today comprises more than 125 MNEs and local firms employing about 100,000 workers, making it one of the largest concentrations of MedTech employment globally. Of the 128 medical device companies in Baja California, 28 firms have 1,000 or more employees, with Medtronic topping the list with 9,500 employees in two plants, and other top employers being Becton Dickison (5,000 employees), Flex (4,300), Foxconn (3,000), Masimo (3,000), Jabil Healthcare (2,950), and Cardinal Health (2,700) (see table A.1 in the annex). The state's proximity to California—home to leading MedTech firms and the largest healthcare market in the United States—provides unique cross-border advantages, including rapid logistics, integrated supply chains, and access to regulatory expertise.

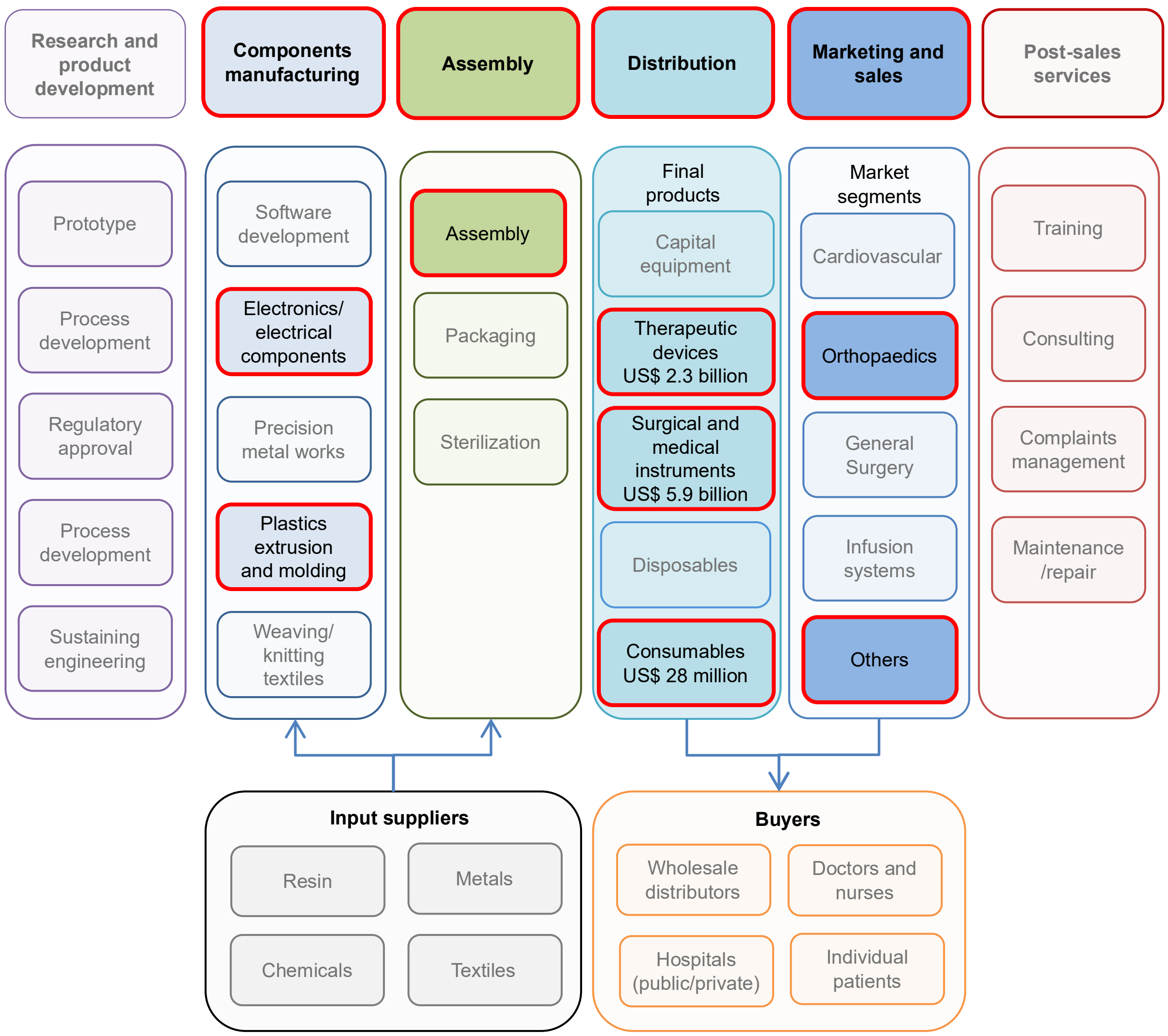
The medical devices cluster in Baja California is shaped predominantly by FDI, with most major firms originating from the United States, Europe, and, to a lesser extent, Asia. Global OEMs such as Medtronic, Cardinal Health, Becton Dickinson, Stryker, and Össur anchor the cluster, complemented by contract manufacturers and specialized service providers. While domestic firms participate primarily as suppliers or service enablers, the structure of the cluster reflects the globalized nature of the MedTech industry, in which MNE subsidiaries serve North American and international markets from their Baja California operations.

From a GVC perspective, Baja California's medical devices cluster participates primarily in manufacturing and assembly stages, producing a wide array of devices such as surgical instruments, orthopaedic implants, diagnostics, and disposables (see diagram 1). However, in recent years, several firms have expanded their functional footprint beyond assembly into higher-value activities:

- Process upgrading: Adoption of lean manufacturing, Six Sigma, and automation systems.

- Product upgrading: Increasing participation in Class II and III devices[2] (e.g., Medtronic and Össur in Tijuana).
- Functional upgrading: New activities such as sterilization (Avantti), design and prototyping (Össur), and supply-chain coordination (CMs like Foxconn and Jabil).

Diagram 1
Baja California, Mexico in the medical devices GVC



Source: Prepared by the authors, on the basis of Hamrick, D., and Bamber, P. (2019). *Pakistan in the medical device global value chain*. Duke University, Duke Global Value Chain Center. https://www.globalvaluechains.org/wp-content/uploads/PakistanMedicalDeviceGVC.pdf.

This trajectory mirrors earlier upgrading seen in Costa Rica, where FDI initially centred on low-value disposables but evolved toward high-tech therapeutics and R&D over two decades (Gereffi et al., 2019; Giblin et al., 2025). Baja California is still in the midst of this transformation, but early signs suggest strong potential for moving into more knowledge-intensive segments of the GVC.

[2] Class II and Class III medical devices carry higher levels of patient-risk than Class 1 devices, and therefore special controls need to be introduced at the firm level. This typology is described in more detail in the next section.

The "Asociación Industrial de Productos Médicos de las Californias" (Medical Devices Cluster Association) provides a collective platform for firms to coordinate training, supplier development, and policy dialogue. The cluster's governance reflects both top-down policy support and bottom-up firm initiatives. This hybrid model is crucial for aligning with the cluster development framework—where geographic concentration, local supplier networks, talent pipelines, and institutional support mutually reinforce competitiveness. Yet challenges remain. Local supplier participation in inputs and advanced services is still limited (often <10%), leaving most value-capture outside the region. Moreover, firms cite infrastructure, workforce skills, and security as ongoing constraints.

The following company case studies—Medtronic, Cardinal Health, Össur, Avantti, and others—illustrate different upgrading pathways within Baja California's medical devices cluster. They highlight how multinational subsidiaries and local firms are moving into higher-value functions, the constraints they face, and the opportunities for building a more competitive, knowledge-based ecosystem.

B. A note on terminology

Internationally, the broad industry is often described as medical technology (MedTech)—a term that encompasses the entire spectrum of medical technologies, not only devices, but also diagnostics and digital health. In Baja California, however, government and industry actors consistently use the term medical devices cluster.[3] This report adopts that label because it aligns with how Mexico tracks and promotes the sector in trade and investment policy (e.g., medical devices are a distinct export category with clear Harmonized System (HS) trade codes and regulatory oversight). However, in international comparisons (e.g., Costa Rica, Ireland), MedTech cluster is the common term in investment promotion and academic research. It signals innovation-driven healthcare technology rather than just assembly of hardware devices. For future policy directions in Baja California, MedTech framing allows policymakers to think beyond assembly and sterilization into digital health, sensors, diagnostics, and R&D, which are the next rungs of upgrading.

Medical device firms are often designated by their ability to make and sell Class I, II and III products. The Class I, II, III system refers to how regulators (like the US Food and Drug Administration) classify devices (not drugs) by risk level and regulatory requirement. Here is a simple breakdown for purposes of this report:

- Class I (low risk): These items are low risk to patients, and most are exempt from premarket approval. Examples include bandages, manual surgical instruments, and non-electric wheelchairs.
- Class II (moderate risk): These are higher risk than Class 1, but well-understood technologies. Examples include infusion pumps, contact lenses, and powered wheelchairs.

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[3] It is helpful to distinguish between various related labels. "Medical devices" is the most precise regulatory category. It refers specifically to instruments, apparatuses, machines, implants, or similar products intended for diagnosis, treatment, or prevention of disease. It covers Class I-III products. "Medical supplies" are typically low-value, high-volume consumables (e.g., rubber gloves, syringes, bandages), usually Class I products. "Personal protective equipment" (PPE) is a subset of supplies, primarily protective gear (e.g., masks, gowns, and face shields). Shortages of PPE items were a problem during the COVID-19 pandemic (Gereffi, 2020; Gereffi et al., 2022). "MedTech" encompasses all the above and more: advanced diagnostics, imaging, digital health solutions, wearables, surgical robotics, and sometimes health IT platforms. It signals innovation in healthcare technology rather than just hardware. MedTech generally does *not* include vaccines or pharmaceuticals, which fall under biopharma or life sciences. Healthcare services (e.g., EMS, hospitals, telemedicine) are not part of MedTech either, although EMS firms use MedTech (monitors, ventilators, infusion pumps, etc.). Thus, services are part of the MedTech ecosystem but not part of the MedTech industry definition.

- Class III (high risk/life-sustaining or implantable): These are the highest-risk devices that support or sustain life, prevent impairment, or present serious potential risk. Examples include pacemakers, heart valves, implantable defibrillators, and prosthetic joints.

In the Baja California context, many firms began in Class I/II (e.g., disposables and basic instruments), but the upgrading trend is toward Class III devices (e.g., implants, advanced prosthetics, cardiovascular systems), which demand tighter regulatory controls, specialized suppliers, and deeper knowledge.

C. Baja California's medical device firms: a dynamic hierarchy of roles

This report focuses on the largest firms (OEMs, CMs, EMS) in Baja California's medical devices cluster. To highlight the main upgrading pathways in this cluster, a subset of the largest firms by employment (see table A.1) are grouped in a dynamic hierarchy of five roles, using categories from the cluster development literature (reviewed in section II). Following this initial listing, a more detailed analysis will be provided for each set of firms in terms of their production and upgrading profiles in the cluster, followed by recommendations for the cluster overall.

1. Lead OEMs (high-complexity, regulatory heavy)

- Medtronic (Tijuana): The cluster's largest anchor firm has large-scale Class II/III manufacturing, global integration, regulatory governance, and cross-border headquarter links. It sets global standards, pulls suppliers into compliance, and extends GVC theory by showing hierarchical governance is not static; MNE subsidiaries can dynamically upgrade (Ryan et al., 2020a).
- Cardinal Health (KENMEX, Tijuana): High product diversity (its stock keeping unit (SKU)[4] count is about 1,700), strong automation, and sterilization logistics.
- Becton Dickinson (Tijuana): New dispensing cabinets plant, combining electromechanical manufacturing with distribution.

2. Propellents/diversifiers (scale, automation, breadth)

- ICU Medical (Ensenada): Disposables and intravenous (IV) sets; stabilizes the consumables side of the chain.

3. Innovators/connectors (R&D, advanced processes, nearshoring signals)

- Össur (Tijuana): Vertically integrated, has moved R&D and product launches into Baja California; strong in textiles, composites, prosthetics.
- Stryker (Tijuana): Own sterilization (ethylene-oxide, EtO) and complex metal-mechanics; expanding advanced finishing capabilities.

4. Specialized enablers (sterilization, logistics, services)

- Avantti MediClear (Tijuana): E-beam sterilization.
- Centerpiece (Tijuana): EtO sterilization. Both firms provide bottleneck-relieving services that enable OEMs to keep SKUs in Baja California rather than exporting for sterilization.

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4 An SKU or "stock keeping unit" is a unique scannable code that a company creates for each distinct product variation in its inventory to help track, manage, and monitor stock levels more efficiently.

5. Emerging electronics/mechatronics anchor

- Masimo (Mexicali): Focused on sensors, monitoring devices, and mechatronics. Masimo brings electronic/sensor capabilities into a cluster otherwise dominated by plastics, metals, and disposables, which opens a new frontier for diversification in the Baja California cluster.

This dynamic hierarchy of roles shows that Baja California is not a monoculture around Medtronic; instead, it is a multi-anchor cluster with complementary roles. Since MNE subsidiaries can act as "instigators, propellents, and connectors" (Giblin and Ryan, 2015), cluster resilience comes from heterogeneity (diverse capabilities) rather than scale alone. Having outlined the dynamic hierarchy of roles that multinational subsidiaries and specialized firms play in shaping Baja California's medical devices cluster, we now turn to company-specific profiles. These company cases illustrate how upgrading pathways unfold in practice—from Medtronic's global reach and regulatory depth across multiple countries to more specialized but pivotal contributions by firms such as Össur, Cardinal, Avantti, and others in the Baja California cluster.

These upgrading dynamics also carry important social implications. As firms in the medical devices cluster expand into Class II and III devices and adopt higher standards of automation, sterilization, and regulatory compliance, they create opportunities for workers to acquire more advanced skills in quality assurance, validation, mechatronics, and specialized clean-room operations. At the same time, the shift toward more sophisticated production increases the need to strengthen occupational health and safety systems—particularly for workers in sterilization, high-volume cleanroom environments, or handling advanced materials. Embedding social upgrading into cluster strategy ensures that the benefits of economic upgrading translate into higher-quality jobs, clearer career ladders, and a more inclusive talent base capable of sustaining functional upgrading in the long term.

Environmental upgrading is increasingly intertwined with the medical devices cluster's functional upgrading, particularly in sterilization, materials handling, and packaging. Firms investing in EtO abatement, alternative sterilization modalities, waste reduction, and energy-efficient cleanroom operations are not only responding to tighter environmental standards but also enhancing their reliability as suppliers in a highly regulated industry. These improvements support economic upgrading by lowering operational risks, reducing cycle times, and aligning Baja California's capabilities with the sustainability requirements of major global OEMs.

D. Medtronic's role as a global anchor – a three-country comparison

Baja California has become a powerhouse of medical device manufacturing, with several lead firms, like Medtronic, Cardinal Health, and Becton Dickenson serving as anchors. In Tijuana, Medtronic produces a wide range of high-volume devices destined primarily for United States market. Its strength lies in scale: cost-effective, efficient assembly and manufacturing close to the border, which ensures rapid turnaround and reliable exports. Yet the very features that make Baja California attractive—low costs, workforce flexibility, proximity to United States hospitals—also define its limits. Most of the higher-value design, R&D, and global supply chain decision-making remain elsewhere. Medtronic in Baja California is thus indispensable to the company's manufacturing network but has not yet become a node for innovation or product leadership.

This contrasts with Costa Rica, where Medtronic has invested in more technologically complex production, including specialized catheters and implantables that require precision engineering and closer quality control. Operating within Costa Rica's free-trade zones (FTZs), the company benefits from a policy environment designed to attract high-value FDI and build human capital around advanced manufacturing. Here, Medtronic plays a double role both as an export anchor and a technology driver, helping the country climb the value ladder while still leaving the most R&D-intensive activities abroad. Costa Rica's case highlights how policy incentives and workforce training can draw Medtronic into more sophisticated roles, deepening the local cluster's competitiveness (Bamber and Gereffi, 2013; Gereffi et al., 2019).

Ireland provides the most advanced example of what anchoring can achieve. In Galway county, on the west coast of Ireland, Medtronic's site has evolved over decades from a basic assembly plant into a recognized centre of excellence for both production and product development. The subsidiary not only manufactures cardiovascular and other advanced devices but also engages in R&D and clinical trials, even co-governing parts of Medtronic's GVC.[5] Galway's ability to scale ventilator production by 40% during the COVID-19 crisis exemplifies how far a cluster can progress when MNE upgrading is fostered through long-term investment, skilled labour, and strong university-industry linkages (Ryan et al., 2022). Unlike Baja California or Costa Rica, Ireland shows what it looks like when a foreign subsidiary is trusted to manage innovation and crisis resilience on behalf of the corporation globally (Giblin and Ryan, 2015; Giblin et al., 2025).

Seen together, these three cases reveal Medtronic's broader global strategy and its place in the medical devices GVC: Baja California is its nearshoring, high-volume workhorse for the United States market; Costa Rica is its export hub for complex but still cost-sensitive devices; and Ireland is its innovation node, embedded in the firm's R&D governance (see table 2). For Baja California, this raises both opportunities and challenges. Reshoring trends in the United States will likely reinforce Baja California's role as a nearshore production base, but whether it can move beyond that role depends on how effectively policymakers create the conditions for upgrading. By encouraging Medtronic to pilot more complex product lines, collaborate with local universities, and build supplier depth, Baja California can secure Medtronic's continued anchor role while nudging it toward the kinds of contributions seen in Costa Rica and Ireland.

Table 2
Medtronic in Baja California, Costa Rica, and Ireland: comparative snapshot

Location	What Medtronic makes	Role in GVC	Strengths	Limits
Baja California (Tijuana)	High-volume, cost-sensitive devices; assemblies for United States hospitals (e.g., surgical kits, disposables, some implantable components).	Nearshoring hub for United States market; process upgrading focus.	Scale efficiency; proximity to the United States; dense supplier base; rapid export turnaround.	Limited R&D or product development; risk of "functional lock-in" at assembly level.
Costa Rica (Coyol FTZ)	More complex products (e.g., catheters, implantables, precision devices).	Export platform for high-value MedTech; selective product upgrading.	FTZ incentives; policy-driven training; expanding technical workforce.	Still reliant on HQ for R&D and design; smaller talent pool than Mexico.
Ireland (Galway)	Advanced cardiovascular devices, R&D prototypes, clinical trial products.	Innovation node & GVC co-governor (shared responsibility with HQ).	Deep R&D integration; university linkages; global recognition; proven crisis ramp-up.	High costs; specialization risk; heavy reliance on skilled talent supply.

Source: Prepared by the authors.

The stakes are high: over the next five years, Baja California's competitive position will be tested by the 2026 USMCA review, the United States' evolving tariff policy, sterilization and regulatory standards, and growing talent pressures. Policymakers in Baja California must act to consolidate Medtronic's role not only as a manufacturing base but also as a hub for innovation, workforce

5 Medtronic's Galway subsidiary is called a "GVC co-governor" because it doesn't just take orders from headquarters (HQ); it shares strategic control over production, innovation, and resilience in Medtronic's GVC. This co-governance role is exceptional—and is exactly what differentiates Ireland from Baja California (process upgrading) and Costa Rica (product upgrading) (Ryan et al., 2020a).

development, and GVC upgrading. Without proactive policy action, Baja California risks stagnating at the "assembly" stage of the GVC ladder while Costa Rica and Ireland climb higher. With the right interventions, Baja California can capture more R&D, supplier development, and innovation mandates.

For policymakers in Baja California, this means the future of the cluster rests not just on attracting more investment from Medtronic, Cardinal Health and other lead firms, but on leveraging their status as global anchors to signal opportunities for the broader ecosystem. Smaller OEMs and CMs already thrive under the umbrella of Medtronic's presence, but their long-term growth will depend on whether Baja can link its anchor role to pathways of upgrading seen in Costa Rica and especially Ireland. The lesson is clear: securing Medtronic's anchor role is not an end in itself, but the starting point for building a more resilient and innovative MedTech cluster in Baja California.

E. Other OEM profiles – upgrading pathways for medical devices in Baja California

Beyond Medtronic, a diverse set of multinational and regional OEMs are shaping Baja California's medical devices trajectory (see figure 1). While smaller in scale, companies such as Cardinal Health, Stryker, Össur, Masimo, and specialized service providers like Avantti and Centerpiece contribute distinctive capabilities that complement Medtronic's anchor role. Their investments in automation, sterilization, composites, electronics, and packaging demonstrate how niche specializations can translate into broader cluster benefits. These firms act as propellents and connectors among other roles, diffusing global standards into local supply chains, piloting supplier upgrades, and fostering cross-border knowledge flows.

Taken together, these cases illustrate that Baja California's competitiveness is not built on a single flagship, but on the interplay of anchors and specialists. The following company profiles highlight how each OEM pursues its own upgrading pathway—whether through process automation, R&D relocation, diversification into new modalities, or supplier development—and how, collectively, they reinforce the resilience and innovative capacity of the cluster. In doing so, they show how Baja California can deepen its specialization while broadening its technological base, securing its position as North America's leading medical devices manufacturing hub.

1. Propellents and diversifiers: Cardinal Health, Becton Dickison, and ICU Medical

Cardinal Health (KENMEX) anchors one of Baja California's largest multi-product facilities, producing more than 1,700 SKUs across molding, extrusion, and assembly. The company has steadily invested in automation and workforce optimization, reducing headcount from over 3,000 to about 2,400 while keeping volumes constant, and building a robust pipeline of engineers through internship programs. Its 500,000 square feet of vacant land positions it as a platform for future expansion into higher-value, more automated production. Cardinal's scale and its reliance on local sterilization partners also make it a propellent for supplier upgrading; tooling, mold-making, and sterilization services all benefit from its demand for speed and compliance

Becton Dickinson (BD) represents another diversification engine. With multiple expansions in Tijuana, BD manufactures a wide array of disposables and diagnostic products, reinforcing Baja California's breadth of MedTech specialization. Unlike firms that focus narrowly on implants or electronics, BD's portfolio drives upgrading in plastics, packaging, and quality systems that cross over into many product families. Its expansion contributes to employment growth and creates training pipelines in regulatory compliance and clean-room operations. This has spillover effects for local small and medium enterprises (SMEs), which must meet BD's stringent supplier qualifications, thereby pushing the cluster outward into new product categories while raising baseline quality.

ICU Medical, a global leader in infusion systems and critical care products, strengthens Baja California's footprint in liquid handling and precision fluid delivery. Its operations in the region involve assembly and packaging of complex disposables, which require validated sterilization and packaging processes. These activities deepen local capabilities in biocompatibility, leak testing, and process validation—functions that move beyond simple assembly. ICU Medical also plays a role in workforce development, offering training in specialized clean-room practices and creating career paths for operators and engineers in high-value functions.

Taken together, Cardinal, BD, and ICU Medical illustrate why Baja California's cluster is not defined by a single anchor, but by a set of diversifiers and propellents. Each expands the technological and product base in different directions—Cardinal through automation and logistics, BD through breadth of disposables and diagnostics, and ICU Medical through precision infusion systems. At the same time, all three propel the cluster forward by forcing supplier upgrades, creating engineering pipelines, and embedding regulatory and validation know-how locally. This combination of scale, specialization, and spillover effects makes them critical complements to the flagship role of Medtronic in Baja California's GVC.

2. Innovators and connectors: Össur and Stryker

Össur has emerged as one of Baja California's most innovative OEMs by consolidating the manufacturing of bracing and prosthetics in Tijuana. Unlike firms that focus narrowly on disposables or high-volume assemblies, Össur's operations span textiles, plastics, metals, adhesives, and specialized surface treatments—giving the local cluster a unique foothold in advanced materials and product design. The company has successfully launched new product lines from its Baja California facilities, proving that complex devices can be developed and validated outside traditional R&D centres in the United States or Europe. In GVC terms, this represents both product upgrading (new brace and prosthetic families) and functional upgrading (relocating engineering and validation work). Össur also invests directly in supplier capability by co-financing specialized processes—such as nickel plating—that were previously unavailable in Mexico. This demonstrates how an innovator can act as a lighthouse, pulling the broader cluster into higher-value domains.

Stryker, by contrast, plays the role of connector. Its large-scale Tijuana operations produce orthopaedic and surgical devices that demand exacting standards for sterilization, packaging integrity, and precision machining. Stryker's presence has raised the bar for sterilization technology in Baja California, as nearly all its product families require validated EtO or radiation sterilization. By working closely with local contract sterilizers and packaging providers, Stryker transmits global regulation and quality expectations through its supply chain, effectively upgrading the entire ecosystem. This is a form of process upgrading (more advanced clean-room and machining practices) and functional upgrading (compliance with the U.S. Food and Drug Administration (FDA) Quality Management System Requirements (QMSR) and International Organization for Standardization (ISO) 13485 standards). It also fosters workforce development: operators, engineers, and quality specialists trained in Stryker's plants acquire transferable skills that diffuse across the cluster.

Together, Össur and Stryker illustrate why Baja California's competitiveness is not only about scale but about innovation and connectivity. Össur demonstrates that Baja California can be a platform for design- and R&D-linked production, creating local capabilities in advanced materials and product launches. Stryker ensures that these capabilities are tied into global markets by embedding international quality, sterilization, and regulatory standards in day-to-day practice. They show how niche specialization and global standard-setting reinforce each other, diversifying Baja California's medical devices cluster while ensuring it remains plugged into the GVC.

3. Specialized enablers: Avantti MediClear and Centerpiece

Unlike the multinational OEMs that dominate Baja California's employment charts, Avantti MediClear and Centerpiece represent a different but equally critical layer of the MedTech ecosystem: specialized service providers that enable the cluster to function. Both firms focus on sterilization[6]—a mandatory step for virtually all Class II and III medical devices. Their role is not in producing devices themselves, but in ensuring that products assembled in Baja California meet stringent sterility, validation, and regulatory requirements before they can be shipped to patients worldwide. Without such capacity inside the region, devices would need to be transported out for sterilization and then reimported for packaging or distribution, adding costly weeks to cycle times. By filling this gap locally, Avantti and Centerpiece dramatically improve the competitiveness of the cluster.

Avantti MediClear was the first specialist to introduce electron-beam (E-beam) sterilization in Tijuana. This modality is increasingly important as the global supply of cobalt-60 for gamma sterilization tightens and as OEMs look for faster, lower-emission alternatives to EtO. Avantti not only provides irradiation services but also offers dose mapping, dosimetry, and validation support—capabilities that smaller suppliers and contract manufacturers could not otherwise access in Baja California. In GVC terms, Avantti promotes process upgrading by shortening sterilization cycle times and functional upgrading by embedding regulatory and validation expertise into local operations. For the workforce, it creates specialized roles in radiation physics, quality assurance, and regulatory compliance, and seeding skills that spill over into other firms.

Centerpiece, by contrast, anchors Baja California's EtO sterilization capacity. Its facility in Tijuana provides high-volume EtO services, including preconditioning, aeration, and validated cycle development. Given that many complex medical devices—especially those with mixed materials or deep lumens—still rely on EtO, Centerpiece has become the linchpin for OEMs like Medtronic and Cardinal Health to keep products in-region. The company has invested in state-of-the-art abatement systems to comply with tightening US EPA standards, demonstrating that Baja California can meet the same environmental and regulatory benchmarks as facilities in the United States or Europe. This is a form of chain upgrading: by providing regulatory-compliant EtO locally, Centerpiece allows global OEMs to shift more product families into Baja California without risking supply chain bottlenecks.

As a pair, Avantti and Centerpiece illustrate why specialized enablers are worthy of recognition, even if they don't employ thousands. They operate at critical choke points in the GVC, where lack of local capacity would constrain the entire cluster's growth. Their presence ensures that Baja California is not merely an assembly platform, but a location capable of end-to-end compliance with international sterilization standards. By diversifying sterilization modalities (EtO and E-beam) and embedding validation expertise locally, they provide resilience and flexibility to OEMs facing global regulatory and supply shocks. In this sense, they are not peripheral but foundational actors: small in headcount, but disproportionately large in strategic importance for the long-term competitiveness of Baja California's MedTech ecosystem.

Figure 1 represents a smile curve that depicts how value added is distributed across the medical devices value chain in Baja California. Popularized in the international business and GVC literatures (Mudambi, 2008; Gereffi and Fernandez-Stark, 2016), a smile curve illustrates how value added is related to the stages and location of international production and the degree of technological complexity in GVCs. High-complexity activities such as R&D, clinical validation, and regulatory strategy remain concentrated in the headquarters of MNEs outside Mexico, while Baja California specializes

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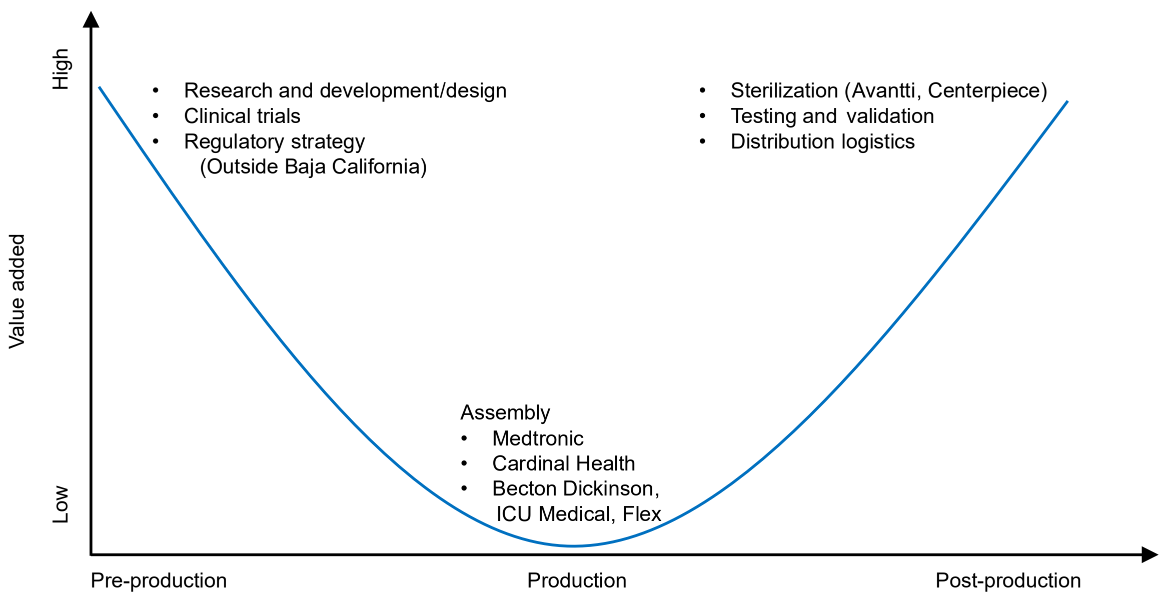
[6] Sterilization capabilities are an important process in medical device clusters. Ethylene oxide (EtO) is a chemical gas sterilization method suitable for heat- and moisture-sensitive materials, but it requires long aeration times and ventilation to remove toxic residues. E-beam sterilization uses a high-energy electron beam, a faster and cleaner process that doesn't use chemicals, leaves no toxic residues, and allows for immediate product release, though it may not be suitable for all materials.

primarily in mid- to low-complexity activities, including cleanroom assembly, high-volume production, and some testing and sterilization. Despite employing fewer workers, specialized enablers such as Avantti and Centerpiece sit on the high-complexity right side of the curve, reflecting their critical role in ensuring regulatory compliance and supply-chain continuity. This distribution highlights both the current strengths of the regional ecosystem and the upgrading opportunities for expanding Baja California's participation into higher-value functions.

Figure 1
Smile curve in Baja California's medical devices value chain



Source: Prepared by the authors.

4. Emerging electronics/mechatronics anchor: Masimo

Masimo, best known globally for its non-invasive patient monitoring systems and pulse oximetry technologies, has steadily expanded its operations in Mexicali. Unlike many of the cluster's firms that specialize in plastics, disposables, or orthopaedics, Masimo brings a different set of capabilities into the region: electronics assembly, sensor integration, and mechatronics[7] manufacturing. The company has reported steady year-on-year growth of around 8%–10% in Mexicali, supported by exports to multiple global markets. This growth is not just about volume—it signals the emergence of an anchor in the electronics niche within Baja California's medical devices cluster.

In concrete terms, Masimo's plant produces precision-molded housings, electronics modules, and final device assemblies for advanced monitoring equipment. While much of the local value addition historically centred on packaging and final assembly, Masimo is moving parts of its bill of materials into Baja California. For example, plastic components are already being molded locally, while other elements (such as screws, LCD screens, or touch panels) remain imported from Europe or Asia. This gradual localization represents product and process upgrading, reducing supply risk and shortening cycle times.

7 Mechatronics is an interdisciplinary field that integrates mechanical systems with electronics and software to create more functional and efficient products and processes. Examples of mechatronics include robotics, automated vehicles, smart appliances, and industrial automation.

More importantly, the company is pushing functional upgrading by demanding local suppliers achieve certifications like ISO 13485 and IPC standards[8] for electronics, effectively raising the bar for Baja California's supply base.

Talent development is another domain where Masimo acts as an anchor. The company has invested in training engineers and technicians in molding, electronics, and assembly validation, creating new career pathways in a part of the cluster where such expertise was previously limited. Young engineers are trained into specialists, especially in molding and quality control for electronic systems. These skills are transferable across the cluster, and in the long term they may spill over into smaller local firms or spinouts. In this way, Masimo is nurturing a mechatronics workforce that complements Baja California's established strengths in disposables and orthopaedic devices.

Masimo fits neatly under the label of "Emerging electronics/mechatronics anchor" because it occupies a niche that no other single OEM in Baja California has yet claimed. Its presence diversifies the cluster's technological base beyond plastics, metals, and sterilization, and positions Baja California to capture a share of the rapidly growing global market for connected monitoring systems and MedTech electronics. While Masimo may not (yet) match the scale of Medtronic or Cardinal in employment, its role in embedding electronic and mechatronic expertise is disproportionately important for upgrading the cluster into higher-value functions.

Finally, while Masimo is unique in its profile, it is not entirely alone. Other firms in Baja California also touch electronics and mechatronics—such as Philips-Respironics (ventilation devices), CareFusion/Becton Dickinson (infusion and monitoring equipment), and Fisher & Paykel (respiratory devices)—though often as part of broader product portfolios. None of these have yet specialized to the extent Masimo has in electronics manufacturing. For policymakers and cluster leaders, Masimo is therefore both a model and a test case: demonstrating how Baja California can grow beyond disposables into advanced electronics, and how one firm's upgrading pathway can anchor a new frontier for the region's MedTech ecosystem.

F. Policy priorities for Baja California to strengthen its medical devices cluster

For Baja California policymakers, the first imperative is to secure local economic development —greater investment, more jobs, and enhanced skills. The starting point is the strength of the existing medical device cluster, which has grown into North America's largest through the decisions of global companies that chose Baja California for its scale, cost profile, and skilled workforce. Drawing on the cluster development framework, the role of the state is not to dictate strategy from the top down, but to strengthen the collective assets that firms already rely upon: specialized suppliers, skilled labour pools, shared infrastructure, and institutional supports. In this way, policies become an enabler of firm-driven growth, ensuring that the upgrading pathways already visible in companies like Cardinal Health, Stryker, Össur, and Masimo can multiply across the ecosystem.

The GVC upgrading perspective reinforces this bottom-up approach. Upgrading occurs when local subsidiaries move from basic assembly to higher-value activities—through product upgrading (Össur developing new prosthetic and brace variants from Tijuana), process upgrading (Cardinal Health embedding automation into clean-room lines), functional upgrading (Masimo driving IPC standards and

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8 IPC standards are a globally recognized set of technical standards for the design, assembly, and testing of electronic equipment and assemblies, issued by IPC (Association Connecting Electronics Industries), formerly known as the Institute for Printed Circuits. In the MedTech context (and more broadly in electronics), these standards ensure that electronic components and assemblies are manufactured and inspected to a consistent, high-quality level that supports safety, reliability, and regulatory compliance.

electronics certification locally), or chain upgrading (Avantti and Centerpiece enabling Baja California to retain more SKUs in-region by providing sterilization services). Each of these is a case where a global firm, embedded in Baja California, is already propelling upgrading. Policymakers can amplify these firm-level moves by supporting supplier quality certification, providing targeted training in mechatronics and sterilization, and easing regulatory and environmental approvals for specialized enablers. The theory underscores the practice: cluster competitiveness emerges from complementary upgrading across firms, not from isolated initiatives.

Policy must also address the external pressures of the GVC—most notably, the uncertainty created by shifting United States trade policy. Drawing again from cluster theory, external linkages are as critical as internal strengths. Border efficiency, predictable logistics, and cross-border institutional cooperation are not merely infrastructure projects but essential cluster support. By fast-tracking Otay Mesa East, creating medical device lanes for sterile and non-sterile shipments, and maintaining clear communication with federal trade negotiators on USMCA compliance, Baja California policymakers reinforce the resilience of the cluster against external shocks. In GVC terms, this is about maintaining resilience within hierarchical governance: ensuring that Baja California subsidiaries remain indispensable nodes in the global production networks of their parent companies, even in the face of tariff volatility.

Most importantly, positioning Baja California's MedTech industry through these frameworks emphasizes that Mexico has strategic autonomy in promoting the medical devices GVC; it is not merely a dependent supplier or secondary partner. By building capacity in sterilization, electronics, and advanced materials, Baja California demonstrates its ability to host complex, innovation-linked functions rather than just assembly. By embedding supplier upgrading and workforce development into cluster strategy, policymakers can show that Baja California's growth delivers not only for global OEMs but also for local workers and SME suppliers. The outcome—grounded in both cluster and GVC theory—is a practical, investment-driven strategy: a cohesive ecosystem that offers global firms speed and resilience, while generating high-quality jobs, skills, and innovation for Mexico.

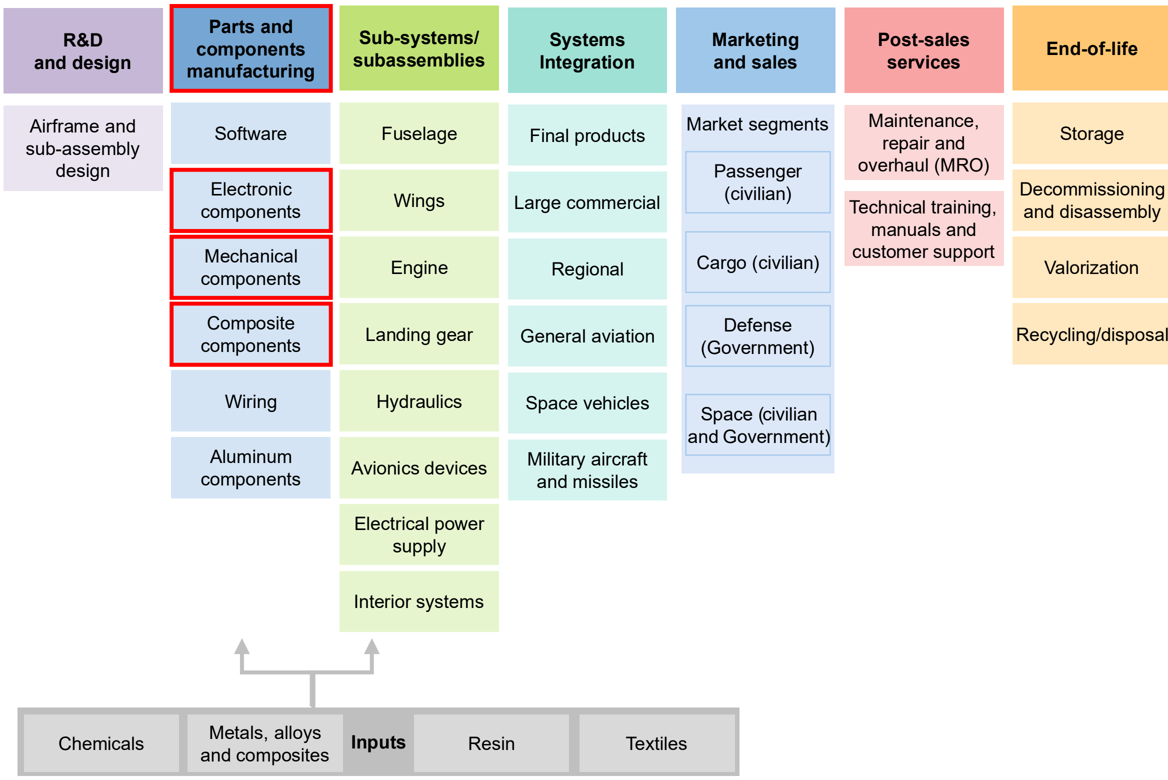
IV. The aerospace cluster in Baja California, Mexico

A. Overview

Baja California's aerospace industry has evolved into one of the state's leading advanced-manufacturing clusters, supported by a diverse mix of multinational firms, specialized production niches, and deep logistical and engineering connections with Southern California. Building on capabilities inherited from the electronics and automotive sectors—such as precision assembly, certified quality systems, and an experienced technician workforce—the region now hosts more than 100 aerospace-related firms across Tijuana and Mexicali. This organizational depth positions Baja California as a significant node in North American aerospace supply chains, even as opportunities remain to expand into higher-value engineering, testing, and post-production services. Diagram 2 shows that Baja California's role in aerospace remains concentrated in parts and component manufacturing. Most production focuses on electronics, mechanical components and composite components.

Baja California's aerospace cluster is dominated by foreign-owned firms, with leading Tier-1 and Tier-2 anchors originating from the United States, Europe, and Canada. Companies such as Collins Aerospace (United States), Honeywell (United States), Safran Cabin (France), Eaton (United States), and Gulfstream (United States) reflect the international composition of the sector, while specialized SMEs and shelter operators provide locally based production platforms for additional MNE entrants. As in medical devices, domestic firms play supporting roles in tooling, engineering services, and niche processes, but the overall configuration of the cluster is shaped by global aerospace MNEs operating manufacturing and service mandates within the region.

Diagram 2
Baja California, Mexico in the aerospace GVC



Source: Prepared by the authors.

B. Dynamic hierarchy of roles

Baja California's aerospace cluster is shaped by a dynamic mix of actors whose roles collectively define the region's upgrading trajectory. Anchors and integrators establish the technological and certification standards that tie the region into global aerospace programs. Surrounding them, propellents and diversifiers broaden the cluster's productive base by enabling new firms to enter and scale quickly. Complementing these are connectors and innovators whose engineering services, automation expertise, and tooling capabilities help diffuse advanced practices across the supplier network. Finally, enablers provide the institutional coordination and logistics infrastructure that sustain cluster-wide performance. Together, these roles highlight a distributed leadership model that reinforces specialization, supports supplier development, and underpins Baja California's potential for further upgrading.

1. Anchors and Integrators

Anchors in Baja California aerospace are large multinational Tier-1 and Tier-2 firms[9] with significant employment and production mandates. While no single company dominates the cluster, together these firms provide the critical gravitational pull that defines quality, certification, and specialization thresholds. They act as integrators, linking Baja California into multiple GVCs simultaneously, and reinforcing the cluster's ability to diversify across aerostructures, interiors, fluid conveyance, and avionics systems. The following firms illustrate this anchor role:

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9 Tier-1 firms in Baja deliver systems or large-scale sub-assemblies directly to OEM or "prime" companies (e.g., Boeing, Airbus, Bombardier, Gulfstream). Tier-2 firms sell parts and sub-assemblies to Tier 1s (and sometimes OEMs).

- Collins Aerospace (Mexicali): thrust reversers, advanced structures, composites.
- Honeywell Aerospace (Mexicali): diverse aerospace components and engineering-intensive mandates.
- Gulfstream (Interiores Aéreos) (Mexicali): interiors and parts for business jets.
- Safran Cabin (Tijuana): metal structures for cabin/interiors.
- Eaton (Tijuana): tubes, ducts, couplings, valves.

2. Propellents/diversifiers

Propellents and diversifiers broaden the cluster's technological base and facilitate the onboarding of new mandates. In Baja California, these roles are played primarily by shelter companies such as MAM de la Frontera and TECMA, which provide turnkey operational, administrative, and compliance infrastructure for aerospace manufacturers. By lowering entry barriers and supporting rapid scale-up, these platforms enable a steady diversification of local activities and contribute to the expansion of mid-tier manufacturing capabilities across the region.

3. Connectors/innovators

Connectors and innovators are specialized firms that bridge technical gaps, accelerate learning, and support supplier upgrading within the cluster. Companies such as Mecánica 4.0 and H.I.J. Precision play this role by offering engineering services, automation solutions, tooling expertise, and rapid problem-solving capabilities for Tier-1 and Tier-2 customers. Although smaller in size, their agility and technical depth help diffuse advanced practices across the supplier base and enhance the cluster's responsiveness to global aerospace requirements.

4. Enablers

Enablers provide the connective tissue and institutional support that sustain Baja California's aerospace cluster over time. Unlike anchors or connectors, they are not production firms, but rather organizations and infrastructures that coordinate certification, promote the cluster externally, and ensure that logistics and maintenance capabilities function efficiently. Their impact is systemic; by reducing bottlenecks and aligning actors, they help other firms compete more effectively in GVCs:

- Cluster Aeroespacial de Baja California A.C. is a regional industry association that integrates aerospace manufacturers, service providers, universities, and government agencies, coordinating certification programs (such as AS9100 and NADCAP), workforce development initiatives, and collective policy advocacy
- CBX/GAP airport ecosystem combines the Cross Border Xpress (a binational terminal connecting Tijuana to the United States airport infrastructure) with Grupo Aeroportuario del Pacífico's logistics and cargo facilities, creating a platform that supports specialized aerospace logistics, rapid cross-border movement, and nascent maintenance, repair and overhaul (MRO) services.

C. Firm profiles

The following firm profiles highlight the most significant anchors and connectors in Baja California's aerospace cluster. Each short case outlines what the company produces locally, the certifications it holds, and the role it plays in the cluster's global value chain upgrading. Unlike the medical devices cluster, where a single lead firm dominates, here the profiles show how a distributed set of MNE anchors and specialized SMEs collectively drive cluster development.

1. Anchors and integrators

Collins Aerospace (Goodrich) manufactures thrust reversers, advanced structures, and composites in Mexicali. With certifications including AS9100, ISO45001, and NADCAP, the company acts as an anchor in aerostructures and composites. It sets the certification and process benchmarks for suppliers and defines upgrading pathways in special processes and materials.

Honeywell Aerospace operates in Mexicali with mandates covering a broad set of aerospace components and subsystems, with potential spillovers into avionics, testing, and aftermarket services. Its engineering intensity positions it as a parallel anchor to Collins, anchoring Baja California in higher-value GVC niches beyond manufacturing alone.

Gulfstream's interiors operation in Mexicali produces aircraft parts and interiors and is recognized with ISO 14001 and the Shingo Prize for operational excellence. It anchors the business-jet interiors segment and serves as a platform for lean practice diffusion across Baja California's supplier base.

Safran Cabin produces metal structures for cabins and interiors, certified to AS9100, NADCAP, and ISO14001 standards. As an anchor in interiors, Safran positions Baja California for a Montreal-style specialization in cabin systems and interiors integration, opening opportunities for suppliers in specialized materials and processes.

Eaton's Tijuana plant manufactures tubes, ducts, couplings, and valves, with AS9100, ISO 9000, and NADCAP certifications. As both an anchor and propellent, Eaton deepens the fluid conveyance niche and opens upgrading corridors for local suppliers in welding, NDT, and heat treatment.

2. Propellents/diversifiers

In Baja California aerospace, the role of propellents and diversifiers is less sharply defined than in medical devices. In MedTech, three major firms—Cardinal Health, BD, and ICU Medical—played clear propellent/diversifier roles by simultaneously broadening the cluster base and diversifying into new product areas. In aerospace, by contrast, these functions are carried primarily by the large shelter platforms, most notably MAM de la Frontera and TECMA.

MAM de la Frontera stands out as the single largest employer in the aerospace directory with around 10,000 employees, nearly three times the headcount of Gulfstream, the next largest company. Unlike the multinational anchors that dominate the cluster, MAM de la Frontera is a Mexican-owned shelter operator, which helps explain its large employment footprint and its role in hosting multiple aerospace programs rather than a single consolidated mandate. This reflects the nature of MAM as a shelter company: it does not represent a single mandate but rather aggregates multiple aerospace programs under its umbrella. Its role is to provide flexible infrastructure, labour force management, and administrative systems to host international companies that might otherwise hesitate to enter Baja California directly. TECMA plays a similar role, albeit at a smaller scale, by managing maquila operations for multiple aerospace clients.

By providing scale, shared services, and turnkey operations, these shelters propel the cluster by enabling new entrants to ramp up quickly and meet regulatory standards. At the same time, they act as diversifiers, because each new client they onboard adds new product niches, certifications, and process capabilities to the regional base. In practice, the distinction between the two roles is blurry: nearly all propellents are also diversifiers, and vice versa. In aerospace, the category appears weaker than in medical devices, since the shelter companies lack the product-development depth and global brand recognition that medical device anchors like Cardinal or BD brought to Baja California. Still, MAM and TECMA are critical in ensuring Baja California can absorb new mandates and broaden its industrial base.

3. Connectors/innovators

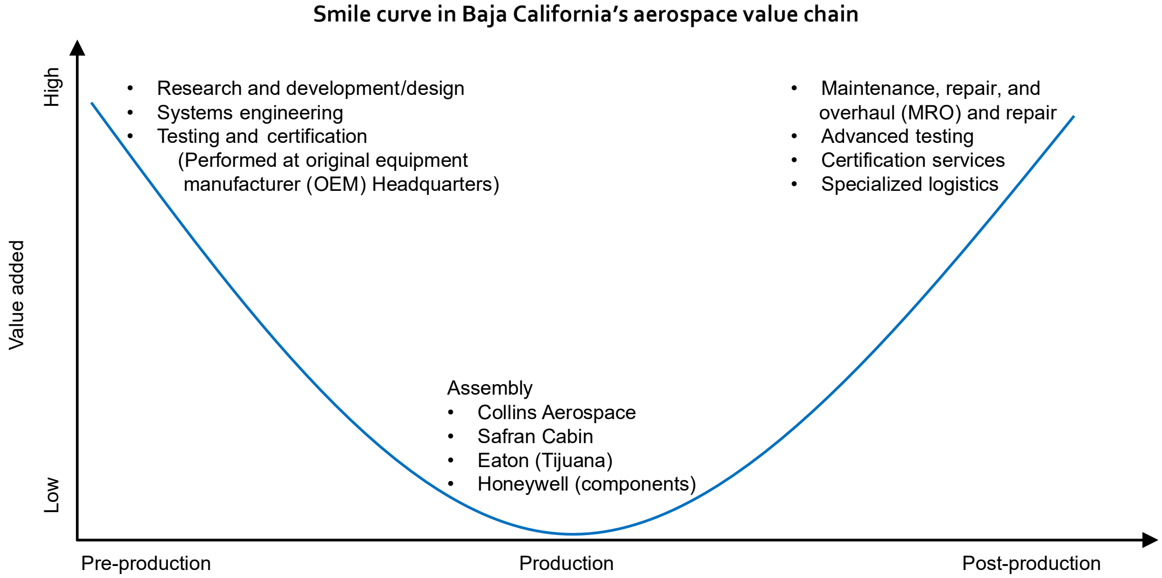
The connector and innovator roles in Baja California aerospace are filled by specialized SMEs that link the cluster to global Tier-1 programs and provide agile, knowledge-intensive solutions. These firms may not employ thousands of workers, but they are vital in bridging technical gaps, solving urgent problems, and enabling supplier upgrading. In the medical devices cluster, connectors often took the form of design houses or specialized testing labs. In aerospace, they emerge as engineering boutiques and established tooling suppliers.

Mecánica 4.0 is an example of a connector-innovator. By offering turnkey automation and engineering services, it links local manufacturing with global aerospace standards. Its strength lies in problem-solving across industries and in adapting automation to aerospace requirements. However, its ability to scale is constrained by limited working capital and financing bottlenecks, underscoring a systemic barrier for Baja California SMEs.

H.I.J. Precision exemplifies a connector-enabler through its three decades of supplying consumables and tooling to major firms such as Boeing and Safran. Its value is not in scale but in responsiveness: it can provide special parts and technical fixes quickly, keeping production programs on track. In doing so, it channels global knowledge flows into Baja California and strengthens the resilience of the cluster's supply base.

Together, these two firms highlight the critical—but often underrecognized—role of connectors in Baja California's aerospace development. They are innovators in process and problem-solving, enabling local suppliers to meet the demands of global aerospace programs. Figure 2 highlights the distribution of value creation and technological sophistication across Baja California's aerospace GVC. At the high-complexity ends of the curve—pre-production engineering, aircraft design, certification, and advanced testing—activities remain centred in global OEM hubs. Baja California participates mainly in the lower-complexity middle of the curve, through assembly of aerostructures, interiors, tubes and ducts, and selected special processes carried out by firms such as Collins, Safran Cabin, Eaton, and Honeywell. High-complexity post-production activities, including MRO, component testing, and certification services, are only partially present in the region. The curve underscores the challenge and opportunity: advancing toward higher-value engineering and post-production niches is essential for long-term upgrading.

Figure 2
Smile curve in Baja California's aerospace value chain



Source: Prepared by the authors.

4. Enablers

Enablers provide the connective tissue and institutional support that sustain Baja California's aerospace cluster over time. Unlike anchors or connectors, they are not production firms, but rather organizations and infrastructures that coordinate certification, promote the cluster externally, and ensure smooth logistics and MRO capabilities. Their impact is systemic: by reducing bottlenecks and aligning actors, they help other firms compete more effectively in global value chains.

The Cluster Aeroespacial de Baja California A.C., an industry association that brings together aerospace manufacturers, service providers, universities, and government partners, plays this role by organizing certification working groups, facilitating cooperation among firms, and representing the region in national and international forums. Its advocacy and coordination strengthen the cluster's collective capabilities and policy voice.

Similarly, the CBX/GAP airport ecosystem—comprising the Cross Border Xpress terminal and the logistics infrastructure operated by Grupo Aeroportuario del Pacífico—supports the cluster by enabling efficient cross-border mobility, specialized cargo flows, and emerging niches in aircraft maintenance and repair.

In aerospace, the distributed anchor structure presents additional opportunities and challenges for social upgrading. Because multiple Tier-1 and Tier-2 firms shape the cluster simultaneously, demand for certified technicians, inspectors, welders, machinists, and engineers spans a broad set of competencies. This creates pathways for workers to move into higher-skilled, more stable employment, but also highlights critical bottlenecks in certification, English proficiency, and specialized technical training. Addressing these gaps is not only a workforce issue—it is a strategic upgrading imperative. Bringing social upgrading to the centre of aerospace development entails expanding training capacity, supporting SME access to certifications, and ensuring that the cluster's growth translates into improved job quality and greater mobility for local talent.

Aerospace upgrading also depends on environmental performance, as global firms face stronger requirements related to chemical handling, waste minimization, and energy-efficient production. NADCAP and AS9100 certifications incorporate many of these expectations, making environmental upgrading a prerequisite for deeper supplier integration. Baja California's efforts to modernize machining, heat treatment, composite manufacturing, and special processes therefore contribute simultaneously to environmental compliance and to the broader economic upgrading needed to secure more complex aerospace mandates.

D. Policy priorities for Baja California in the aerospace cluster

The analysis of firm roles and the dynamic hierarchy shows that Baja California's aerospace cluster demands a distinct set of policy priorities compared to medical devices. Medical devices are organized around global flagship anchors (such as Medtronic, Cardinal Health, or BD) that define upgrading opportunities across the cluster. Aerospace, by contrast, has a distributed anchor structure, with several Tier-1 and Tier-2 firms (Collins, Honeywell, Safran, Eaton, Gulfstream) acting in parallel. This difference matters: policy must support coordination across multiple anchors and strengthen the enabling environment rather than relying on a single lead firm's governance.

From a cluster development perspective, Baja California's policy priorities are to:

- Strengthen propellents/diversifiers: support large shelters like MAM and TECMA to keep onboarding new mandates while embedding higher-value activities.

- Empower connectors/innovators: provide financing solutions, certification support, and linkage programs that enable SMEs—especially emerging Mexican-owned suppliers such as Mecánica 4.0 and H.I.J. Precision—to scale their capabilities and deepen their participation in the cluster.
- Enhance enablers: reinforce the role of the Cluster Aeroespacial de Baja California and logistics infrastructure to coordinate actors and reduce systemic bottlenecks.
- Promote distributed leadership: foster collaboration among multiple anchors—together with universities, technical institutes, and research centres—to encourage technology transfer, strengthen workforce capabilities, and facilitate coordinated upgrading across the cluster without relying on a single global integrator.

From a GVC upgrading lens, priorities should include:

- Certification and special processes: accelerate SME upgrading into AS9100, NADCAP,[10] and special-process capabilities to deepen local supplier participation in global programs.
- Functional upgrading: encourage the shift of certain mandates from pure manufacturing toward testing, repair, engineering support, and eventually design-related tasks.
- Knowledge flows: leverage connectors and enablers to channel global knowledge from anchors into the broader cluster base, reducing dependency on foreign decision centres.

The absence of a global flagship in aerospace means that policy must build collective strength rather than relying on a single firm's local governance. This contrasts with medical devices, where policy can be more tightly aligned with the upgrading pathways defined by a few dominant anchors. For aerospace, therefore, the priority is not just supplier upgrading, but also coordination, institutional support, and diversification across niches to ensure resilience and long-term competitiveness.

These priorities provide the intermediate policy frame for Baja California's aerospace cluster. They set the stage for later integration of international geographic case study insights (e.g., Costa Rica, the Dominican Republic, and Ireland for medical devices, and Phoenix, Montreal, Morocco, and Querétaro for aerospace) into the final policy takeaways of the full report. The policy comparison in table 3 highlights why Baja California policymakers should treat aerospace and medical devices with differentiated policy strategies, even while using the same theoretical frameworks of cluster development and GVC upgrading.

Table 3
Comparative view: medical devices vs. aerospace policy priorities

Dimension	Medical devices cluster	Aerospace cluster
Anchor structure	Dominated by a few global flagships (Medtronic, Cardinal Health, Becton Dickinson) that define upgrading pathways for the cluster.	Distributed among multiple Tier-1/Tier-2 firms (Collins, Honeywell, Safran, Eaton, Gulfstream). Requires coordination across anchors.
Cluster development focus	Support global flagship mandates, develop strong supplier ladders aligned with lead firm needs.	Strengthen shelters (MAM, TECMA), empower connectors (Mecánica 4.0, H.I.J.), reinforce enablers (cluster association, airport).
GVC upgrading priorities	Deepen integration into the lead firm's GVC through compliance, process upgrading, and R&D spillovers.	Certification and special-process upgrading; functional upgrading into testing, repair, and engineering; channelling knowledge across anchors.
Policy approach	Align tightly with anchor's requirements, facilitate supplier upgrading in line with Medtronic's governance.	Collective strength, distributed leadership, institutional coordination, diversification across niches.

Source: Prepared by the authors.

[10] AS9100 is the international quality management system standard for the aerospace industry. National Aerospace and Defense Contractors Accreditation Program (NADCAP) is the leading global cooperative accreditation program for special processes and products in aerospace and defense, covering activities such as welding, heat treatment, composites, and non-destructive testing.

V. Lessons for medical devices upgrading from comparative cases

Three comparative cases of similar clusters in medical devices can offer key lessons for Baja California as it seeks to upgrade its cluster to further benefit from GVC participation. The first case explores the role of workforce development and policy initiatives to attract high-value FDI in Costa Rica. The second looks at Ireland, focusing on policies for FDI incentives, support for indigenous firms, workforce and skills development strategies, and regulatory alignment with European and global standards. Finally, the third case explores the Dominican Republic's efforts to upgrade its medical devices GVC via cluster coordination, free processing and the promotion of forward linkages for local suppliers. Table 4 presents a short summary of the three cases and highlights key steps taken to achieve their current position in the medical devices GVC.

Table 4
Summary of comparative cases in the medical devices GVC

	Costa Rica	Galway (Ireland)	Dominican Republic
Exports	US$ 9 billion (2023)	US$ 18 billion (2023)	US$ 2.9 billion (2024)
Direct employment *(number)*	55 000	40 000	34 000
Firms operating *(number)*	86	300	41
Key global firms	• Boston Scientific (United States) • Medtronic (Ireland/ United States) • Abbott Laboratories (United States) • Philips (Netherlands) • Hologic (United States)	• Medtronic (Ireland/ United States) • Boston Scientific (United States) • Abbott (United States) • Johnson & Johnson (United States) • Stryker (United States)	• Johnson & Johnson (United States) • Medtronic (Ireland/ United States) • Cardinal Health (United States) • B. Braun (Germany) • Fresenius Medical Care (Germany)
Policy areas for upgrading	• Workforce development • FDI attraction • Marketing and branding of local cluster	• Workforce development • FDI attraction • EU Regulatory alignment	• Workforce development • Fiscal incentives • Cluster Coordination • Regulatory modernization

Source: Prepared by the authors.

Across the comparative cases, a consistent finding is that sustained economic upgrading was closely linked to deliberate investments in social upgrading. Costa Rica's success in attracting high-value mandates was inseparable from long-term efforts to professionalize the workforce and expand access to specialized technical training. Ireland's ability to evolve into a global MedTech innovation hub was reinforced by strong university-industry linkages, enabling workers to advance into R&D, regulatory, and product-design roles. The Dominican Republic likewise strengthened its competitiveness by modernizing training institutions and promoting forward linkages for local suppliers. These examples show that improvements in skills, job quality, and institutional capabilities are not ancillary to upgrading; they are foundational pillars that determine how much value clusters can capture and retain.

The comparative cases also show that environmental upgrading supports economic upgrading in medical devices. Ireland's adherence to stringent European Union sustainability standards, Costa Rica's promotion of eco-efficient manufacturing within its free-trade zones, and the Dominican Republic's modernization of environmental regulatory frameworks all helped strengthen their positioning in global markets. For Baja California, aligning cluster development with similar environmental practices can enhance regulatory credibility and attract higher-value mandates from multinational firms.

A. Costa Rica in the medical devices GVC

Costa Rica entered the medical devices GVC in a notable way in the mid-2000s, working primarily in low-tech, lower-value segments (Bamber and Gereffi, 2013). However, the last decade has seen a coordinated effort to move the country into higher-value segments. These efforts, largely led in the past by the Costa Rican Investment Promotion Agency (CINDE) and at present by the Costa Rican Foreign Trade Promotion Agency (PROCOMER), a non-profit organization focused on FDI attraction, were successful with several firms increasing investments and building linkages with local suppliers.[11]

Post-pandemic recovery brought renewed investment in skills and innovation. The National Apprenticeship Institute (INA) introduced specialized biomedical engineering and advanced manufacturing programs to meet rising demand for skilled labour. At the same time, firms such as Philips and Hologic expanded R&D operations, enabling Costa Rica to diversify into higher-value functions beyond assembly and manufacturing. These developments enhanced the country's competitiveness in the global health economy (CINDE, 2022). This occurred as Costa Rica also worked to diversify into new markets, notably European and Asia markets. These expansions further cemented its position as a global medical device manufacturer. Most recently, PROCOMER's focus has remained on helping build links between global medical device firms, primarily those based in the United States, and local OEM suppliers.[12] Tax incentives, robust training and coordinated branding efforts are all being deployed to help the cluster both maintain and grow its position (García Nice and Tovar, 2025).

1. Costa Rica's current participation in the medical devices GVC

Emerging as the second-largest medical device exporter in Latin America, behind Mexico who has over US$ 33 billion in exports, Costa Rica has nearly 100 companies operating in the GVC with exports nearing US$ 9 billion (García Nice and Tovar, 2025). Its participation spans multiple segments but is concentrated in capital equipment, therapeutic devices, and disposables (see diagram 3).

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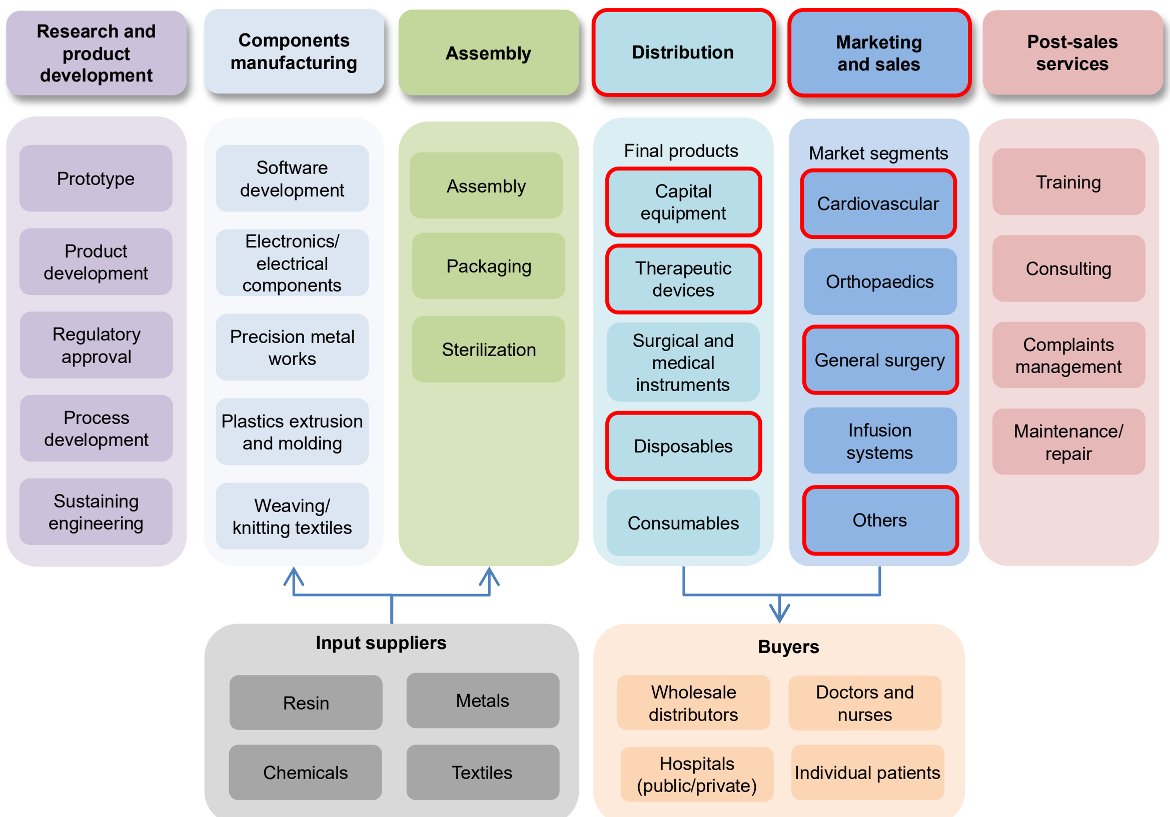
[11] In a significant shift, the functions previously carried out by CINDE have now been assumed by PROCOMER, Costa Rica's export and investment promotion agency (https://procomer.com/).

[12] See https://procomer.com/.

From 2015 to today, Costa Rica has deepened its specialization in medium- to high-complexity medical devices and scaled rapidly in both firms and output. The number of companies grew from about 67 in 2017 to 86 by 2023, while direct employment more than doubled from around 22,400 to over 55,000. Exports rose from US$ 3.5 billion in 2018 to US$ 7.4–7.5 billion by 2022–2023 and surpassed US$ 9 billion in 2024, making the country a top supplier to the United States (CINDE, 2024). Twelve of the global Top 30 medical device MNEs operate locally, underscoring Costa Rica's move up the value chain (CINDE, 2024).

Diagram 3
Costa Rica in the medical devices GVC



Source: Prepared by the authors.

2. Key upgrading policies for Costa Rica in the medical devices GVC

Costa Rica's upgrading in the medical devices GVC was the direct result of coordinated policy interventions. These policies focused on workforce development, FDI attraction via tax incentives, and country branding efforts. Selected policies and programs are summarized below and in table 5.

Skilled workers who could move to advanced product lines were crucial for Costa Rica's ability to upgrade in the medical devices GVC. From 2015 onward, the government partnered with industry associations and MNEs to strengthen technical education and provide sector-specific training. Programs such as Alianza para el Bilingüismo (ABi) and new curricula introduced at the National Training Institute (INA) aimed to expand English proficiency and technical competencies in cleanroom manufacturing, quality assurance, and precision engineering. In addition, collaborations with United States and European firms enabled knowledge transfer in areas like regulatory compliance and R&D, which supported the industry's move into higher-value segments such as cardiovascular, endoscopy, and neurostimulation devices (ECLAC, 2020; CINDE, 2022).

Table 5
Key policies to facilitate Costa Rica's upgrading

Program name	Year(s)	Lead institution	Description
Alianza para el Bilingüismo (ABi)	2017–present	Government of Costa Rica/ Ministry of Education	National program to expand English proficiency and prepare bilingual workforce for global industries, including medical devices.
INA Technical Training Reforms	2016–2019	National Training Institute (INA)	Reforms to curricula and training programs to include cleanroom manufacturing, quality assurance, and regulatory compliance.
Free Zone Regime Law Reforms	2016, 2018	Government of Costa Rica/COMEX/ PROCOMER	Policy framework providing tax exemptions and incentives for FDI in medical devices, expanded to include local suppliers.
Essential Costa Rica Branding Campaign[a]	2013–present (intensified 2019-2023)	PROCOMER/CINDE	Country branding strategy emphasizing sustainability, stability, and skilled workforce to attract global investment.
Trade Fair Participation (MD&M West)	2019–2023	CINDE/PROCOMER	Active participation in international trade fairs to showcase Costa Rica's medical device sector and attract investment.

Source: Prepared by the authors.
[a] A function currently carried out exclusively by PROCOMER.

Costa Rica's medical device sector also benefited from targeted fiscal policies and free trade zone (FTZ) incentives that encouraged FDI (ECLAC, 2020; CINDE, 2022). The Free Zone Regime Law, which continued the free-trade model established in the 1970s, remained central, offering exemptions from income taxes, import duties, and value-added taxes for export-oriented firms, while reforms in 2016 and 2018 expanded eligibility to smaller suppliers in the medical supply chain (CINDE, 2022).[13] These policies attracted leading firms such as Medtronic, Philips, and Boston Scientific, as well as contract manufacturers, reinforcing Costa Rica's position as one of the top exporters of medical devices in Latin America by 2022 (García Nice and Tovar, 2025). Complementary investments in infrastructure and streamlined regulatory procedures further strengthened the ecosystem and reduced entry costs for new investors (CINDE, 2024).

Finally, branding and promotional efforts were critical in positioning Costa Rica as a trusted global hub for life sciences. Initiatives led by the CINDE and PROCOMER, including the "Essential Costa Rica" country brand, highlighted the nation's political stability, skilled workforce, and commitment to sustainability (PROCOMER, 2021). Between 2019 and 2023, Costa Rica intensified its participation in international trade fairs such as MD&M West in California, showcasing domestic suppliers alongside global lead firms. These campaigns not only enhanced Costa Rica's visibility in competitive markets but also built investor confidence, which contributed to the diversification of export destinations and entry into new specialty niches in the medical devices GVC (CINDE, 2024).

B. Ireland in the medical devices GVC

Ireland first entered the medical device industry in the 1980s, taking advantage of its geographic location and local labour force. However, since 2015, specific actions have helped to solidify its position as an international leader in medical devices. Several distinct eras over the last decade highlight the evolution of the industry.

[13] The special regime has been in place for over 35 years and has evolved into a robust, dynamic, and innovative model: 66% of the companies operating under the Free Zone Regime belong to the services sector, with prominent activities including shared services centers, leasing services, and business-process outsourcing, among others. Manufacturing represents the remaining 34%, with a strong presence in sectors such as medical devices, food, and the electrical and electronics industries (Barrantes, 2025).

In 2015, companies such as Medtronic, Boston Scientific, and Johnson & Johnson expanded their Irish manufacturing and R&D sites, strengthening Ireland's reputation as a hub for both high-value production and innovation. These developments reinforced the sector as a pillar of Ireland's industrial policy, spearheaded by the Industrial Development Authority (IDA) (IDA Ireland, 2016). This was quickly followed by a period of local firm growth, fuelled by export promotion programs and the establishment of regional clusters in Galway, Limerick, and Dublin, which deepened specialization in cardiovascular and orthopaedic devices. This dual structure of multinational and domestic participation bolstered Ireland's integration into global supply chains while diversifying the innovation ecosystem (IDA Ireland, 2016).

By 2019, Ireland's medical devices sector employed more than 38,000 people, making it one of the largest per capita employers in the industry worldwide. Medical devices accounted for roughly 10% of total Irish exports, cementing the country's strategic position in the European and global health economy. This success reflected a balanced mix of FDI and state support for research-driven innovation (IDA Ireland, 2019). The onset of COVID-19 disrupted GVCs across all sectors, but Ireland's medical devices industry adapted quickly by ramping up production of ventilators, diagnostic kits, and personal protective equipment (PPE) components. Firms collaborated with universities and government agencies to respond to urgent needs, showcasing the agility and resilience of the Irish ecosystem. The crisis accelerated digital health initiatives and further highlighted the strategic importance of Ireland's medical devices industry (Irish Medical Times, 2020).

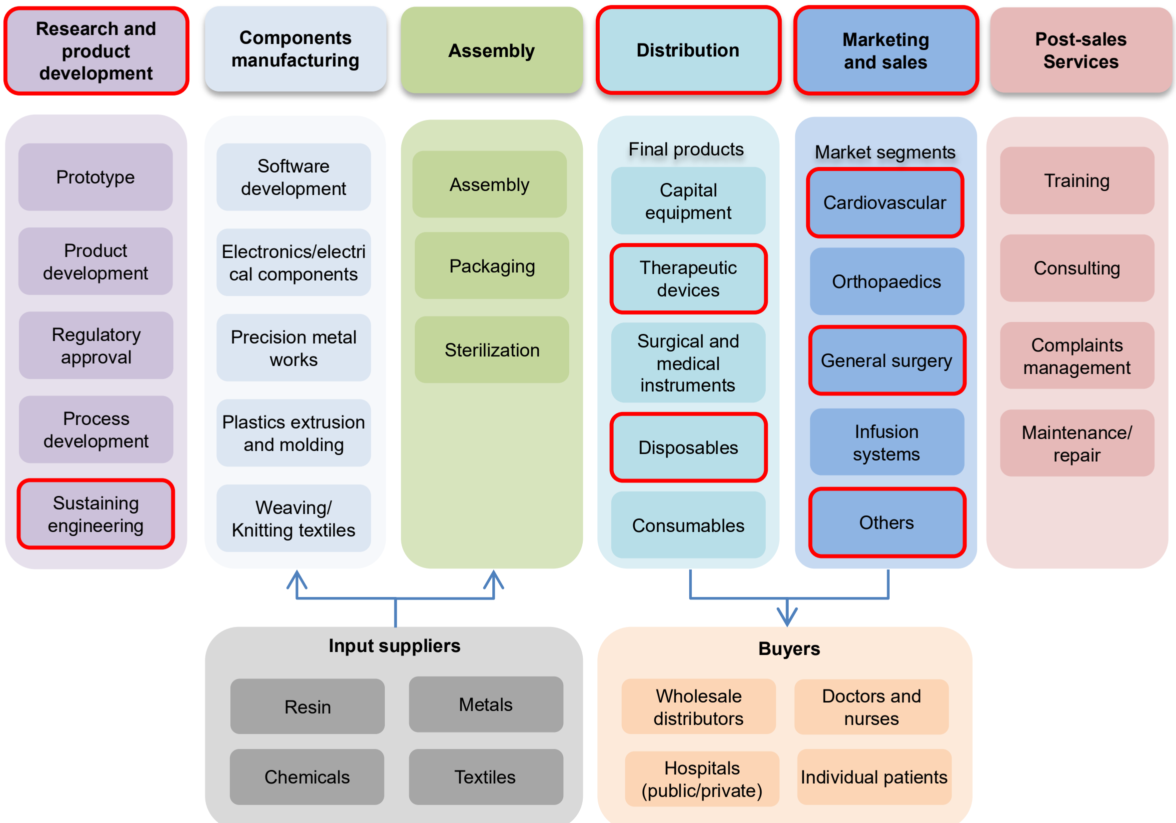
Following the pandemic, Ireland doubled down on innovation. Government-backed initiatives, such as the Disruptive Technologies Innovation Fund (DTIF) and Science Foundation Ireland (SFI) programs, channelled resources into R&D. Companies like Stryker and Abbott also expanded their R&D centres, while indigenous firms gained traction in wearable technologies and digital health solutions. This period marked Ireland's shift toward becoming not only a manufacturing base but also an innovation leader. This was further enhanced by Ireland's push to capitalize on nearshoring and supply chain resilience strategies, particularly for the United States and European Union markets. Firms are investing in greener manufacturing processes and digital technologies, aligning with European Union sustainability and health data regulations. With expansions by Medtronic, Boston Scientific, and indigenous leaders like Aerogen, Ireland has further entrenched its role as Europe's medical device capital (Irish Medtech (Ibec), n.d.).

1. Ireland's current participation in the medical devices GVC

Ireland stands as a dominant force in the medical device sector, ranking as the second-largest exporter of medical devices and technologies in Europe and contributing significantly to national exports (MEETinIRELAND,2026). In 2023, Ireland exported approximately US$ 18 billion worth of medical devices, placing it third in Europe behind the Netherlands and Germany (O'Shea 2024). Its medical and pharmaceutical exports surged to nearly US$ 110 billion in 2024—an increase of more than US$ 24 billion over 2023—and these products accounted for 45% of all Irish goods exports (Central Statistics Office [CSO], 2025). Diagram 4 highlights Ireland's position in the medical devices GVC.

This performance is bolstered by a robust industry structure featuring over 300 medical device firms, including leading MNEs, and a workforce exceeding 40,000 directly employed in MedTech (Medical Device Network, 2024). Ireland leads Europe on a per-capita basis in MedTech employment, underlining the sector's economic weight (MEETinIRELAND, 2026).

Diagram 4
Ireland in the medical devices GVC



Source: Prepared by the authors.

MNEs anchor Ireland's medical devices ecosystem. Medtronic, for example, is legally headquartered in Galway, reflecting Ireland's role as a base for global medical device giants. Local figures underscore this dynamic: eight of the world's top ten medical device companies have operations in Ireland, and Galway alone, as a cluster, contributes nearly 40% of sectoral employment (Irish Medical and Surgical Trade Association [IMSTA], 2020).

For products and segments, Ireland is globally vital in several areas: it manufactures 33% of the world's contact lenses and supplies injectables to one quarter of the global diabetic population (MEETinIRELAND, 2026). The industry's innovation focus is reinforced by a strong R&D culture: 70% of medical device companies in Ireland engage in research and development (METinIRELAND, 2026). The industry remains strong, with exports totalling more than US$ 35 billion in 2024 (UN Comtrade, 2025).

2. Key upgrading policies for Ireland in the medical devices GVC

Ireland's rise as one of the world's leading medical device exporters has been driven by a deliberate mix of FDI incentives, workforce and skills development strategies, and regulatory alignment with European and global standards, summarized in table 6. Together, these policies have created an ecosystem where MNEs and domestic SMEs co-exist and innovate, making medical devices a pillar of Ireland's high-tech economy.

The cornerstone of Ireland's policy mix has been the role of IDA Ireland, which since the 1980s has provided targeted investment grants, tax incentives, and tailored aftercare services to attract medical device MNEs, such as Medtronic, Boston Scientific, Abbott, and Johnson & Johnson. By continuously updating its incentive structure and ensuring access to highly educated workers, IDA Ireland helped the nation become a global hub for cardiovascular, orthopaedic, and diagnostic devices (IDA Ireland, 2016; IDA Ireland, 2022).

Table 6
Key policies to facilitate Ireland's upgrading

Program name	Year(s)	Lead institution	Description
IDA Ireland's FDI Incentives	1980s–present	IDA Ireland	Investment grants, tax incentives, and tailored support services to attract and retain multinational firms such as Medtronic, Boston Scientific, and Abbott.
Enterprise Ireland SME & Export Support	2000s–present	Enterprise Ireland	Funding, mentoring, and export promotion for indigenous SMEs to expand international market presence and scale innovation.
Irish Medtech Association (IBEC)	2000s–present	IBEC (Irish Business and Employers Confederation)	Industry association coordinating firms, government, and academia on competitiveness, workforce development, and regulatory advocacy.
Science Foundation Ireland (SFI) Research Centres	2000s–present	Science Foundation Ireland	Provides research grants to universities and firms in biomedical engineering, diagnostics, and digital health, supporting innovation.
Cluster Development Supports	2010s–present	IDA Ireland, Enterprise Ireland	Support for regional MedTech in Galway (cardiovascular), Limerick (orthopaedics), and Dublin (diagnostics and digital health).
National Skills Strategy & Regional Skills Fora	2016–present	Government of Ireland / Regional Skills Fora	Policies and partnerships to align MedTech workforce training with evolving industry needs across Galway, Limerick, and Dublin.
Disruptive Technologies Innovation Fund (DTIF)	2018–present	Government of Ireland / Department of Enterprise, Trade and Employment	Competitive funding scheme supporting collaborative R&D projects in MedTech, digital health, and advanced manufacturing.
EU Regulatory Alignment (MDR Implementation)	2021–present	HPRA (Health Products Regulatory Authority)	Alignment with EU Medical Device Regulation (MDR), strengthening Ireland's compliance and export readiness in global markets.

Source: Prepared by the authors.

C. Dominican Republic in the medical devices GVC

The Dominican Republic first entered the medical device industry in the early 2000s, leveraging its geographic proximity to the United States and competitive labour force to attract multinational manufacturers to its free zones. However, since 2015, targeted initiatives have helped to strengthen the sector's competitiveness and deepen its integration into GVCs. Several distinct phases over the last decade illustrate how the Dominican Republic has evolved from a primarily assembly-focused base into one of Latin America's leading exporters of medical devices.

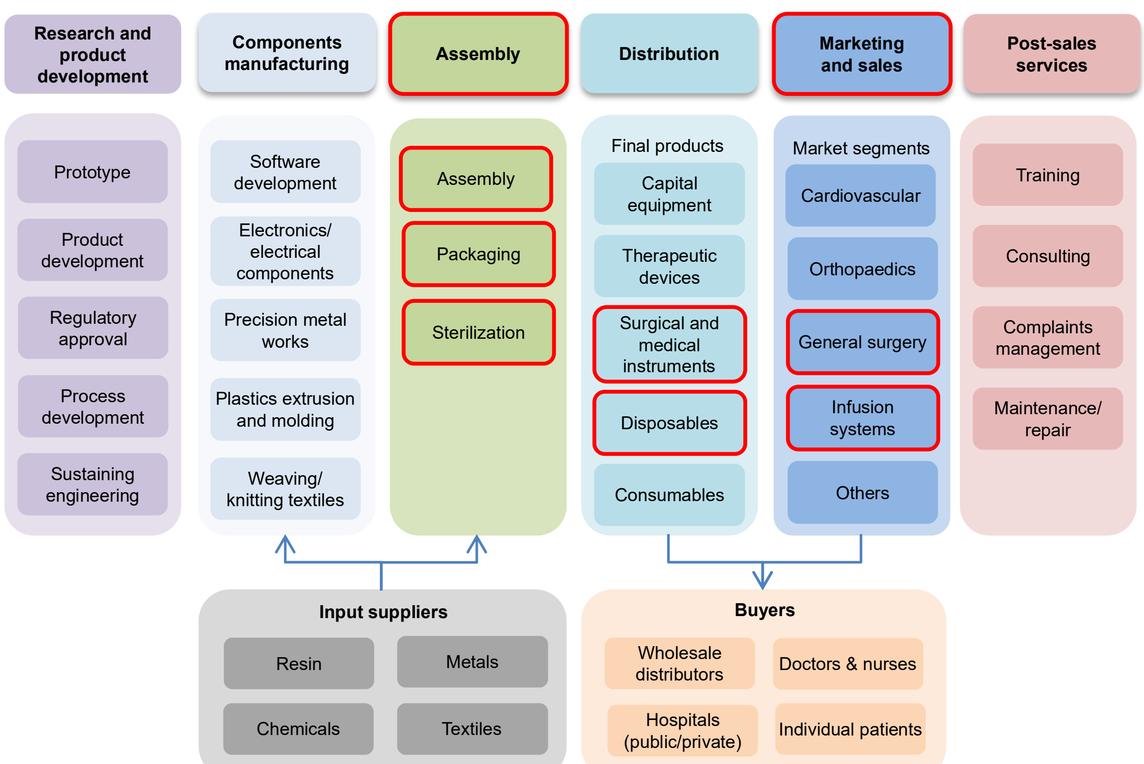
In 2015–2016, the Dominican Republic took an important step in formalizing its medical devices sector through the creation of the Medical Devices and Pharmaceuticals Cluster (CDMF) under the Dominican Association of Free Zones (ADOZONA). This initiative helped align MNEs with public institutions, particularly on workforce development, supplier upgrading, and quality standards, building on decades of free zone manufacturing experience and setting the stage for targeted industry upgrading (ADOZONA, n.d.). This was quickly followed in 2017-2018 by policies to promote local supplier linkages. The Ministry of Industry, Commerce, and MSMEs (MICM), working alongside the National Council of Free Trade Zones (CNZFE) and the cluster, highlighted opportunities for SMEs to integrate into medical device supply chains. These efforts began to reduce import dependence and created new channels for domestic firms to participate in the industry's growth (Downing, 2024).

By 2019, the sector had become one of the largest free-zone export categories. Between January and November, medical devices and pharmaceuticals reached US$ 1.54 billion in exports, representing 27.5% of all free-zone exports, with production concentrated in major parks such as San Isidro, Las Américas, and Santiago (CNZFE, 2019). The onset of COVID-19 in 2020 disrupted global supply chains, but the Dominican Republic's industry adapted quickly. By 2021–2022, the industry was scaling up significantly. The country hosted 37 multinational manufacturers, employing 28,688 workers directly, while exports reached US$ 1.93 billion (26.9% of free-zone exports). To meet rising sophistication requirements, CNZFE and the National Technical and Professional Training Institute (INFOTEP) introduced a 90-hour operator training curriculum covering cleanroom practices, good manufacturing practices (GMP), and quality systems—helping align the workforce with international production standards (Resumen de Salud, 2016). These strategic moves helped to solidify growth. In 2024, the cluster reported 41 companies, employing 34,149 workers and generating US$ 2.87 billion in exports (CNZFE, 2024; Florentino, 2025).

1. Dominican Republic's current participation in the medical devices GVC

Strong performance in the medical devices GVC is anchored by a coordinated cluster of MNEs, with 41 companies operating in the country and employing more than 34,000 workers directly in medical device and pharmaceutical manufacturing (ADOZONA, 2024). Production is historically centred on surgical instruments, though the country is moving into disposables and diagnostics as well (see diagram 5). In 2023, the sector generated approximately US$ 2.5 billion in exports, representing more than one-quarter of all free zone exports, and by 2024 this figure had climbed to US$ 2.9 billion, confirming the country's upward trajectory in the medical devices GVC (Florentino, 2025; LATAM FDI, 2024). These results underscore the sector's growing importance as a driver of foreign exchange and industrial upgrading.

Diagram 5
Dominican Republic in the medical devices GVC



Source: Prepared by the authors.

Global lead firms like Johnson & Johnson, Medtronic, B. Braun, and Cardinal Health anchor the cluster. The Dominican Republic is now the largest exporter of medical devices in the Caribbean Basin, specializing in disposables, surgical instruments, and diagnostic equipment. Its competitiveness is reinforced by free zone incentives, workforce training programs through INFOTEP, and regulatory modernization efforts led by Dirección General de Medicamentos, Alimentos y Productos Sanitarios (DIGEMAPS), the government agency that oversees medical device regulations. At a regional level, the Dominican Republic stands out as a nearshore hub for the United States market, underscoring its economic weight within Latin America's medical technology landscape (Downing, 2024).

2. Key upgrading policies for the Dominican Republic in the medical devices GVC

The Dominican Republic's rise as one of Latin America's leading medical device exporters has been supported by a deliberate mix of fiscal incentives, industrial competitiveness laws, cluster-based governance, workforce development strategies, and regulatory modernization summarized in table 7. Together, these measures have helped transform the country from a low-cost assembly base into a strategic nearshore hub for the United States market, with growing potential for upgrading and diversification. The cornerstone of the Dominican Republic's policy framework has been the Free Zone Law (Law 8-90), which since 1990 has provided broad fiscal and customs incentives, including tax holidays and tariff exemptions, that underpin the competitiveness of free zone operations. This framework has attracted medical device MNEs to establish and expand their operations, creating an export platform that now generates billions in foreign exchange each year (CNZFE, 2024). Complementing this regime, the Industrial Competitiveness and Innovation Law (Law 392-07), overseen by the Ministerio de Industria, Comercio y Mipymes (MICM), introduced instruments to modernize domestic industry and promote SME integration into GVCs, reinforcing the free zone model with a broader competitiveness strategy.

Table 7
Key policies to facilitate the Dominican Republic's upgrading

Program name	Year(s)	Lead institution	Description
Free Zone Law (Law 8-90)	1990-present	National Council of Free Trade Zones (CNZFE)	Provides fiscal and customs incentives (tax holidays, tariff exemptions, expedited trade) that underpin medical device cluster growth.
Industrial Competitiveness & Innovation Law (Law 392-07)	2007-present	Ministerio de Industria, Comercio y Mipymes (MICM)	Framework for industrial competitiveness and innovation, supporting SME participation and modernization within GVCs.
Medical Devices & Pharmaceuticals Cluster (CDMF)	2016-present	ADOZONA with CNZFE	Cluster platform aligning MNEs, government, and academia on workforce, quality, and supplier upgrading strategies.
Encadenamientos Productivos (Supplier Linkages)	2017-present	CNZFE, ProDominicana, MICM	Business roundtables and SME matchmaking programs designed to deepen domestic sourcing and reduce import dependence.
SME Integration Initiatives	2018-present	MICM	Targeted support for SMEs to qualify as suppliers (quality systems, certifications) to multinational medical device firms.
INFOTEP Medical Device Operator Training Program	2020-present	National Technical and Professional Training Institute (INFOTEP)	Standardized curriculum (~90 hours) in cleanroom operations, GMP, and quality systems to supply technicians/operators for device manufacturing.
DIGEMAPS Functional Autonomy (Decree 231-23)	2023	Ministry of Public Health/ DIGEMAPS	Grants DIGEMAPS (national regulator) financial and administrative autonomy to modernize oversight of medical devices.
DIGEMAPS Affiliate Membership in IMDRF	2024	DIGEMAPS	Joins the International Medical Device Regulators Forum, aligning DR's regulatory system with global standards to facilitate upgrading.

Source: Prepared by the authors.

Further, in 2023, the government granted DIGEMAPS financial and administrative autonomy enabling it to strengthen oversight and align its practices with international norms. This progress was reinforced in 2024 when DIGEMAPS joined the International Medical Device Regulators Forum (IMDRF) as an affiliate member, advancing the Dominican Republic's integration into the global regulatory community and enhancing its credibility as a reliable exporter.

D. Key lessons for Baja California

Collectively, the cases of Costa Rica, Ireland, and the Dominican Republic underscore that Baja California's continued growth in the medical device GVC will hinge on three interrelated pillars: FDI attraction, branding and promotion, and coordination with specialization. Each country offers distinct lessons that Baja California can adapt to its own industrial trajectory.

First, in terms of FDI attraction, Costa Rica and Ireland highlight the importance of well-structured incentives and strong promotion agencies. Costa Rica leveraged free trade zone regimes and tax incentives to draw global leaders like Boston Scientific and Medtronic, while Ireland built its competitiveness on tailored aftercare and a regulatory framework aligned with European Union standards. Both experiences show that incentives alone are insufficient; success requires complementary workforce programs and regulatory credibility. For Baja California, strengthening aftercare for existing firms, expanding dual-training and advanced engineering programs, and ensuring clear and predictable regulatory alignment will be essential to deepen integration and retain investment.

Second, branding and promotion efforts are central to global positioning. Costa Rica's "Essential Costa Rica" campaign and Ireland's cultivation of its image as "Europe's MedTech capital" elevated their visibility in competitive markets. The Dominican Republic, though newer to higher-value production, has successfully positioned itself as a nearshore hub for the United States, emphasizing efficiency and cost competitiveness. Baja California already benefits from proximity to the United States and compliance with FDA standards. However, it lacks a unified, globally recognizable brand. Building such an identity—one that emphasizes its binational ecosystem, innovation capacity, and reliability—can amplify its attractiveness to investors and reinforce supplier linkages.

Finally, coordination and specialization are decisive in shaping sustainable growth. Costa Rica's cluster-driven approach, Ireland's innovation-oriented regional specialization, and the Dominican Republic's coordinated cluster governance through ADOZONA all highlight the benefits of aligning industry, government, and academia around shared goals. Specialization in areas such as cardiovascular devices, diagnostics, or surgical instruments has enabled each country to consolidate global leadership niches. Baja California's manufacturing base is extensive, but, as elaborated in section VII, the next step lies in cultivating more specialized, high-value segments while reinforcing collaboration between firms, training institutions, and policymakers.

Taken together, these lessons suggest that Baja California must move beyond a cost-competitive platform toward a comprehensive strategy. By combining targeted FDI attraction, deliberate branding, and cluster-based specialization, it can secure a position not only as a key supplier to the United States but also as a globally recognized hub for innovation and advanced medical device manufacturing.

VI. Lessons for aerospace upgrading from comparative cases

This section highlights key lessons for Baja California from four comparative geographic cases as it seeks to upgrade to further benefit from GVC participation. The first case explores the role of workforce development and investment promotion to attract global lead firms to Phoenix, Arizona (AZ) (United States). The second looks at Montreal (Canada), focusing on policies for developing strong supplier linkages and FDI attraction. The third case explores Morocco's efforts to upgrade its aerospace GVC via integration into European markets, specialization in specific GVC segments (wiring), and expansion into post sale services, specifically MRO. Finally, we look at Querétaro, Mexico's development of a highly specialized cluster using workforce trainings and promotions to pull in global firms. Table 8 presents a short summary of the four cases and highlights key steps taken to achieve their current position in the aerospace GVC.

The aerospace cases reveal similar patterns with respect to talent development. Regions such as Montreal and Querétaro achieved advanced GVC roles not only through investments in engineering infrastructure but also by cultivating robust talent ecosystems with clear pathways for technician and engineering mobility. Morocco's rapid scaling in aerostructures demonstrates how targeted vocational programs and inclusive workforce policies can accelerate both social and economic upgrading. In Phoenix, investment in workforce retraining supported the transition from legacy manufacturing to advanced aerospace systems. Taken together, these cases illustrate that upgrading in aerospace relies on systematic efforts to elevate job quality, expand training access, and integrate local workers into increasingly complex stages of production and engineering.

In aerospace, international experience demonstrates that environmental upgrading—through improved materials efficiency, reduced chemical emissions, and advanced waste-management systems—is now an essential component of GVC competitiveness. Regions such as Montreal, Querétaro, and Morocco have integrated environmental considerations into training, certification, and supplier upgrading programs. This alignment not only supports compliance with global aerospace standards but also strengthens their attractiveness as hubs for advanced manufacturing and engineering activities.

Table 8
Summary of comparative cases in the aerospace GVC

	Phoenix, AZ (United States)	Montreal (Canada)	Morocco	Querétaro (Mexico)
Exports	US$ 8 billion	US$ 20 billion[a]	US$ 2 billion	US$ 9 billion
Employment *(number)*	40 000	200 000[b]	20 000	10 000
Firms operating *(number)*	1 250 (state level)	185	140	80
Key GVC segments	R&D, defense, avionics, propulsion	Engines, aircrafts, simulation technologies	Components, and wiring	Components, landing gear
Key global firms	• Honeywell Aerospace (United States) • Boeing (United States) • General Dynamics Mission Systems (United States) • Northrop Grumman (United States)	• Airbus (France) • Bombardier (Canada) • Pratt & Whitney Canada (United States/ Canada) • CAE (Canada) • Safran (France)	• Safran (France) • MATIS Aerospace (JV Safran & Boeing) (Morocco) • Airbus Atlantic (France) • Boeing (United States)	• Safran (Franc) • GE Aerospace (United States) • Delta TechOps (USA, with Aeroméxico JV) • Aernnova (Spain) • ITP Aero (Spain)
Policy areas for upgrading	• Workforce Development • Financial Incentives to Attract Leading Firms • Branding • Specialization along GVC			

Source: Prepared by the authors.
[a] Revenue.
[b] Includes indirect employment.

A. Phoenix, Arizonia (United States) in the aerospace GVC

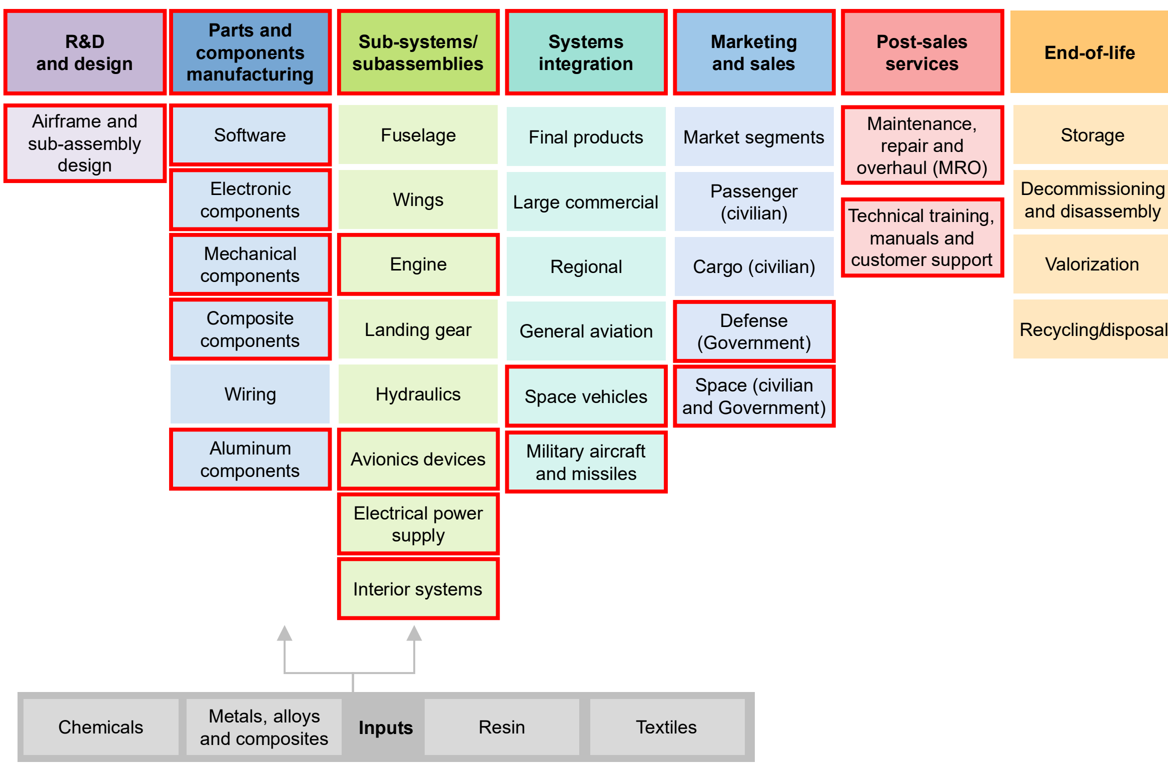
Aerospace has long been a cornerstone of economic competitiveness and national security in the United States, representing nearly US$ 955 billion in sales and over 2.2 million jobs nationwide in 2023 (Aerospace Industries Association [AIA], 2024). Across the country, Washington (Seattle and Everett), California (Los Angeles, San Diego, and the Bay Area), Texas (Dallas-Fort Worth, Houston, and San Antonio), and Arizona (Phoenix and Tucson) anchor the United States aerospace GVC, specializing in commercial aviation, defense systems, space technologies, and MRO. Within this landscape, Phoenix, Arizona stands out as a key hub, hosting over 40,000 aerospace and defense workers in Greater Phoenix, nearly double the national average employment concentration (Greater Phoenix Economic Council [GPEC], 2024). Building on a long history of defense manufacturing and sustained state-level policy support, Phoenix has transitioned from primarily serving as a base for legacy defense production into a diversified hub for advanced manufacturing, avionics, space technologies, and MRO services.

Phoenix entered the aerospace GVC decades ago, historically focused on defense manufacturing and MRO activities tied to the Cold War era (Arizona Commerce Authority, 2023). However, the past decade has seen a deliberate effort to transition into more advanced segments of aerospace and defense, including avionics, space systems, and autonomous technologies. These efforts, supported by the Greater Phoenix Economic Council (GPEC) and the Arizona Commerce Authority, have attracted substantial investments and strengthened supplier linkages across the region. By the mid–2010s, Phoenix began moving into higher-value aerospace functions. In Mesa, Arizona, Boeing opened a US$ 150 million Advanced Composite Fabrication Center, producing advanced composite components for future combat aircraft (Beinart, 2022). Meanwhile, Honeywell Aerospace, headquartered in Phoenix, remains the state's second-largest defense contractor, winning nearly US$ 658 million worth of contracts in fiscal year 2024 (Huguley and Gifford, 2025).

1. Phoenix's current participation in the aerospace GVC

Diagram 6 shows Phoenix's current role in the aerospace GVC. While Phoenix's participation spans most segments, activity is mainly located in highly complex and specialized manufacturing. Firms in the Phoenix cluster are particularly concentrated in avionics, propulsion systems, advanced composites, military aircraft, and MRO. Phoenix's aerospace cluster is anchored by major global firms, including Honeywell Aerospace, Boeing, General Dynamics, and Northrop Grumman. Honeywell Aerospace, headquartered in Phoenix, is the state's second-largest defense contractor, employing over 7,100 workers and specializing in avionics, propulsion, and electrical systems (Huguley and Gifford, 2025). General Dynamics Mission Systems operates in Scottsdale and Phoenix, focusing on avionics, secure communications, and defense electronics (General Dynamics Mission Systems, n.d.). Northrop Grumman's Chandler site has grown into a leading node for space launch vehicles, propulsion systems, and missile defense integration, reinforcing Phoenix's role in advanced aerospace systems (Greater Phoenix Economic Council, 2024).

Diagram 6
Phoenix in the aerospace GVC



Source: Prepared by the authors.

2. Key upgrading policies for Phoenix in the aerospace GVC

Phoenix's upgrading in the aerospace GVC was the direct result of coordinated policy interventions at the state and regional levels. These policies focused on workforce development, targeted incentives to attract and retain investment, and branding efforts to position Arizona as a global aerospace hub. Selected programs are summarized below and in table 9. Skilled workers who could transition into advanced aerospace and defense product lines were crucial for Phoenix's ability to move into higher-value segments of the GVC. From 2015 onward, Arizona State University (ASU), Maricopa Community Colleges, and the Arizona Commerce Authority (ACA) partnered with industry leaders like Honeywell and Boeing to design curricula in aerospace engineering, unmanned aerial systems, and advanced composites. Initiatives such as the ACA's Workforce Training Grants and ASU's expanded aerospace engineering programs emphasized digital avionics, propulsion, and space technologies (Honeywell, 2024; ACA, n.d.; Maricopa Community Colleges, n.d.).

Table 9
Key policies to facilitate Phoenix's upgrading

Policy/program	Year(s)	Lead institution	Description	Impact
Workforce Training Grants	2015–present	Arizona Commerce Authority (ACA)	Funding to support customized workforce training programs for aerospace and defense firms, often in partnership with ASU and Maricopa Community Colleges.	Expanded skilled labour pool for avionics, propulsion, and composites; improved knowledge transfer from MNEs.
ASU Aerospace Engineering Expansion	2016–present	Arizona State University (ASU)	Expansion of aerospace engineering, unmanned aerial systems, and digital avionics curricula with industry partnerships.	Created a pipeline of specialized engineers and technicians aligned with industry needs.
Qualified Facility Tax Credit	2015–present	Arizona Commerce Authority (ACA)	Income tax credits for aerospace firms investing in new or expanded facilities in Arizona.	Attracted major investments including Boeing's US$ 150 million composite facility and Honeywell expansions.
Military Reuse Zone Incentives	2018–present	Arizona Commerce Authority (ACA)	Property tax reductions and incentives for aerospace and defense companies operating in designated reuse zones near former military bases.	Encouraged defense contractors and suppliers to expand in the Phoenix region.
GPEC & ACA Branding Campaigns	2019–present	Greater Phoenix Economic Council (GPEC) & ACA	Promotional campaigns and trade fair participation (e.g., Farnborough, Paris Air Show) to highlight Arizona's aerospace capabilities.	Enhanced global visibility, attracted NewSpace firms, diversified export markets.

Source: Prepared by the authors.

B. Montreal (Canada) in the aerospace GVC

Similar to the United States, aerospace has long been a key component of Canada's economic competitiveness and technological innovation, representing nearly US$ 20 billion in annual exports and supporting over 200,000 direct and indirect jobs nationwide in 2023 (Innovation, Science and Economic Development Canada [ISED], 2024). Across the country, Quebec (Montreal), Ontario (Toronto, Ottawa), Manitoba (Winnipeg), and British Columbia (Vancouver) anchor Canada's aerospace GVC, specializing in commercial aircraft, business jets, engines, flight simulation, and MRO. Within this landscape, Montreal, Quebec stands out as a global hub, hosting more than 60,000 aerospace workers, one of the highest concentrations of aerospace employment worldwide (Aéro Montréal, 2024). Building on a century of aviation leadership and sustained policy support at both federal and provincial levels, Montreal has transitioned from primarily serving as a base for commercial aircraft production into a diversified hub for engines, advanced simulators, and sustainable aviation technologies.

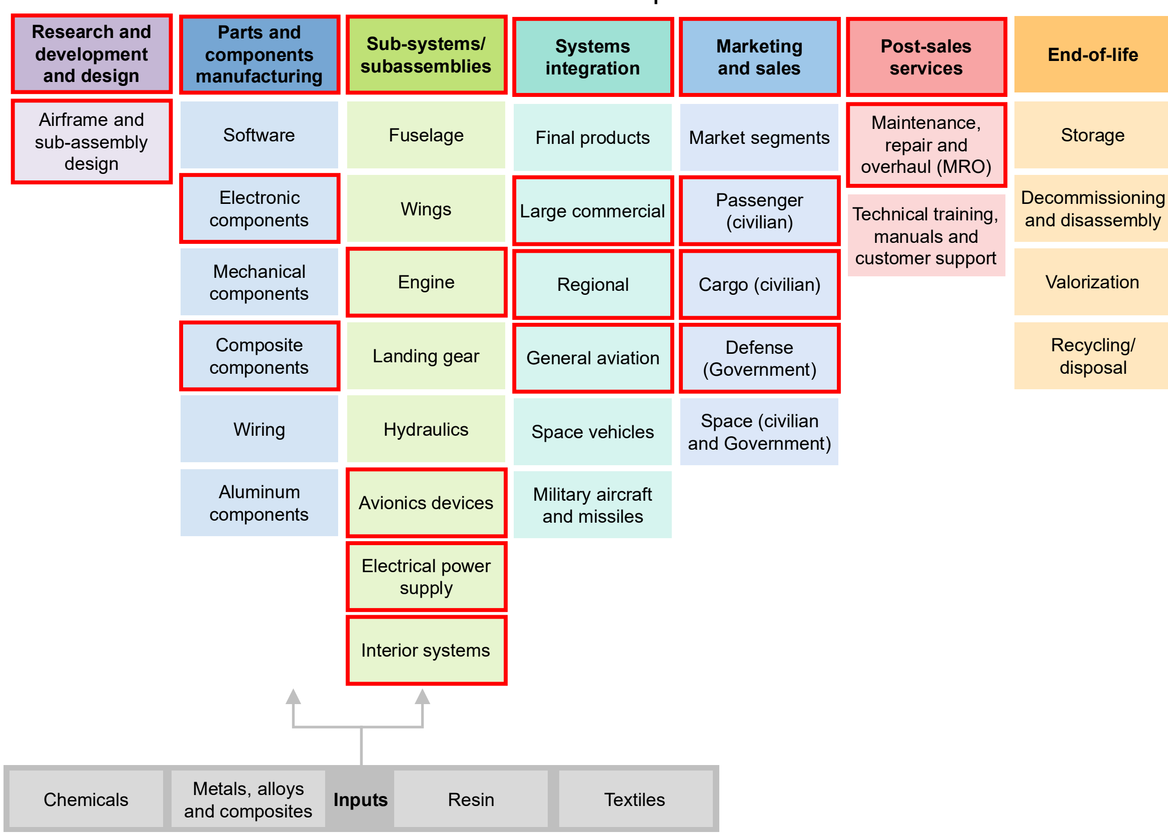
Montreal entered the aerospace GVC decades ago, historically focused on aircraft assembly and engine manufacturing activities tied to Canada's industrial policies of the mid-20th century (Couillard and Anglade, 2016). However, the past decade has seen a deliberate effort to transition into more advanced segments of aerospace and defense, including green propulsion, digital simulation, and sustainable aircraft technologies. These efforts, supported by Aéro Montréal and the Government of

Quebec, have attracted substantial investments and strengthened supplier linkages across the region. The post-pandemic recovery has reinforced Montreal's role as a hub for innovation and sustainable aviation. Polytechnique Montréal, ÉNA, and McGill University now offer targeted programs in aerospace engineering, green propulsion, and artificial intelligence applications, responding to rising demand for specialized talent (Innovation, Science and Economic Development Canada [ISED], 2023).

1. Montreal's current participation in the aerospace GVC

Montreal has emerged as one of the world's leading aerospace hubs, with more than 200 companies active across the cluster, operating in diverse segments (Aéro Montréal, 2024). Its participation, captured in diagram 7, spans multiple segments but is particularly concentrated in aircraft assembly (Bombardier, Airbus Canada), aircraft engines (Pratt & Whitney Canada), flight simulation (CAE), and advanced composites and avionics produced by a dense SME base. Montreal's aerospace industry is anchored by the presence of major global firms—Airbus, Bombardier, Pratt & Whitney Canada, CAE, and Safran—each playing a critical role in different segments of the GVC. Bombardier, a historic Quebec-based OEM, remains one of the world's leading business jet manufacturers, specializing in the Global and Challenger series. Pratt & Whitney Canada has long been a global leader in engines for small and medium aircraft, with major R&D and production facilities in Longueuil.

Diagram 7
Montreal in the aerospace GVC



Source: Prepared by the authors.

2. Key upgrading policies for Montreal in the aerospace GVC

Montreal's upgrading in the aerospace GVC from 2015 to 2024 was enabled by coordinated policy interventions at the federal, provincial, and cluster levels. Policies focused on workforce development, targeted incentives to attract and retain investment, and branding efforts to position Montreal as a global aerospace hub (see table 10). Skilled workers able to transition into advanced aerospace and defense product lines were crucial for Montreal's ability to move into higher-value segments of the GVC. From 2015 onward, the Government of Quebec, Polytechnique Montréal, and École nationale d'aérotechnique (ÉNA) partnered with industry leaders like Bombardier, Pratt & Whitney, and CAE to design curricula in aerospace engineering, sustainable aviation, and digital avionics. Initiatives such as the federal Student Work Placement Program and Quebec's Workforce Skills Development Grants emphasized simulation, propulsion, and green aviation technologies (ISED, 2023; Aéro Montréal, 2024).

Table 10
Key policies to facilitate Montreal's upgrading

Policy/Program	Year(s)	Lead institution	Description	Impact
Workforce Skills Development Grants	2015–2024	Government of Quebec	Funding for customized workforce training programs in aerospace and defense, in partnership with ÉNA and universities.	Expanded skilled labour pool for simulation, propulsion, and sustainable aviation.
Aerospace Engineering Curricula Expansion	2016–2022	Polytechnique Montréal & ÉNA	Expansion of aerospace engineering and digital avionics curricula with industry partnerships.	Created a pipeline of specialized engineers and technicians aligned with cluster needs.
Quebec Aerospace Strategy	2016–2026	Government of Quebec	Comprehensive strategy with CAD$ 500 million commitment to innovation, supply chain, and investment attraction.	Anchored Airbus A220 program, strengthened supply chains, fostered green aviation R&D.
Strategic Innovation Fund	2017–2024	Government of Canada	Federal funding program for R&D in aerospace technologies and advanced manufacturing.	Supported Bombardier, CAE, Pratt & Whitney in upgrading into sustainable and digital niches.
Aéro Montréal Branding Campaigns	2019–2024	Aéro Montréal	Promotional campaigns and trade fair participation to highlight Montreal's aerospace capabilities.	Enhanced global visibility, attracted green aviation SMEs, diversified export markets.

Source: Prepared by the authors.

C. Morocco in the aerospace GVC

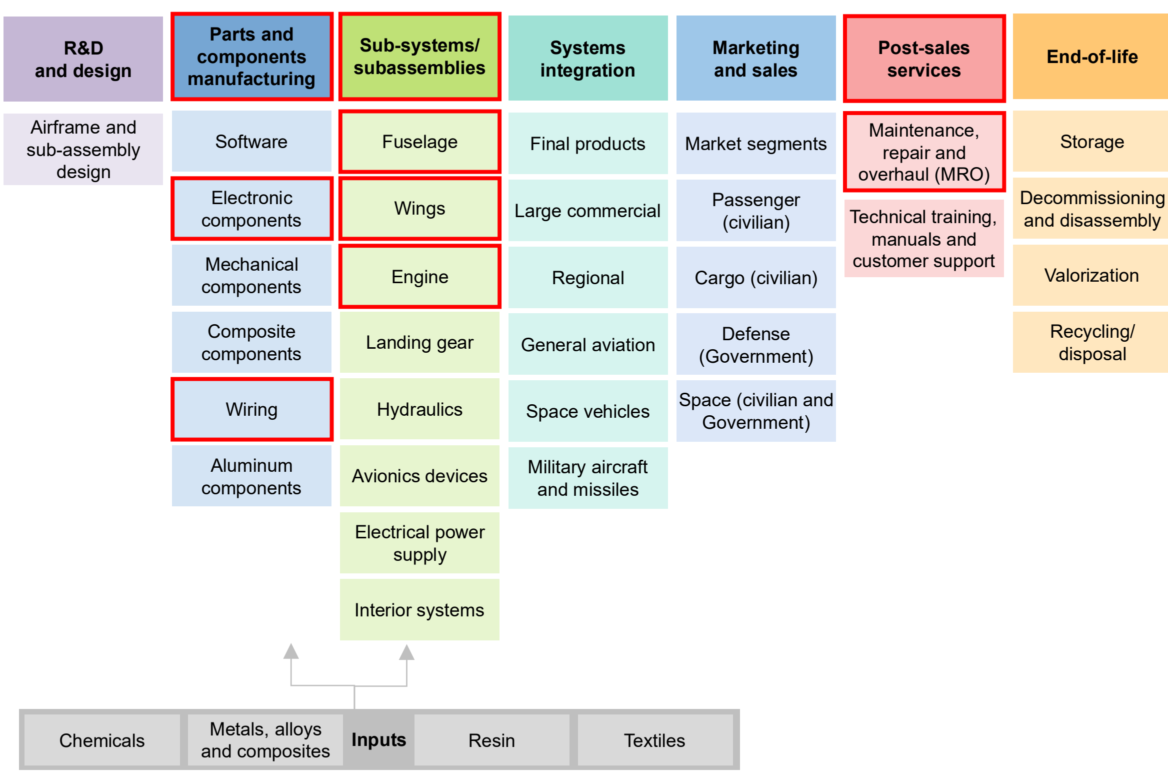
Aerospace is one of Morocco's fastest-growing advanced manufacturing sectors, representing more than US$ 2 billion in annual exports by 2023 and employing over 20,000 workers nationwide (Moroccan Agency for Investment and Export Development [AMDIE], 2023). The industry is concentrated in Casablanca, Nouaceur, and Tangier, where MNEs such as Boeing, Airbus, Safran, and Bombardier (until its 2019 divestments) anchor production alongside a growing base of SMEs. Morocco's aerospace specialization spans aerostructures, composite materials, wire harnesses, engine components, and MRO services, integrating the country into global supply chains for commercial aircraft and engines (AMDIE, 2023).

Since entering the aerospace GVC over two decades ago, the Moroccan government has pursued deliberate upgrading strategies under successive Industrial Acceleration Plans (2014–2020, 2021–2025), which identified aerospace as a strategic sector. Building on free zone infrastructure, targeted industrial policies, and workforce development initiatives, Morocco has positioned itself as a competitive nearshore platform for European and North American aerospace markets. The cluster has expanded rapidly over the past decade, with more than 140 companies operating in aerospace by 2023, up from fewer than 80 in 2010. At the same time, challenges remain in scaling R&D capacity and moving beyond build-to-print manufacturing. Nonetheless, Morocco's aerospace industry has demonstrated resilience, capitalizing on nearshoring dynamics, free trade agreements, and investment promotion campaigns (AMDIE, 2023).

1. Morocco's current participation in the aerospace GVC

Morocco's GVC participation is concentrated in specific subsegments of the GVC including components, engines and wiring (see diagram 8). The bulk of Morocco's production remains build-to-print and assembly work; capabilities in composites, precision machining, and MRO have expanded since 2020. Participation in the aerospace GVC primarily centres around wiring and engine components though some movement into MRO services is occurring. Notably, Morocco is one of the top global suppliers of aircraft wire harnesses with multiple OEM suppliers working in this GVC subsegment. Finally, partnerships with European firms expanded regional MRO capabilities, allowing the nation to move into new, higher-value GVC segments. Morocco's aerospace industry is anchored by the presence of major global firms. Airbus has consolidated its footprint through the Morocco Composites Plant, integrating local production into global aircraft programs.

Diagram 8
Morocco in the aerospace GVC



Source: Prepared by the authors.

2. Key upgrading policies for Morocco in the aerospace GVC

Morocco's upgrading trajectory in aerospace since 2015 has been enabled by targeted state policies, investment promotion, and workforce initiatives. Policies have focused on three major areas: workforce development, investment attraction, and global branding (see table 11). Specialized training programs were critical to supplying skilled technicians for wiring, composites, and MRO. The Institut des Métiers de l'Aéronautique (IMA) in Casablanca, launched in partnership with GIFAS (the French Aerospace Industries Association), has trained thousands of technicians since 2011, with expanded curricula after 2016 focusing on composites, avionics, and digital manufacturing. Partnerships with ONTP (Office of Vocational Training and Employment Promotion) and universities have further reinforced the talent pipeline. Beyond workforce development, Morocco leveraged tax exemptions, customs benefits, and streamlined procedures in free zones (notably Midparc and Tangier) to attract FDI (Ministère de l'Industrie et du Commerce [MCIENT], n.d.).

Table 11
Key policies to facilitate Morocco's upgrading

Policy/program	Year(s)	Lead institution	Description	Impact
Institut des Métiers de l'Aéronautique (IMA) Expansion	2015–present	IMA, ONTP, GIFAS	Specialized training in composites, avionics, and MRO	Expanded technician pipeline; enhanced skill base
Boeing Ecosystem Agreement	2016	Boeing & Ministry of Industry	Creation of 120 suppliers linked to Boeing	US$1 billion target exports; 8,700 jobs projected
Industrial Acceleration Plans	2014–present	Ministry of Industry	Priority sector designation with incentives and free zone support	Attracted Safran, Spirit AeroSystems, Stelia
Spirit AeroSystems Acquisition of Bombardier	2020	Spirit AeroSystems	Integration of Moroccan aerostructures into global Spirit supply chain	Secured FDI, stabilized employment
AMDIE Branding Campaigns	2019–present	AMDIE & GIMAS	Promotion at Paris/Farnborough Air Shows	Enhanced visibility, new European supplier linkages

Source: Prepared by the authors.

D. Querétaro, Mexico in the aerospace GVC

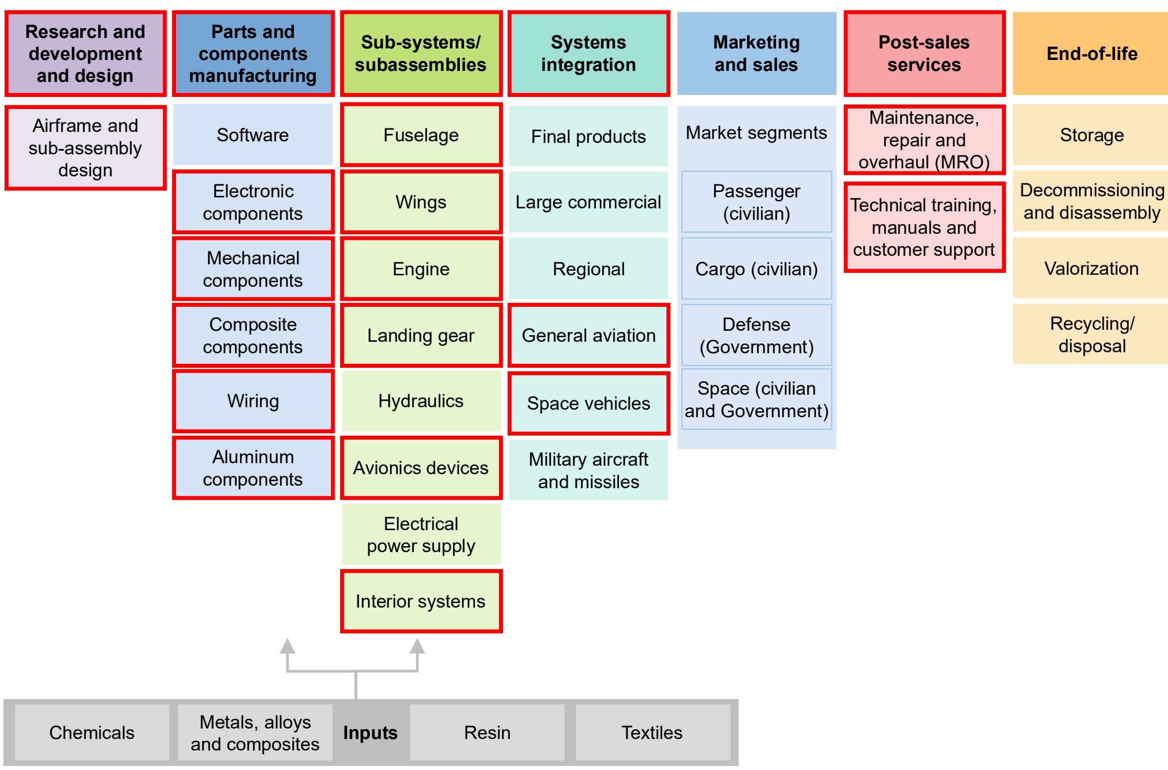
Like Morocco, aerospace has emerged as one of Mexico's most dynamic advanced manufacturing sectors, with exports exceeding US$ 9 billion by 2023 and employing over 60,000 workers nationwide (Rainsford, 2023, International Trade Administation, 2023). Within this landscape, Querétaro has become one of the country's premier aerospace hubs, hosting more than 90 companies and nearly 10,000 direct jobs (ProMexico, 2025; Becerril, 2024). The cluster is concentrated around Querétaro City, anchored by global firms such as Bombardier, Safran, Airbus Helicopters, and GE Aerospace, as well as a growing network of suppliers specializing in aerostructures, engines, and MRO services. Querétaro has transitioned from a low-value assembly platform into a specialized hub for aerostructures, engine components, and engineering services. This evolution has been supported by targeted industrial policies, the establishment of the Aeronautical University of Querétaro (UNAQ), and the development of the Querétaro Aerospace Park.

Querétaro entered the aerospace GVC in the mid-2000s, and since then, state and federal authorities have promoted Querétaro as Mexico's aerospace gateway, leveraging proximity to North American markets and bilingual engineering talent. Bombardier's arrival in 2006 was followed by the establishment of UNAQ in 2007–2008 to train specialized technicians and engineers, Safran's expansion with nacelle[14] and landing gear facilities in 2010–2012, and the opening of Airbus Helicopters' rotorcraft assembly plant. Between 2014 and 2016, GE Infrastructure Querétaro Engineering Center (GEIQ) expanded to become one of GE's largest global R&D hubs outside the United States. The period 2018–2020 saw rapid growth in MRO services, including Aeroméxico and Delta TechOps joint investments at Querétaro International Airport. Most recently, in 2021–2024, the cluster recovered strongly from the pandemic, consolidating Querétaro's position as a hub for engine components, MRO, and aerostructures (Aeroclúster de Querétaro, 2023).

1. Querétaro's current participation in the aerospace GVC

Querétaro's participation in the aerospace GVC spans multiple segments, summarized in diagram 9. In 2024, Querétaro's aerospace cluster included more than 90 firms and nearly 10,000 workers (FEMIA, 2024). Bombardier employed about 2,000 workers in Querétaro and produced fuselages and wings for business jets. Safran employed around 2,500 people, producing engines, nacelles, landing gear, and wiring, while Airbus Helicopters had about 500 workers focused on helicopter assembly, MRO, and rotorcraft systems. These anchor firms highlight Querétaro's specialization in aerostructures, engines, helicopters, MRO, and R&D, with strong integration into transnational supply chains. The presence of global Tier-1 and Tier-2 suppliers such as Safran, GE Aerospace, Delta TechOps, Aernnova, and ITP Aero underscores Querétaro's growing specialization in complex subsystems and support services within the aerospace GVC.

Diagram 9
Querétaro, Mexico in the aerospace GVC



Source: Prepared by the authors.

[14] In the context of Safran's expansion and aerospace engineering, a *nacelle* is the streamlined housing or casing that surrounds an aircraft engine. It is much more than just a cover; it is a complex, high-technology system designed to protect the engine, optimize aerodynamic performance, reduce noise, and aid in braking.

2. Key upgrading policies for Querétaro in the aerospace GVC

Querétaro's upgrading trajectory since 2006 has been enabled by policies in workforce development, investment attraction, and global branding. For example, programs at CONALEP and state technical institutes have reinforced this pipeline, producing thousands of bilingual graduates each year (Universidad Aeronáutica en Querétaro [UNAQ], 2023). Querétaro has also benefitted from federal programs such as ProAéreo (Mexico's Aerospace Industry National Program) and state-level tax incentives, as well as infrastructure investments in the Querétaro Aerospace Park. Streamlined permitting and support services from ProMéxico (until 2019) and the state's Secretaría de Desarrollo Sustentable further enhanced competitiveness. Finally, Querétaro has actively promoted itself at international trade fairs such as Farnborough and Paris, highlighting its engineering talent and integrated cluster. Cluster organizations like the Aeroclúster de Querétaro, founded in 2012, coordinate local suppliers and strengthen global visibility (Aeroclúster de Querétaro, 2023). Querétaro's upgrading trajectory has been enabled by policies in workforce development, investment attraction, and global branding (see table 12).

Table 12
Key policies and programs supporting Querétaro's aerospace industry

Policy/Program	Year(s)	Lead institution	Description	Impact
Aeronautical University of Querétaro (UNAQ)	2007–present	State of Querétaro, federal government, industry (Bombardier, Safran)	Specialized training in aeronautical engineering and technician programs	Built Mexico's largest aerospace talent pipeline; thousands of bilingual graduates placed in industry
ProAéreo (National Aerospace Program)	2010–2020	Mexican federal government (Secretaría de Economía, ProMéxico)	National strategy to promote aerospace FDI, exports, and cluster development	Attracted global OEMs and suppliers to Querétaro; aligned with NAFTA/USMCA integration
Querétaro Aerospace Park Development	2007–2015	State of Querétaro, private investors	Creation of a specialized aerospace industrial park	Clustered global firms (Safran, Aernnova, Delta TechOps) near logistics infrastructure
Delta TechOps–Aeroméxico JV	2018–present	Delta Airlines & Aeroméxico	Establishment of Latin America's largest MRO hub	Expanded post-sales capabilities; created ~1,000 skilled jobs in MRO services
Aeroclúster de Querétaro	2012–present	Industry association (state-supported)	Regional aerospace cluster organization to coordinate suppliers, training, and promotion	Strengthened supplier networks; improved branding at global trade fairs

Source: Prepared by the authors.

E. Key lessons for Baja California

Baja California stands at a pivotal moment in the development of its aerospace industry. A comparative review of four successful cases—Phoenix (United States), Montreal (Canada), Morocco, and Querétaro, Mexico—reveals a consistent set of lessons that can guide the state as it seeks to upgrade its position in GVCs. Across all four cases, upgrading has rested on three interrelated pillars: workforce development, institutional coordination, and strategic specialization.

Workforce development emerges as the most visible constraint. In every case, from Phoenix's partnerships with Arizona State University to Querétaro's creation of the Universidad Aeronáutica de Querétaro (UNAQ), specialized training and certification systems created the talent pipelines needed to move beyond basic assembly into higher-value activities such as avionics, composites, and engineering services. Montreal's emphasis on green aviation curricula and Morocco's technician-focused training at the IMA further demonstrate that human capital is the foundation of aerospace competitiveness.

Institutional coordination constitutes a second, equally critical pillar. In all four cases, successful upgrading was supported by organizations capable of aligning firms, training institutions, and public authorities around shared priorities. Montreal benefits from long-standing coordination mechanisms that link OEMs, suppliers, universities, and government agencies within a coherent aerospace ecosystem. Querétaro's aerospace cluster similarly relies on close collaboration between state government, firms, and educational institutions to synchronize training supply with industry demand. In Morocco, centralized coordination has enabled the rapid scaling of certification systems and supplier integration. These experiences underscore that fragmented governance limits upgrading, while effective coordination reduces collective-action problems and accelerates capability-building across the cluster.

Strategic specialization represents the third pillar. None of the comparator regions attempted to compete across the entire aerospace value chain. Instead, each anchored its upgrading strategy in a limited number of niches aligned with lead-firm mandates and existing capabilities. Phoenix leveraged its strengths in avionics, systems integration, and defense-related engineering. Montreal consolidated a global specialization in aircraft structures, engines, and increasingly green aviation technologies. Morocco focused on precision manufacturing and labor-intensive components, while Querétaro specialized in aerostructures, wiring harnesses, and maintenance-related activities. These cases show that specialization—rather than generic assembly—allows regions to embed themselves more deeply in GVCs and capture more stable, higher-value mandates.

Collectively, these cases suggest that Baja California's aerospace upgrading will depend not on isolated interventions, but on the coordinated advancement of skills, institutions, and specialization strategies. Workforce development enables upgrading, but only when reinforced by strong coordination mechanisms and a clear strategic focus within global aerospace programs. An integrated approach across these three pillars is essential for moving the cluster toward higher value-added, greater resilience, and sustained competitiveness.

VII. Recommendations for Baja California policymakers

Baja California stands at a turning point. Its medical devices and aerospace clusters have matured into globally recognized production hubs, employing tens of thousands of workers and linking the state to some of the most dynamic GVCs. But the challenge now is not growth for its own sake—it is upgrading. Baja California must shift from being primarily a high-volume workhorse to becoming a platform for innovation, advanced supplier linkages, and higher-value knowledge functions. The stakes are high: global competitors like Costa Rica and Ireland in medical devices, or Phoenix (United States) and Querétaro (Mexico) in aerospace, show that decisive policies can move a region up the value chain ladder within a decade.

At the same time, Baja California's situation is distinctive. It is not developing a single cluster in isolation, but rather managing two diverse and partially overlapping ecosystems: one centred on medical devices, with a few global flagships (such as Medtronic, Cardinal Health, BD) supported by contract manufacturers (Flex, Foxconn) and specialized enablers (Avantti); and one in aerospace, with a distributed anchor structure (Collins, Honeywell, Safran, Eaton, Gulfstream) operating across multiple niches. On the one hand, this diversity is a challenge: there is no single roadmap or dominant anchor that can dictate the cluster's trajectory. On the other hand, it is a potential advantage: by cultivating complementary strengths across two clusters, Baja California can build resilience, cross-sectoral innovation (e.g., in materials, automation, or regulatory expertise), and a broader base of high-value capabilities. Policymakers must therefore embrace the complexity of Baja California's industrial landscape, while focusing resources on targeted levers that can make both clusters competitive against global peers.

A. FDI attraction

Attracting and deepening FDI remains the cornerstone of Baja California's industrial future. But incentives cannot be generic. Instead, Baja California should pursue a dual-track strategy: deepen the mandates of existing anchors while selectively attracting connector firms that can plug critical ecosystem gaps.

In medical devices, Medtronic has demonstrated that global flagships can anchor regional ecosystems, but its Baja California plants remain focused largely on high-volume, low-complexity assembly. Ireland's experience shows how staged incentives can gradually shift such subsidiaries into higher-value functions like design for manufacturing (DfM), quality management systems, and eventually R&D. Baja California can adopt this playbook and offer targeted incentives tied to milestones, such as transferring a set number of Class II/III devices or creating engineering posts in regulatory affairs. Such an approach will require encouraging local suppliers to engage in innovation and entrepreneurship, like the experiences of Costa Rica and Ireland. This is discussed below.

In aerospace, Baja California's challenge is different. With multiple Tier-1 and Tier-2 anchors (Collins, Honeywell, Safran, Gulfstream), no single firm dominates. This requires building collective strength. Here, lessons from Phoenix and Montreal are instructive. Baja California should pursue a similar identity, branding itself as North America's premier binational aerospace-medical device platform, while tailoring incentives to attract design houses, validation labs, and MRO services that complement existing manufacturing.

B. Economic upgrading (exports + local linkages)

Beyond FDI attraction, the real measure of cluster success is whether it deepens local linkages and upgrades export profiles. Comparative cases show that countries which treated supplier depth as a key performance indicator (KPI), rather than a slogan, captured greater value. For Baja California, this means building programs that measure the share of local inputs in cluster exports and the time it takes local suppliers to qualify for MNE contracts. State-supported supplier funds—co-financed by anchors and contract manufacturers—could accelerate automation, molding, extrusion, and sterilization capabilities in medical devices, while supporting NADCAP and precision machining certifications in aerospace.

Export diversification is also critical. Baja California's medical device exports remain concentrated in disposables and low-complexity devices, while aerospace is still dominated by components. Comparative cases show that specialization pays: Morocco became a global leader in wiring harnesses, Querétaro in engine components, and Montreal in propulsion and simulation. Baja California should identify niches where it can compete globally—for example, surgical wearables, unmanned aerial vehicle (UAV) systems, or digital avionics integration—and deliberately channel investment and supplier upgrading into these areas.

C. Strengthening cluster lead firms

Anchors drive clusters, but they must be incentivized to share their benefits. In Baja California, policy should focus on strengthening lead firms through co-governance models and multi-anchor coordination.

In medical devices, lead anchors like Medtronic, Cardina Health, and Becton Dickinson should be encouraged to follow the Galway path of co-governance, where subsidiaries share responsibility for R&D, regulatory compliance, and crisis response. The COVID-19 ventilator surge in Ireland demonstrated how a trusted subsidiary can take on global responsibilities if it proves its capabilities. Baja California can encourage this by tying incentives to spillovers: for example, requiring Medtronic and other large manufacturers to run supplier academies or co-fund proof-of-concept budgets with local SMEs.

In aerospace, distributed anchors mean no single firm can lead cluster upgrading. This is a challenge but also an opportunity for collective action. Phoenix and Montreal solved this by creating multi-anchor councils that coordinated training, supplier audits, and shared infrastructure.

Baja California should establish a permanent aerospace council, bringing together Collins, Honeywell, Safran, and Gulfstream to jointly fund NADCAP pipelines, share specialized tooling, and coordinate supplier qualification.

D. Supplier capabilities

Upgrading local suppliers is the fastest way to deepen Baja California's participation in GVCs. Comparative lessons show that supplier upgrading requires a mix of open-access enablers and certification accelerators. The Dominican Republic modernized its sterilization and regulatory agencies (DIGEMAPS), which boosted local credibility and enabled more SKUs to stay in-country. Baja California can replicate this by investing in shared sterilization facilities and regulatory affairs hubs accessible to SMEs. Such an approach allows SMEs to minimize expenditures on energy while also helping address many regulatory hurdles they face.

Similarly, aerospace suppliers need support to obtain NADCAP and FAA certifications, which are expensive and time-consuming. Baja California could create a certification accelerator program that subsidizes audits, consultants, and software upgrades, reducing the entry barrier for smaller firms. The modernization of Mexico's regulatory agency, COFEPRIS, or the establishment of programs to aid Baja California suppliers in navigating their processes are essential to help enhance supplier capabilities.

Finally, transparency matters. Publishing cluster-wide supplier capability scorecards —such as benchmarking SMEs on certifications, delivery performance, and innovation capacity—would create both peer pressure and visibility for global buyers seeking reliable partners in Baja California.

E. Human talent development

Every comparative case emphasizes human capital as the foundation of upgrading. Querétaro created UNAQ, Montreal invested in École nationale d'aérotechnique, and Phoenix expanded ASU programs. Costa Rica's INA and the Dominican Republic's INFOTEP developed modular curricula that lifted workers from operator roles into engineering pipelines.

Baja California should do the same: create laddered curricula that take workers from operator → technician → quality specialist → engineer, with tracks in English proficiency, quality management systems, and biomedical/aerospace engineering. Coordination between local firms, government agencies and local academic institutions to ensure both curriculum and skill development is crucial. The alignment of curriculum to workforce needs is also required. Following the curriculum reforms, large plants in Tijuana and Mexicali should form consortia that pre-commit to hiring graduates, ensuring training aligns with market demand.

Equally important is aligning STEM (science, technology, engineering, and mathematics) education with cluster needs. Baja California's universities should expand biomedical engineering, regulatory affairs, and aerospace digital systems programs, while integrating hands-on internships with anchor firms. The long-term goal is to reduce dependence on imported managerial and engineering talent by building a sustainable local workforce pipeline. For example, existing programs, such as Jabil's Summer Camp, CETYS's medical manufacturing diploma, and Ibero's internship-based coursework, all represent scalable initiatives that can develop Baja California's future workforce and align its curriculum with emerging technologies.

F. United States nearshoring opportunities

Nearshoring is Baja California's competitive trump card. No other region combines such proximity to the United States with decades of manufacturing expertise and an FDA/FAA-compliant workforce. But realizing this potential requires deliberate strategy.

The United States is currently prioritizing resilient supply chains in semiconductors, electric vehicles, pharmaceutical active ingredients, aerospace parts, and critical minerals (White House, US Government, 2021). Baja California should align with these priorities, positioning itself as the United States' nearshore lab for regulated industries. Branding campaigns can emphasize Baja California's track record of regulatory compliance, bilingual workforce, and binational logistics advantages.

Comparative cases show that timing matters. Phoenix and Morocco capitalized on global supply chain disruptions to position themselves as nearshore alternatives. Baja California should do the same: emphasize its stability versus Asian competitors, highlight USMCA advantages, and move quickly to secure specialized contracts in areas where the United States wants redundancy.

G. Innovation

Upgrading cannot rely on manufacturing alone; it must be paired with innovation capacity. Here, Baja California can learn from Ireland and Montreal. Galway evolved from basic assembly to a hub of MedTech spinouts, creating resilience through technological heterogeneity (Giblin and Ryan, 2015; Ryan et al., 2020b). Montreal built innovation capacity in simulation and green propulsion through university–industry collaborations.

For Baja California, the first step is to attract connectors: design houses, testing labs, and validation centres that link local firms to global R&D. Simultaneously, Baja California should support spinouts from MNE subsidiaries, encouraging former employees of Medtronic, Collins, or Safran to launch start-ups in related niches. Over time, this will create an ecosystem where MNEs, SMEs, and start-ups co-exist, building innovation resilience.

Finally, innovation requires funding. Baja California can establish joint innovation funds, co-financed by anchors, SEI, and universities, to support proofs of concept. These funds should prioritize cross-cluster innovations—for example, applying aerospace materials to medical devices, or using MedTech automation techniques in aerospace assembly.

H. Strengthening local cluster development

Clusters do not evolve on their own; they require institutional infrastructure. Baja California should strengthen cluster organizations beyond networking forums, giving them real responsibilities in joint procurement, workforce pipelines, and infrastructure planning.

Comparative cases highlight this clearly. Querétaro's Aeroclúster became a powerful platform coordinating training and branding. Montreal's Aéro Montréal positioned Quebec at the global level, while Morocco's Midparc created physical spaces for cluster integration. Baja California can build similar institutions, but with a binational twist: cross-border cluster councils that integrate Baja California firms with California universities and United States suppliers.

However, in its current form the aerospace cluster in Baja California is less cohesive. A strategic two-to-three-year plan with key leadership at the cluster level is needed to help solidify the cluster and form cross-border ties with actors in the United States. An initial step towards further developing and empowering the local clusters would be to develop a survey to capture existing activities and capabilities across all firms. Such knowledge, which should be updated every three to five years, would help policy makers and industry leaders develop stronger strategies at the cluster level, drawing on data across all firms.

The broader lesson from entrepreneurial ecosystem research is that clusters in "knowledge deserts" can evolve only if international connectivity (through MNEs) is matched with local absorptive capacity (through universities, start-ups, SMEs) (Giblin et al., 2025). Baja California should therefore balance global ties with local capability-building, ensuring that the region becomes not just a manufacturing hub but a generator of knowledge and innovation.

As a cohesive and integrated set of policy insights, these recommendations underscore that Baja California's future competitiveness will depend not only on continued economic upgrading, but also on the incorporation of social and environmental upgrading as integral components of cluster development. Strengthening worker capabilities, improving job quality, and ensuring safer production environments will reinforce the region's ability to absorb more complex functions, while investments in cleaner processes, emissions control, and waste reduction will help firms meet tightening global standards. By aligning economic, social, and environmental upgrading within a unified strategic framework, Baja California can build more resilient and innovative industrial ecosystems that are well-positioned to capture higher-value opportunities in both the medical devices and aerospace GVCs.

VIII. Conclusion

The findings of this study show that Baja California's industrial transformation cannot be explained by any single theory of development. The region's trajectory—from electronics and auto parts to medical devices and aerospace—illustrates how local capabilities and global governance interact over time. The cluster development perspective explains the "who": the mix of firms and institutions that drive collective upgrading through their differentiated roles as anchors, propellents, connectors, and enablers. The GVC perspective explains the "how": the governance structures and international standards that shape what kinds of upgrading are feasible, and how value is captured or constrained within GVCs.

The complementarity of these frameworks offers a more complete understanding of Baja California's development path. Cluster dynamics reveal the internal ecosystem—the balance of roles that generates resilience, innovation, and spillovers—while GVC analysis exposes the external linkages that define opportunities for product, process, and functional upgrading. When these insights are combined, policymakers can see both sides of the equation: the need to cultivate a diversified local base of firms and institutions, and the importance of negotiating favourable positions within the global industries that govern trade, technology, and standards.

The evidence from Baja California's medical device and aerospace clusters shows that upgrading succeeds when internal and external dimensions align. In medical devices, MNE anchors such as Medtronic and Cardinal Health have catalysed supplier upgrading, human talent development, and specialized services when supported by strong local enablers like SEI and the cluster association. In aerospace, distributed leadership among multiple Tier-1 and Tier-2 firms has created a broad but more disaggregated network, requiring collective action to deepen supplier capabilities and certification. In both sectors, the lesson is that competitiveness emerges not from isolated firms but from coordinated ecosystems that link global and local strengths.

Beyond technological and organizational improvements, Baja California's experience also points to the importance of social upgrading, in which participation in GVCs leads to improved working conditions, greater social inclusion, and higher living standards for the local workforce. In the case of medical devices, workforce development programs, partnerships with technical institutes, and growing demand for specialized skills have created pathways for upward mobility, particularly among young workers and women. These dynamics show that upgrading is not only about enhancing firm-level capabilities, but also about ensuring that value creation translates into broader local development. When clusters foster decent employment, social protection, and access to lifelong learning, they become platforms for inclusive industrial transformation. Integrating social upgrading into cluster and GVC strategies thus reinforces the long-term sustainability and legitimacy of development trajectories.

Finally, the study suggests that Baja California can capture new opportunities by fostering collaboration between its leading clusters. Cross-sector linkages between aerospace and medical devices—especially in precision manufacturing, additive technologies, and materials engineering—offer a platform for shared innovation. Examples such as Airbus-Medtronic cooperation on ventilator systems during the COVID-19 crisis, or Boeing's research with universities on biocompatible materials, show how seemingly distinct industries can generate mutual upgrading through knowledge transfer. For Baja California, promoting cross-cluster R&D initiatives and joint supplier development programs could multiply the benefits of integration into GVCs.

Looking ahead, the challenge for Baja California is to sustain this dual vision. Policies must continue to leverage integration into GVCs while strengthening the institutional and human foundations of local clusters. By maintaining this balance between global governance and local collaboration, the state can turn its current manufacturing success into an enduring model of inclusive, innovation-driven growth. The future of Baja California's economy will depend on how effectively it combines scale with specialization, production with knowledge, and global connectivity with local value creation.

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Annex

Table A.1
Baja California, Mexico: largest medical device companies, 2025

Name of firm	City	Employees	Firm type[a]
Medtronic – Planta el Lago	Tijuana	6 000	OEM
(Becton Dickison) Sistemas Médicos Alaris, SA de CV planta 1	Tijuana	5 000	OEM
Flex	Tijuana	4 300	CM
Medtronic – Blvd. Insurgentes	Tijuana	3 500	OEM
Carl Zeiss Vision Manufactura de México	Tijuana	3 000	OEM
Foxconn Baja California	Tijuana	3 000	CM
Masimo - Planta 1	Mexicali	3 000	OEM
Jabil Healthcare–Planta 1/NPA de México, S de RL de CV	Tijuana	2 943	CM
Cardinal Health	Tijuana	2 700	OEM
ICU Medical de México	Ensenada	2 500	OEM
ICU Medical Healthcare – Tijuana	Tijuana	2 500	OEM
Mediméxico, S de RL de CV	Tijuana	2 200	OEM
(Envista – Planta 1) SDS de México, SA de CV	Mexicali	2 100	OEM
Merit Medical	Tijuana	2 100	OEM
Posey, S de RL de CV	Tijuana	2 100	OEM
Stryker Tijuana Operations, S de RL de CV	Tijuana	1 900	OEM
(Enovis) DJ Orthopedics de México, SA de CV	Tijuana	1 800	OEM
Productos Urológicos de México, SA de CV (Airlife)	Mexicali	1 780	OEM
Fisher & Paykel Healthcare – Planta 1	Tijuana	1 750	OEM
Martech Medical Products	Mexicali	1 700	OEM
Greatbatch Medical CRM&N (Integer)	Tijuana	1 700	OEM
Corza Medical	Tijuana	1 650	OEM
Honeywell SPS	Tijuana	1 300	OEM
Haemonetics México Manufacturing	Tijuana	1 200	OEM
Tri-State de México, S de RL de CV (Medline)	Mexicali	1 200	OEM
Jabil Healthcare - Planta 3	Tijuana	1 189	CM
Essilor Tijuana Óptica - Planta 1	Tijuana	1 054	OEM
(Baxter-Hillrom) Welch Allyn de México, S de RL de CV	Tijuana	1 000	OEM
Total employment for firms >1,000 employees (28 firms)		66 166	
Total employment for all firms (128 firms)		99 061	

Source: Prepared by the authors, on the basis of Directorio de la Industria Maquiladora. Retrieved on 20 May 2025, from https://industriamaquiladora.com.
Note: Shelter firms in Mexico (like MAM de la Frontera) do not make products under their own name (like OEMs). Instead, they act as a compliance umbrella under which foreign OEMs or CMs can manufacture in Mexico.
[a] OEM: original equipment manufacturer; CM: contract manufacturer; EMS: electronics manufacturing services.

Table A.2
Baja California, Mexico: largest aerospace companies, 2025

Name of firm	City	Employees	Firm type[a]
MAM de la Frontera	Tijuana	10 000	Shelter[b]
Interiores Aéreos (Gulfstream)	Mexicali	3 500	OEM
TECMA (border assembly/Técnicas Mexicanas de Ensamble)	Tijuana	3 000	CM
Industrias Hunter	Tijuana	2 002	OEM
Safran Cabin Tijuana	Tijuana	1 860	OEM
Eaton Industries	Tijuana	1 300	OEM
Honeywell Aerospace de México	Mexicali	1 230	OEM
Hutchinson Seal de México	Ensenada	1 200	OEM
Benchmark Electronics Tijuana	Tijuana	1 150	EMS
Ascotech (Emerson)	Mexicali	1 100	OEM
Placas Termodinámicas	Mexicali	1 026	OEM
Collins Aerospace Mexicali (Goodrich Aerospace de México Engineering Center, S de RL de CV)	Mexicali	1 011	OEM
Collins Aerospace – Avionics (Ensambladores Electrónicos de México, S de RL de CV)	Mexicali	1 000	OEM
Tyco Electronics Tecnologías (TE Connectivity)	Tijuana	1 000	OEM
Aptiv Contract Services Tijuana, SA de CV	Tijuana	1 000	CM
Total employment for firms >1,000 employees (15 firms)		31 379	
Total employment for all firms (77 firms)		46 564	

Source: Prepared by the authors, on the basis of Directorio de la Industria Maquiladora. Retrieved on 20 May 2025, from https://industriamaquiladora.com.

[a] OEM: original equipment manufacturer; CM: contract manufacturer; EMS: electronics manufacturing services.

[b] Shelter firms in Mexico (like MAM de la Frontera) do not make products under their own name (like OEMs). Instead, they act as a compliance umbrella under which foreign OEMs or CMs can manufacture in Mexico.

Table A.3
Product codes for the medical device GVC

Product category	Product examples	HS code aggregation	HS96 codes 6-digit (HS02-07 changes)
Disposables	Needles, syringes, catheters, tubing, IV sets, bandages, surgical gloves	90183	901831: Syringes, with or without needles
		3005	901832: Tubular metal needles and needles for sutures
		401511	901839: Needles, catheters, cannulae etc. (medical) (changes to Catheters, cannulae & the like in HS02)
			· 9018391010-90: Infusion equipment
			· 9018399010-20: Infusion and transfusion of serum
			· 9018399090: Other needles and catheters, cannulae and the like
			3005: Wadding, gauze, bandages and similar
			401511: Surgical gloves
Medical and surgical instruments	Dental instruments, forceps, medical scissors, dialysis devices, defibrillators	90184	901841: Dental drill engines (expands to dental drill engines, whether/not combined on a single base with other dental equipment in HS02)
		90185	901842: Instruments and appliances, used in dentistry
		90189	901850: Ophthalmic instruments and appliances (expands to nes 90.18 in HS02)
			901890: Instruments, appliances for medical, etc. science, nes (expands to Instruments & appliances used in medical/ surgical/veterinary sciences, incl. other electro-medical apparatus & sight-testing instrument, nes in 90.18 in HS02)
			· 9018900010-30: Surgical equipment for collection of semen and artificial insemination
			· 9018900090: Other medical devices
Therapeutic devices	Artificial body parts, hearing aids, pacemakers, crutches, implants, prosthetics	9021	902111: Artificial joints (changes to 902131: Artificial joints HS02)
			902119: Orthopedic/fracture appliances, nes (changes to 902110: Orthopedic/fracture appliances in HS02)
			902121: Artificial teeth
			902129: Dental fittings, nes
			902130: Artificial body parts, aids, and appliances, etc. (changes to 902139: Artificial parts of the body other than teeth, dental fittings & joints in HS02)
			902140: Hearing aids, except parts and accessories
			902150: Pacemakers
			902190: Orthopedic Appliances, nes (expands to appliances which are worn/carried/implanted in the body, to compensate for a defect/disability (excl. of 9021.10-9021.50) in HS02)
Diagnostic/ imaging	MRI, ultrasound machine, X-rays, patient monitoring systems	90181	901811: Electro-cardiographs
Equipment	Blood pressure monitor	90182	901812: Ultrasonic scanning apparatus
		9022	901813: Magnetic resonance imaging apparatus
			901814: Scintigraphic apparatus
			901819: Electro-diagnostic apparatus, nes (expands to used in medical/ surgical/dental/ veterinary sciences (incl. apparatus for functional exploratory examination/for checking physiological parameters), nes in 90.18) in HS02)
			901820: Ultra-violet or infra-red ray apparatus (expands to used in medical/surgical/dental/veterinary sciences in HS02)

Product category	Product examples	HS code aggregation	HS96 codes 6-digit (HS02-07 changes)
			90221: Apparatus based on the use of X-rays, whether or not for medical, surgical, dental or veterinary uses, including radiography or radiotherapy
			90222: Apparatus based on the use of alpha, beta or gamma radiations, whether or not for medical, surgical, dental or veterinary uses, including radiography or radiotherapy apparatus
			902230: X-ray tubes
			902290: Other, including parts and accessories

Source: Prepared by the authors, on the basis of Bamber, P. and Gereffi, G. (2013, August). *Costa Rica in the medical devices global value chain: opportunities for upgrading*. Duke University, Center on Globalization, Governance & Competitiveness. https://gvcc.duke.edu/cggclisting/costa-rica-in-the-medical-devices-global-value-chain-opportunities-for-upgrading-chapter-2/.

Table A.4
Product codes for the aerospace GVC

VC stage	VC sector	HS code	HS code six-digit description	VC subsector
Final products	Helicopters	880211	Helicopters of an unladen weight ≤ 2000 kg	
		880212	Helicopters of an unladen weight > 2000 kg	
	Airplanes and other aircraft	880220	Unladen weight not exceeding 2,000 kg	
		880230	Unladen weight > 2,000 kg but not > 15,000 kg	
		880240	Unladen weight > 15,000 kg	
Sub-assemblies	Landing gear	880320	Under-carriages & parts thereof of goods of 88.01/88.02	Under-carriages
	Aircraft parts & assemblies (generic)	880330	Parts of airplanes/helicopters, other than propellers, rotors, under-carriages & parts thereof	
	Propellers & rotors	880310	Propellers & rotors & parts thereof, of goods of 88.01/88.02	
	Other parts	880390	Parts of goods of 88.01/88.02, nes in 88.03	
	Main engine (propulsion)	841111	Turbo-jets of a thrust ≤ 25 kN	
		841112	Turbo-jets of a thrust > 25 kN	
		841121	Turbo-propellers of a power ≤ 1,100 kW	
		841122	Turbo-propellers of a power > 1,100 kW	
		841181	Other gas turbines of a power ≤ 5,000 kW	
		841182	Other gas turbines of a power > 5,000 kW	
	Other engines (other on-board engines)	840710	Spark-ignition reciprocating/rotary internal combustion piston engines for aircraft	
		841210	Reaction engines other than turbo-jets	
	Launching gear	880510	Aircraft launching gear & parts thereof; deck-arrestor/similar gear & parts thereof	
	Ground trainers	880529	Ground flying trainers other than air combat simulators, & parts thereof	
	Interior seats	940110	Seats of a kind used for aircraft	Seats
Components/ parts	Main engine parts	841191	Parts of the turbo-jets/turbo-propellers of 8411.11–8411.22	Parts
		841199	Parts of the other gas turbines of 8411.81 & 8411.82	
	Other engines parts	840910	Parts suitable for use solely/principally with the aircraft engines of 84.07	Parts
	Landing gear tires	401130	New pneumatic tyres, rubber, used on aircraft	Tires
		401213	Retreaded pneumatic tyres, rubber, used on aircraft	
	Electronic instruments	901420	Instruments & appliances for aeronautical/space navigation (excl. compasses)	Navigation Systems

Source: Prepared by the authors, on the basis of Bamber, P., Frederick, S. and Gereffi, G. (2016). *The Philippines in the aerospace global value chain.* Duke University Center on Globalization, Governance & Competitiveness. USAID/Philippines. https://dukespace.lib.duke.edu/items/e83c06a0-3b35-49d8-bf58-31fd9834a5d0.

This study presents an analysis of the role of the medical device and aerospace sectors in Baja California's recent productive transformation and integration into global value chains (GVCs). Drawing on a combined cluster development and GVC approach, the authors examine how firms, institutions and public policies interact to shape upgrading opportunities and development outcomes at the subnational level. The industrial base of Baja California has been overhauled, reflecting a shift from large-scale consumer electronics assembly towards more knowledge-, regulation- and quality-intensive manufacturing activities. The medical devices sector is organized around global lead firms, such as Medtronic, Cardinal Health and Becton Dickinson, that structure production networks and define upgrading pathways for suppliers and workers. In contrast, the aerospace sector is characterized by a distributed anchor structure, with multiple tier-1 and tier-2 firms jointly shaping cluster dynamics. Despite their strong integration into North American production networks, both sectors remain concentrated in manufacturing and assembly functions. The study identifies opportunities to advance economic, social and environmental upgrading through targeted policies that strengthen supplier development, workforce skills, innovation capacity and sustainability.

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