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Clustering for Space: A Case Study on Strategies for Developing a Space Sector in Costa Rica

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Abstract– ***This paper explores strategies for developing a nascent space sector in Costa Rica, using the Costa Rica Aerospace Cluster (CRAC) as a case study. It investigates how CRAC can leverage existing capabilities to enter the space sector, considering its unique context without a defense industry and the potential to exploit resources from adjacent industries like semiconductors and medtech. The research also examines how the cluster can serve as a launchpad for indigenous space startups. Through a structured methodology involving a case study approach and SWOT analysis, the paper analyzes internal factors such as CRAC's governance, capability inventory, shared infrastructure, market access, branding, and risk management, alongside external opportunities and threats related to New Space trends, regulatory environments, capital markets, and human capital availability. The findings converge on actionable strategies aimed at reducing friction and risk for sector entry, including initiatives like specialized startup memberships, aggregating demand for testing capabilities, enhancing international presence, streamlining legal frameworks, hosting investor workshops, attracting anchor clients, establishing shared test infrastructure, and launching a cluster-operated seed fund. The paper emphasizes the transferable capacity from Costa Rica's successful medtech ecosystem to accelerate aerospace and space sector development.***

Keywords-- cluster, new space, capacity building, SWOT, funding.

I. Introduction

The space sector has evolved from a publicly led, upstream-heavy domain into a broad, dual-use infrastructure that permeates the global economy through downstream services, data, and timing. Beyond launchers and satellites, it now functions as a “general-purpose” platform: satellite communications, Earth observation, and global navigation satellite systems (GNSS) underpin critical infrastructures (energy, transport, finance, food supply, law enforcement) and supply indispensable inputs for climate monitoring and disaster management [1], [2], [3]. The economic weight is no longer marginal: the global space economy reached $613 billion in 2024 with the commercial segment driving nearly four-fifths of activity and is projected to triple to around $1.8 trillion by 2035 as space-enabled applications diffuse across non-space industries [4]. This embeddedness creates both opportunity and exposure: GNSS-based timing and positioning, navigation, timing have become systemic dependencies for telecoms, power grids, and financial networks, sharpening the business case for resilient architectures and diversified space services [5]. For decision makers, the implication is straightforward: investing in space capabilities is not a niche technology bet but a lever for productivity, competitiveness, and national resilience across the whole economy.

Costa Rica enters 2025 with broadly solid macro-fundamentals and improved external buffers. The World Bank reclassified the country as high-income for FY26, reflecting sustained growth momentum (real GDP grew 4.3% in 2024) and rising GNI per capita [6]. Price dynamics normalized in 2024, headline inflation hovered around zero (annual average –0.4%), with year-end readings near 1%, allowing the central bank to resume easing and lower the policy rate to 3.75% (July 17, 2025). Labor market slack continues to narrow but remains non-trivial (national unemployment 7.4% in 2025Q2) [7]. On the fiscal side, public debt fell below 60% of GDP by end-2024, a notable consolidation from its pandemic peak [8]. The external account is anchored by competitive, high-tech exports and resilient services. In 2024, exports of goods and services totalled $30.6 bn (+8% y/y), with medical devices consolidating their role as the top goods export (44% of the total). Foreign Direct Investment (FDI) inflows reached a record $4.32 bn in 2024, reinforcing the ecosystem around advanced manufacturing and business services. The combined surplus in goods and services widened to 6.6% of GDP in 2024 [9].

Costa Rica’s productive structure shifted from import-substitution to a resolutely export-oriented, FDI-anchored model. The pivot began in the mid-1980s and was institutionalized through Export/Free Trade Zones, and subsequent reforms that empowered the investment and export promotion apparatus (today led by PROCOMER and CINDE). This transition diversified the economy beyond agro-based goods and created capabilities in electronics, precision metalworking, plastics, medtech, and knowledge-intensive services [10], [11]. Relative to Latin America, Costa Rica’s manufacturing base is mid-sized but comparatively sophisticated. Manufacturing value added stood at 13% of GDP in 2024, close to Guatemala (14%), Dominican Republic (12%), and Colombia (10%) below Mexico (20%), and far above logistics-centric Panama (5%) [12]. Technological intensity is where Costa Rica differentiates: high-technology goods were 24% of its manufactured exports in 2023, outperforming Mexico (18%) and far exceeding peers like the Dominican Republic (6%), Guatemala (5%), Colombia (9%) and Chile (11%), placing it closer to countries like Australia (25%), Thailand (26%) and the Netherlands (24%) [13], underscoring accumulated capabilities in regulated, high-tech manufacturing.

A sequence of anchor investments catalysed upgrading (most notably Intel’s 1997 entry) and, while cyclical, left behind durable human capital, supplier quality systems, and process know-how that spill over to adjacent sectors [14]. In parallel, medical devices consolidated into the country's flagship advanced-manufacturing cluster and now dominate the goods export basket, reflecting accumulated capabilities in cleanroom operations, regulatory compliance, and precision processes [15]. Over the last decade, Costa Rica has built a dense, export-oriented medtech ecosystem that now anchors its advanced manufacturing base. The footprint currently stands at 90+ companies and 54,000+ jobs by 2025, with a 10-year sectorial growth figure of 216% [16]. Global OEMs (e.g., Hologic, Boston Scientific) continue to expand multi-site operations reinforcing local capabilities in R&D, cleanroom manufacturing, validation, quality systems, and regulated supply chains.

Costa Rica's contemporary space trajectory is young but demonstrably capability-building. The country's first satellite, Irazú (a 1U CubeSat conceived by Central American Association of Aeronautics and Space and Costa Rica Institute of Technology (TEC) was launched to the ISS on 2 April 2018 (SpaceX CRS-14) and deployed on 11 May 2018 via JAXA's Kibo module. Its mission coupled a ground sensor network with space links to estimate forest growth and carbon fixation, establishing end-to-end know-how across design, testing, operations, and data use [17]. Together, these steps provided a domestic foundation in small-sat engineering, ground operations, and environment-oriented applications that is directly relevant to downstream geospatial services and future CubeSat missions. Beyond Irazú, Costa Rica has engaged in international joint projects that extend practical skills and networks. Notably, GW-Sat, a 3U CubeSat led by The George Washington University, is designed to flight-test micro-cathode arc thrusters (μCAT), act as a digipeater, and demonstrate store-and-forward communications [18], [19]. An arrangement that embeds Costa Rican partners in propulsion, attitude-control software, radio operations, and mission ops workflows. These collaborations are steadily broadening the country's human capital pipeline and operational experience.

Institutionally, the Costa Rica Space Agency (AEC) was created in 2021 by Law, with the Ministry of Science, Technology, and Telecommunications stewardship, to articulate a national space strategy and coordinate R&D, talent, and international cooperation [20]. While its operational ramp-up has involved subsequent adjustments and governance refinements, the AEC provides a formal locus for policy, partnerships, and project selection, complementing the private-sector and the technical base at TEC, Costa Rica University and partner universities. For decision makers, this combination constitutes a credible starting platform from which to target focused upstream and downstream niches over the next planning cycle.

The traditional space supply chain includes satellite manufacturing, launchers, ground equipment industry, space exploration, and space sciences, while the "New Space" supply chain also includes energy, mining, processing, assembly, and satellite services [21]. Costa Rica has signalled a deliberate and growing intent to capture "New Space" opportunities [22], by pairing policy instruments (the AEC's mandate, FTZ incentives, export and FDI promotion, and university-led CubeSat programs) with capability upgrades (STEM pipelines, quality systems, and dual-use R&D aligned to downstream data services and upstream subsystems). Within this architecture, the Costa Rica Aerospace Cluster (CRAC) functions as the nexus that can translate intent into investable projects: convening Tier-2/3/4 suppliers, startups, aerospace companies, articulating with universities and the AEC; mapping certification pathways, supplier development, export readiness, and coordinating shared assets and collective actions. The strategic logic is classic cluster economics adapted to knowledge-intensive manufacturing: firms co-locate to reduce transaction costs, deepen specialized labor pools, accelerate learning spillovers, strengthen absorptive capacity, and crowd in private capital. Effects that, in a small economy, are essential to reach a minimum efficient scale and to integrate into global aerospace value chains [23], [24].

These ideas converge to the central topic of this paper, which has been largely unexplored in the academic literature: generating strategies in a structured manner for developing the nascent space sector in Costa Rica. For this, basic questions such as: how can the CRAC leverage its existing capabilities to effectively enter the space sector? Is the space industry the best choice for the cluster's growth in a country with no defence industry? How can the resources from other adjacent industries such as semiconductors and medtech be exploited for this purpose? How can the cluster work as a launch platform for indigenous space startups? The following sections outline the methodology and obtain results, utilizing a structured approach to analyse internal and external factors influencing the sector's growth potential and formulating actionable strategies.

II. Methodology

A case study [25], [26], selected due to the exploratory nature of the task, and for its affinity for situational analysis and strategy generation, with the CRAC selected as the study subject due to the cluster's significant activity and coverage of the local aerospace industry. The selection also allows this research to address recommendations directly at high level decision-makers within the CRAC, allowing for a greater potential impact. The internal situation at the cluster and the relevant external factors will be uncovered and analyzed extensively. Within the study, a SWOT [27] framework is then applied to analyze the synthesized internal (strengths and weaknesses) and external (opportunities and threats) factors impacting the cluster's development and incidence in the space sector, and to converge on strategic options in a structured and repeatable manner.

A. *Data Collection Process*

Specific quantitative data related to the CRAC was directly consulted with cluster representatives. Information regarding production, export, and R&D figures within the structure is critical to assessing potential opportunities and shortcomings in the cluster's operational structure, as well as its overall strategic plan for growth and development. Quantitative data pertaining specifically to Costa Rica's industrial base and technological infrastructure relevant to the space sector was also gathered from publicly available sources, including academic papers, reports from the Central Bank of Costa Rica, the Ministry of Science, Technology, and Telecommunications, international organizations, and market studies. This data provides a broad understanding of the conditions to which the cluster is subjected, enabling the identification of external challenges for sectorial development, and offering a baseline for comparison and benchmarking the cluster against others with similar imposed conditions. Qualitative data was collected through semi-structured interviews. The interview questions were designed to elicit perspectives on the current state of the space sector in Costa Rica, potential opportunities and challenges for its development, and strategies for fostering growth and innovation. In some cases, the scope of the interviews was broadened to cover the full aerospace sector to obtain more meaningful results from the information received. The interviews were held with top directives from the CRAC and Orbital Space Technologies (OST), a deep-tech startup specializing in microgravity research hardware and services that has worked many times with the CRAC.

B. Analytical Approach

Due to the nature of the situation at hand, a case study approach was determined as adequate for conducting the proposed research. The specific approach is based on the cases described in [28], [29], [30], [31]. The case study methodology involves an in-depth investigation of a particular phenomenon within its real-world context. In this particular case, the case study aims to provide a situational analysis of the CRAC’s situation within aerospace and, more specifically when the data allows, of specifically the space sector in Costa Rica. The case study approach allows for a holistic understanding of the factors influencing the development of space business in Costa Rica, incorporating the collected quantitative and qualitative data to provide a comprehensive analysis. The baseline generated through this process is later used to generate strategies for sectorial development and improvement utilizing the SWOT methodology, in which a traditional SWOT matrix analysis facilitates the generation of strategies derived from the previously identified internal and external factors. The outcomes are finally discussed and recommended actions are given to the CRAC’s decision makers.

III. Study Outcomes

A. International Factors: CRAC-controllable elements

1) Cluster Governance & Execution Capacity: The CRAC is legally established and registered as a business association, governed by a board of directors and a set of statutes that provide a general framework for its operations [32], [33]. Its structure has undergone a timeline of development, reaching maturity in the present, following its legal establishment with a corporate ID and board of directors by August 2015, and the formal start of a self-sustainable management system. The CRAC aims to centralize the needs and opportunities arising in the global aerospace sector. Its vision is to enhance Costa Rica's current capabilities, achieve sustained growth, and increase competitiveness for both the entire sector and its individual members. A specific performance goal is to be recognized as the best Cluster in Latin America by the year 2025, based on the European Secretariat for Cluster Analysis evaluation system.

The CRAC has a dedicated Cluster Manager, Esteban Carrillo, with significant experience in the aerospace industry, including expertise in certifications and product transfers. The board of directors performs actual work, including an accounting committee, implying active involvement in governance. While formal board meetings are not explicitly detailed, the cluster conducts networking events approximately every three months, though these primarily serve a commercial purpose rather than direct decision-making. An annual assembly is held for legal requirements. While there is a dedicated Cluster Manager and an active board of directors, some board-level work is conducted by a small core team, with three people in total involved in assisting this work, suggesting a substantially lean operational staff for governance tasks [34].

The CRAC comprises more than 40 companies with diverse technological capabilities across contract manufacturing, machining, chemical processing, Maintenance, Repair, and Overhaul, embedded software, sheet metal/stamping, casting, plastic injection molding, and various services. This membership actively works with government agencies and academic organizations towards increasing Costa Rica's participation in the global aerospace supply chain.

2) Capability Inventory, Compliance & Readiness: The CRAC offers a comprehensive range of productive processes, products, and services, positioning it as a significant supplier network not only for the aerospace sector but also for industries such as medical devices and automotive [35]. Machining is a primary specialization for 41% of CRAC companies, and MRO-specialized companies demonstrate strong performance in aerospace sector linkage, idle capacity, and internationalization.

The cluster's capabilities include critical and non-critical electromechanical systems, high-standard embedded software development and testing, and electronic assemblies (including electromechanical assemblies, electronics, PCBs, and cable and harness assemblies). The CRAC also boasts over 50 years of experienced Maintenance, Repair, and Overhaul capabilities [32]. MRO service firms (COOPESA) are notably mature within the sector. Most companies can be positioned within Tiers 2, 3, and 4 of the aerospace industry value chain, providing sub-assembly services, light manufacturing, and supporting processes like plastic and metal molding [36].

Many CRAC members are currently expanding their operations, investing in machinery, infrastructure, and new warehouses. The cluster is nearing its historical general growth average of 15% since data is available [34].

Requirements in the space sector are exceptionally high, demanding unconventional engineering solutions due to unique conditions such as high vacuum, extremely low temperatures, and micro-gravity. Space-dedicated mechanisms must be lightweight, durable, and highly reliable [37]. Key technical areas for the space sector require unconventional engineering solutions, including the design, production, and testing of integrated circuits, along with monitoring and control systems for spacecraft. This also encompasses structural, thermal, and chemical analysis, particularly focusing on vibration resistance. Stringent quality assurance is vital given the high costs associated with errors. Additionally, specialized software development, precision machining for complex components, and forecasting potential damage from orbital operations are crucial [30]. Enough of these capabilities are covered to an extent by the cluster capability matrix already, except for the testing and validation of space-specific systems.

Compliance has also been crucial for the CRAC's ability to integrate into global aerospace supply chains, particularly regarding certifications such as AS9100 and NADCAP [32]. Twelve companies are AS9100 certified for electromechanical assemblies, electronics, cable and harness assemblies, machining, and embedded software. 32% of companies in the CRAC hold AS9100 certification, which is crucial for the aerospace sector [35]. AS9100 supplements ISO 9001 requirements with additional quality system requirements established by the aerospace industry to satisfy Department of Defense (DoD), National Aeronautics and Space Administration (NASA), and Federal Aviation Administration (FAA) quality requirements, and 11 companies within the aerospace sector have AS/EN 9100 certification. Other standards are also met for specific processes, such as ESD controls (ANSI/ESD-S-20.20), crimping (NASA-STD-8739.4 and MSC-Spec-Q-1A) and others. Initiatives with interested parties, such as universities (TEC and UNA), technical schools, government agencies, ministries, and international organizations, involve introducing AS9100 training programs, developing a Technical Degree in Advanced Manufacturing, modifying existing training, developing Costa Rican AS9100 auditors, and specialized training in International Traffic in Arms Regulations (ITAR) / Export Administration Regulations (EAR). These programs contribute to building a national quality brand and skilled workforce.

3) Shared Infrastructure & Test Ecosystem: The absence of a wide offer of thermal treatments and non-destructive testing (NDT) in Costa Rica significantly affects the linkage of machining companies with the aerospace sector. Products must often be sent abroad for these procedures, potentially reducing competitiveness, as NDT for aerospace products is not currently certified domestically. The cluster is actively working on consolidating demand for these tests to potentially attract a local service provider [33], [35]. Current testing practices involve functional testing, with environmental testing (incorporating thermal cycles, corrosion chambers, and vibratory tests) representing the next evolutionary step. The integration of functional and environmental testing enables design and development capabilities, moving beyond the "build to print" model [34].

This lack of advanced testing infrastructure poses a considerable barrier, forcing companies to develop prototypes without full validation against demanding space conditions or to seek costly external facilities [38]. Space sector requirements are exceptionally high, necessitating unconventional engineering solutions due to unique conditions like high vacuum, extremely low temperatures, and micro-gravity, requiring mechanisms to be lightweight, durable, and highly reliable [37]. While the CRAC's capability matrix covers many key technical areas for the space sector (including integrated circuit design/testing, monitoring/control, structural/thermal/chemical analysis, vibration resistance, quality assurance, software development, and precision machining), a critical gap remains in the testing and validation of space-specific systems. Vital infrastructure investments are needed to advance national technological capabilities and support technology-generating companies. These essential shared resources could be provided by more established companies within the cluster for broader use and have been considered by the cluster.

4) Market Access & Commercial Traction: Key market access advantages for the CRAC include geographical and logistical benefits, such as being in the same time zone as major US cities and having direct flights, which provides a competitive edge over companies in other continents [33]. This proximity facilitates tighter supply chain integration and quicker response times, attributes highly valued in the demanding aerospace industry. The export destination distribution possess as clear evidence of this advantage.

On the commercial traction side, the CRAC has successfully attracted 10 new customers over the last four years, significantly increasing invoicing for the country and demonstrating effective business development and foreign direct investment attraction for its members [32]. In 2022, the CRAC recorded estimated sales of USD 205 million. Its sales are highly diversified across various client sectors, including medical devices, automotive, and other specialized industries. Sales directed to the aerospace sector reached 39% of the total, a notable increase from 24% in 2017. Approximately 99% of these aerospace sales are exports, with the United States remaining the primary destination. Despite a nearly 100% internationalization rate, a notable weakness is the high concentration of aerospace-related sales and exports. As of 2023, 91% of sales directed to the aerospace sector were concentrated among just four companies, and similarly, 91% of exports originate from these same four companies, with six cluster members not exporting at all. This high concentration poses a significant risk if these key companies face disruptions. Furthermore, participation in aerospace sector sales varies by specialization, with companies in Maintenance, Repair, and Overhaul and electromechanical systems showing better results than machining companies, which tend to support local operations rather than exports [35].

5) Cluster Branding & Operating Advantages: Costa Rican labor costs are higher than other operational costs in Latin America, impacting competitiveness. Despite this, compared to countries like India, China, or even other Latin American Clusters, the cluster's contract manufacturers differentiate themselves by offering superior quality and a high-mix, low-volume production model. They can produce smaller quantities that large-scale suppliers find unattractive [39]. This specialized low-volume, high-mix business model makes the CRAC extremely attractive for aerospace companies, as many suppliers in other countries, like Mexico, prefer high-volume production for sectors like automotive and medical devices [33].

On the marketing side, the CRAC has established a strong brand, consistently recognized as the best cluster in Costa Rica for two consecutive years. This reputation is built upon an active promotion of Costa Rica's ecosystem, stability, culture of quality, and emerging talent for the aerospace industry [32]. The CRAC's brand identity is rooted in values such as excellence, innovation, sustainability, and social progress, emphasizing "Costa Rican origin" and a commitment to achieving success in harmony with environmental and social conditions [40]. Paradoxically, the country's small size is leveraged as a strength, fostering close coordination with government and academia, which enables quick response times. This coordination also directly enhances the cluster's marketing presence through active participation in international commercial fairs, with plans to attend four this year [33]. For generating commercial leads, companies within the CRAC primarily rely on direct commercial management, supplemented by references from parent companies and leads generated by the cluster itself. For international clients, external sales representatives are also utilized [35].

6) Risk Management & Continuity: A significant challenge for the cluster is the difficulty in retaining space startups as active members due to their lack of consistent income. The current membership model for space initiatives is not highly functional, leading to companies sometimes leaving the cluster for financial reasons after months of membership or, in some scenarios, after several years of membership in the case of consolidated members [34]. This is especially relevant, as almost 100% of startups approaching the cluster are related to space applications. A study carried out by the AEC showed that the great majority of the 10+ space ventures in the country are early stage startups. To address the issue of retaining space startups, there is a proposal to create a special membership category within the ecosystem. This would allow them to remain engaged under different conditions, potentially through channeling these initiatives via the space agency, offering them a membership that doesn't incur direct expenses.

On the operational side, what could be perceived as a lean administrative infrastructure of the cluster could also implicate operational risks due to lack of redundancy in the hierarchy. It is currently perceived as a bottleneck for the execution capacity. This suggests a significant operational limitation within the CRAC [33]. The executive director of the cluster implicitly acts as a single point of failure, being the main decision maker, but also one of the main technical experts and carrying out other roles on an as-needed basis. There is an explicit priority within the cluster to find administrative stability or ensure that the cluster is administratively sustainable, acknowledging that it currently operates under a lot of risk and under an extremely low-cost model that could hinder its ability to capitalize on market trends and opportunities.

B. External Factors: Contextual Opportunities & Threats

1) New Space, Anchor Clients & Value-Chain Shifts: The current landscape of the space sector presents itself as a massive opportunity for new actors such as the CRAC. The Earth Observation (EO) segment is undergoing a transformation, shifting from traditional defense and military applications to a diverse range of new uses. This shift is attracting innovative data-intensive service providers and is projected to lead to strong market growth in various regions, including Asia, Latin America, and Africa [41]. New private actors, including startups and large web corporations, are disrupting the space supply chain by introducing innovative approaches such as smaller satellites, new orbits, and the utilization of Commercial Off-The-Shelf (COTS) components, which collectively contribute to lowering barriers to market entry [2], [42]. This lower barrier of entry means that there are new actors operating outside the traditional government contracting models, fostering a more agile, competitive, less regulated landscape within the sector (e.g., it's easier to do business with a satellite plantation monitoring startup from Brazil than with the US government) [29], [43].

The lower cost to orbit has also implied a significant increase in demand for space activities from defense customers, as evidenced by a nearly 280% (x3.7) rise in satellites launched for defense purposes over the past five years. In 2024, defense customers also accounted for 67% of satellite manufacturing orders [5]. There are many intersections on the commercial and defense sectors. The emergence of massive constellations in Low Earth Orbit presents substantial opportunities for global broadband connectivity, primarily driven by their key selling point of low latency [2]. The ongoing war in Ukraine, for example, highlights the increasing reliance on small satellite constellations for efficient, real-time deployment and communication, further underscoring this trend [44].

Internally, Costa Rica's potential competitiveness in the aerospace sector is constrained by its small market size, the absence of defense spending (no standing armed forces), and limitations in cost-competitive labor [39]. The establishment and growth of a local aerospace sector are significantly influenced by the presence of an anchor firm, defined as a category of firms within a cluster that possess the ability to integrate and establish a high level of linkage among members, investing in human capital development and creating a pull effect for suppliers. On the aeronautics side, COOPESA, for instance, is described as a "sleeping anchor" within the cluster due to its limited interaction with the local ecosystem, preventing it from fully acting as an anchor company. Recognizing this, a key strategy for the CRAC in the coming years is to actively seek to attract a large aerospace company operation to the country. This initiative is viewed as a game-changer that could create a snowball effect for growth, aiming for a stronger impact than simply bringing in manufacturing projects [33], [34].

2) Regulatory & Legal Environment: The regulatory framework bears critical importance as an enabler for the space industry. States bear international responsibility for "national activities in outer space", including those conducted by private, non-governmental entities. This necessitates that states authorize and continuously supervise the activities of private companies, adding layers of regulatory complexity and potential liability [36], [45]. The definition of "national activities" can be broad, encompassing activities by citizens, within a state's territory, or on board its ships and aircraft. The absence of a well-structured national space law or a clear policy framework can deter space industry development and attract less foreign direct investment. Countries lacking specific space legislation, or a coherent policy framework may struggle to foster a commercial space industry, as this regulatory void can generate uncertainty and increase operational risks, especially concerning international responsibility and liability for the activities of private entities in space. On the other hand, a tailored legislative and regulatory approach can significantly enhance a country's attractiveness for New Space operations. For instance, Luxembourg and Finland have successfully implemented regulations to boost their appeal for New Space companies and small and medium-sized enterprises [44].

Efforts have already been made on the legislative front thanks to the AEC and work by local actors such as the CRAC, local startups and national universities, but ambiguous language and legal holes in existing proposals might hinder their effectiveness in establishing a clear, supportive framework for nascent space sector development, especially for ventures trying to operate in orbit, forcing them to recur to launch and operation proxies in other, better suited jurisdictions [38].

A significant threat is the lack of integration of space-related themes into the State's budgetary allocations by the current government. Costa Rica's National Development and Public Investment Plan 2023-2026 has no specific mention of the space sector, indicating a lack of governmental strategic and financial recognition [46]. Many space-related initiatives within the cluster are dependent on the space agency, which was recently established. Concerns exist regarding its stability, as there have already been attempts to dissolve it. This highlights a potential single-point failure or vulnerability in the support structure for space activities dependent on the AEC [33].

3) Capital Markets and Deeptech Appetite: A primary threat stems from the significant disparity in available capital for space technology development in the region compared to international markets. Local investment funds, typically accustomed to smaller software startups, often lack the risk tolerance for capital-intensive space ventures, particularly those focused on hardware. Access to international funds, while an option, usually comes with conditions such as registering the company in different jurisdictions or requiring subsidiaries in select markets [38]. This capital market dynamic has directly affected companies like OST, which, currently in the seed capital raising stage, has experienced a slowdown in its fundraising process. The cluster, however, presents a unique opportunity to bridge this funding gap for technology and capacity building, leveraging both private and state-sponsored development funds. It could serve as a crucial nexus for accessing financing, potentially by organizing calls or allocating funds, thereby significantly boosting industry growth and de-risking investments. Moreover, the CRAC is perceived to be in a strong position to act as a program manager for open calls from international agencies such as NASA, ESA, and JAXA.

4) Human Capital Availability & Competition: While Costa Rica's total labor pool exhibits limited growth potential and a lower proportion of engineers and technicians experienced in advanced manufacturing compared to other regions [39], the presence of the medical devices and electronics industry has fostered a significant R&D-intensive, highly skilled labor pool [14], [47]. This dual dynamic presents both an opportunity and a threat, as competition from the medtech and semi-con sectors could take away talent essential for aerospace development, leading to wage inflation and a reduced pool of expertise for nascent space ventures. Added to this, the local industry faces competition from developed nations, as brain drain from highly specialized Costa Rican talent seeking opportunities abroad further exacerbates the scarcity of specialized personnel required for scaling a space sector.

However, the nascent nature of the local space sector contributes to a challenge in finding specialized personnel and a notable absence of specialized education in critical space technology standards within local curricula. This educational gap poses a threat, potentially leading to projects failing to meet international requirements, resulting in delays and wasted resources [38]. OST addresses this by adapting talent from other technological, manufacturing, and engineering sectors, operating on the principle that skills can be repurposed and developed through training and a learning curve, even without direct space sector experience.

IV. Strategic Analysis & Discussion

Fig. 1 is the SWOT matrix obtained from the strategic analysis in the previous section. The strategic analysis is divided in two lines of thinking: the legal framework required for attracting FDI and its connection to VC, and the industrial ecosystem and potential for shared infrastructure as a catalyzer for the space industry.

	Internal	External
Positive	**Strenghts** ◉ Formal cluster governance; dedicated manager and active board. ◉ 40+ member firms across machining, MRO, electronics, embedded software, services. ◉ Compliance base: AS9100; ESD/IPC/NASA practices; ITAR/EAR training underway. ◉ Mature MRO and Tier 2–4 supply experience. ◉ Multi-sector linkages (medtech, auto). ◉ Export-centric with U.S. time-zone and direct-flight advantage. ◉ Rising commercial traction. ◉ Differentiated high-mix/low-volume quality positioning. ◉ Strong cluster brand and international promotion.	**Opportunities** ◉ New Space: smallsats, COTS, agile procurement; expanding demand in emerging markets. ◉ Defense-driven demand growth. ◉ Repurpose medtech/electronics talent. ◉ Market opportunities to attract an anchor aerospace operation, nearshoring. ◉ National need for an articulator for the industry ◉ Local market initiatives and startups. ◉ NASA/ESA/JAXA open calls.
Negative	**Weaknesses** ◉ No anchor firms. ◉ Small admin core; execution bottlenecks and single-point-of-failure risk. ◉ Testing gaps: no accredited aerospace NDT and reliance on foreign labs. ◉ Slow move beyond "build-to-print" due to validation void. ◉ Concentration risk: 91% of aerospace sales/exports in 4 firms. ◉ No space-specific verification/validation capabilities. ◉ Membership model ill-suited to pre-revenue space startups. ◉ Higher labor costs vs LATAM peers.	**Threats** ◉ Regulatory uncertainty and incomplete space law. ◉ AEC instability. ◉ No national plan for space. ◉ Capital gap for deeptech, local VC are low-risk, international funds often require subsidiaries. ◉ Small domestic market, no defense procurement. ◉ Talent competition and brain drain. ◉ Export-control regulations.

Fig. 1 SWOT Matrix – Costa Rica Aerospace Cluster (CRAC).

A. Legal Framework, FDI and Ventura Funding

As mentioned before, a textbook strategy involves attracting foreign companies to qualify and enhance the capabilities of these clusters. This highlights that external investment and foreign company integration are key for the task at hand [48]. It is already possible to do business with external companies (even in the heavily regulated defense sector) without a specific local regulatory framework. In fact, some of the member companies already work with clients in the defense industry as supply chain providers. But as shown by the literature, lacking this regulatory element is critical and will otherwise hinder the acquisition of an anchor company through FDI and the development of an indigenous space ecosystem. The CRAC could lobby for adoption of an existing regulatory framework (essentially a copy-and-paste approach) to enable the attraction of a major OEM in the space sector, rather than attempting to create a new framework from scratch.

If the goal of attracting an anchor company is to be achieved, it will be necessary to maintain visibility at sector events, conduct direct outreach with target companies, and secure strong public-sector cooperation through fiscal incentives and other supportive mechanisms. Agreements can be established with members of the diaspora working in the space sector so that they may serve as ambassadors under mutually agreed terms. This would facilitate international business engagement and provide the cluster with increased initial credibility. Costa Rica's national branding can also be leveraged to strengthen the brand identity of associated companies, as there is a strong component of sustainability and responsible development in the space sector. Any initiative connected to environmental stewardship, positive-impact technologies, or sustainability is inherently synergistic with the country's existing brand strategy. This perception can amplify outreach and marketing effectiveness at the cluster level.

Another strategy for attracting companies in the medium-long term may be to focus on New Space rather than attempting to recruit traditional legacy actors. Targeted programs could be established to attract startups, including fiscal incentives and investment from universities, government entities, and interested private-sector stakeholders. These startups would be integrated into the cluster by affinity, receive interns, and participate in shared development initiatives. Comparable models can be found in Malta and Luxembourg, where financing is provided under the condition that companies establish legal presence and operational offices in the country, thereby generating employment and increasing domestic sector activity.

Due to the cluster's composition, R&D activity is significantly limited, as it consists primarily of Tier 2/3/4 suppliers. This capability is far more relevant for emerging initiatives within the national space sector previously discussed, making it essential to reduce friction in intellectual property protection and patent management. On the same legal front, enabling the streamlined creation of subsidiaries in the North American, the European, and Asian markets, or at minimum ensure access to a service reseller capable of acting as a proxy for local companies would increase market access, and reduce both the friction for clients purchasing from local companies and funding friction for space startups and could be achieved by the legal branch of the CRAC. This requirement becomes especially relevant if the goal is to establish OEMs within a context where the domestic and/or regional market remains limited in size. VCs and state-sponsored grants usually require subsidiaries in specific jurisdictions to provide venture funding. On the domestic side, the CRAC could work to lower the technical barrier for investing in space tech for local VCs and angel investors, given the high level of technical understanding needed to adequately assess the potential of certain space applications and technologies. The cluster could play a role in reducing perceived risk and/or increasing investor competence and familiarity with the sector, thereby improving the rate of successfully financed ventures.

On the funding side, a possible strategy that simultaneously addresses multiple identified challenges is for the cluster to establish a VC branch to finance local startups. Funding could be provided in the form of capital or services (e.g., manufacturing credits for prototyping, access to laboratories, technical facilities, access to experts, software licenses, etc.). This approach stimulates the creation of future customers, as local companies would primarily operate as Tier-2/3/4 suppliers rather than OEMs. OEMs rely on suppliers, creating vertical integration; additionally, OEMs benefit from significantly lower technology development costs, therefore requiring less external funding. It is important to highlight that, very often, a substantial portion of startup capital requirements in this sector are related to hardware development and validation, as is the case with OST. Other expensive elements like launch services can often be obtained through grants or partnerships, potentially at no cost, leveraging existing networks (e.g., MUSA project from OST).

The local industry could also aim to enter and exploit the downstream services sector. As mentioned before, the space sector is expected to grow substantially in the coming years, primarily driven by data generated by satellites and activity in Low Earth Orbit (LEO) [4]. The workforce must be better equipped with skills applicable to this environment, such as data analysis, geospatial engineering, and related competencies. This approach is easily attainable through modifications to engineering programs at universities and professional training pipelines already in place within the CRAC. It also facilitates entry through the software domain rather than hardware, the latter of which can already be financed with capital available within the local market (i.e., it does not require multimillion-dollar investments) and involves less risk in general. As mentioned, shared licenses could be secured and used as part of the support package and/or financing mechanism for startups within this New Space sector. This approach could enable future vertical integration and absorption of more steps in the supply chain by the ecosystem (e.g., design of EO satellite components and similar activities). Additionally, market validation is more feasible, as the government could figure as an anchor client by contracting services such as climate monitoring, disaster prevention and relief, and other similar services. This opportunity should not be overlooked, as foreign companies are already supplying these capabilities to the region, indicating existing demand and competitive pressure.

B. Industrial Ecosystem & Shared Infraestructure

The cluster self-funded operational model and its possible role as an industry nexus is highly attractive in a context of fiscal austerity. The AEC has been criticized by certain legislative sectors, as it is perceived as an "unnecessary expense" when other priorities appear to take precedence. A self-sustaining model is therefore highly attractive to the general public and reduces both risk and dependency on political cycles and could also ease cooperation from the political sector. For example: the AEC could function as the legal and diplomatic arm, as well as the point of interface with the government (concessions, state-interest space missions), while the cluster serves as the operational core and strategic leader of the sector (more efficient, less bureaucratic, and more business-focused). Friction should be minimized as much as possible for potential customers, including both external clients and internal members. For example, externally, the cluster could deploy an automated manufacturing service platform (e.g., Protolabs or similar), while internally, members should have streamlined access to client leads, shared infrastructure and capabilities from other participants, facilitating interoperability and vertical integration, and financing mechanisms.

One of the most valuable transferable assets from adjacent industries is the specialized R&D workforce from the medtech and semiconductor industry. The manufacturing component is already present and scaling within the cluster, but the absence of R&D activity (highlighted in the CRAC interview) remains a critical gap. This talent pool is highly transferable to the space industry. OST serves as a strong example, given its team composition of engineers originating from medtech and semiconductor backgrounds.

University laboratories (e.g., SETEC Lab) are the most likely actors to serve as prototyping, testing and validation hubs in the short term, providing early contact with the sector to cultivate a skilled workforce that transitions into industry roles upon graduation with a more useful set of skills. Nonetheless, it is crucial for these academic laboratories to actively engage with the industry to ensure that research and development efforts are aligned with industry needs and contribute to tangible commercial outcomes. More efforts should be made for developing testing and validation capabilities commonly used by the industry (e.g., standard vibration, vacuum, thermal testing platforms) and avoid going for niche areas that could be left unused. This approach is further reinforced by the fact that the sector operates under mixed-volume or low-volume production conditions, making it is difficult for a single company to justify acquiring highly specialized and costly manufacturing and testing equipment, as there is a significant risk of failing to achieve the necessary return on investment within an acceptable timeframe. Shared infrastructure presents a viable method for de-risking technology development, specially for OEMs.

Overall, what is missing from the cluster to enter the space sector are companies capable of linking the local supply chain to sector-specific products (OEMs and Tier-1), as well as key validation infrastructure, as the rest of the capacity is mostly present. A flagship illustration of the current capability is Establishment Labs, founded in Costa Rica in 2004, headquartered in the Coyol Free Zone, which evolved from a local startup into a listed multinational. The firm opened the Sulayom Innovation Campus in 2023 to expand manufacturing, R&D, training, and medical education, followed by commercial launches in major markets (including the U.S. and China) and continued revenue growth in 2025 [49], [50]. Establishment Labs' trajectory in R&D, regulatory clearance, global commercialization, and scale manufacturing from Costa Rica demonstrates that the country's ecosystem can incubate home-grown firms to world-class standards, not merely host foreign subsidiaries. For decision makers in the CRAC and the nascent space sector, the key point is translational capacity, as the very institutions, labor pipelines, and compliance disciplines that allowed medtech to scale are directly reusable for aeronautics/space suppliers.

V. Conclusion & Recommended Actions

The following recommended actions are aimed at two simple objectives: reduce friction and reduce risk. This is the whole strategy behind every possible action to take in favor of entering the space sector, as the intent is already in place. Specific business ideas must be developed by companies on a case-by-case basis. For decision makers at the CRAC and the overall aerospace ecosystem, these are the recommended actions on a short-medium and medium-long term basis:

A. Short-medium Term Actions:

1) Launch Startup-tier membership to avoid losing membership.

2) Gauge and aggregate demand for test and validation capabilities. Start coordinating with universities for implementation.

3) Plan for increased presence in space-related events. Map and reach out to diaspora networks to increase credibility and client connection.

4) Develop a fast-track program for subsidiary and reseller access to reduce contracting friction.

5) Gauge government interest, initiatives and current services provided on the downstream services sector. Evaluate license/data sharing feasibility.

6) Start hosting investor workshops focused on space technologies to increase technical knowledge and awareness, introduce de-risking strategies to increase VC funding.

7) Evaluate the feasibility of implementing/adapting an already existing space law framework from other jurisdictions to speed-up the legislative process.

B. Medium-long Term Actions:

1) Land an anchor client operation (OEM or Tier-1) to catalyze sector development and supplier upgrading.

2) Establish a specialized test and validation center as shared infrastructure.

3) Deploy a booking system for shared infrastructure together with a centralized manufacturing quoting portal for quick lead follow-up and reduced client friction.

4) Launch a Seed Fund or VC branch operated by the cluster. Facilitate access to services from member companies to promote vertical integration and increase demand.

Increasing hierarchical redundancy by appointing a deputy manager and ensuring continuity of operations is also recommended, but out of the scope of this research.

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