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Meeting Growth Challenges of Mexico Aerospace: The Querétaro Cluster

Mónica Casalet

Growing the Aerospace sector in Mexico requires multilevel agreement between original equipment manufacturers (OEMs), including foreign companies, and national and sub-national governments to stimulate programs and instruments for sector growth. In addition, space for local learning must be cultivated within a process of production organized hierarchically and highly regulated on the international level. The case of the Queretaro cluster is important due to the density of networks created, extensive public-private collaboration, and the emergence of specialized institutions to train and shape highly skilled (professionals and technicians) in the aerospace industry. Ultimately, there remains an important vacuum to fill in the future, in particular, integration of Mexican small and medium-size enterprises (SMEs) in the international value chain of the sector.

High technology in the design and manufacture of products within the aerospace industry (AI), combined with international certification, encourages centralized management and close business-government relationships for companies looking to compete in the global economy.[1] Domestic concentration of the industry is very high; in every subsector there are but few competitors. Aeronautics and astronautics demand heavy investment up front and are characterized by exceptionally long production cycles. Financing product development is a critical factor for companies' success, which affects not only small suppliers but also the big contractors, although the latter have more possibilities to share risks and costs.

From the beginning, AI has been considered strategic by national governments, especially with frequent and close interdependence between the industry's civil and defense markets, where state support and market protection have functioned as instruments for organization and financing. Widespread national efforts to maintain technological development and the role of high salaries for attracting specialized human capital lead to globalization of the sector: new emerging countries line up to make an incursion as manufacturers or as assemblers along the AI value chain. Evolution of the global aerospace industry has become a kind of microcosm for understanding the national politics behind strategic international development. In emerging markets as well as industrialized countries, the aerospace sector is supported by government strategies, which have nurtured strong commercial support (on quality, price, and service) to sustain this industry.

Expanding attention towards emerging markets for both aerospace products and services represents a growth opportunity for the sector globally as well as emerging countries. New national players in the sector have become conversant in specialized production processes involving multidisciplinary discoveries; an accelerated innovation process facilitated by novel management methods; and multisector spillover applications available in general platforms.[2] Advanced manufacturing within industrialized countries contributed to a global paradigm for AI in the organization of production and institutional structure. This triggered multiple political strategies oriented towards the development of R+D programs and reinforcing approval of public funds to stimulate research—in close collaboration with productive sectors—all while increasing industrial competitiveness.

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[1] Mónica Casalet is a member of the Facultad Latinoamericana de Ciencias Sociales – FLACSO, México.

[2] Roco, M., W. S. Bainbridge, and B. Whitesides, "Convergence of Knowledge, Technology and Society," *Science Policy Reports,* 2013.

Among other things, aerospace research drove applications of new models with a high percentage of composite materials for fuel efficiency and lower maintenance costs, and engine innovation to diminish noise, fuel consumption, and carbon emissions. At the same time, institutional structure became dynamic with new modes of professional and technical training to guarantee the acquisition of better skilled labor, which raised qualifications across a broad range of workers and managers, as well as tapped into professional experience from retired professional personnel in developed countries with an aerospace tradition.

Construction of complex multilevel networks intertwined domestic technology in emerging regions like Latin America with the global production chain. As these networks continue to expand and deepen, emerging countries are playing an increasingly important economic role because of the opportunities they offer AI with respect to established companies, at home and abroad, as well as a growing number of small, highly innovative enterprises.[3]

DEVELOPMENT OF THE AEROSPACE SECTOR IN MEXICO

In various policy studies completed by public and private institutions within Mexico such as the "road maps," which arose to orient growth of the sector, the name, aerospace industry, was adopted even prior to growth of Mexico's aerospace production or sales.[4] The single label for the sector conceals differences in growth and consolidation among industries, including how close each has approached international technological standards and concentration of sales around a single product or platform. The structure of knowledge networks, for example, prevailing in the aeronautics versus space sub-sectors is quite distinct, the space industry being linked more with knowledge based on science while aeronautics tends toward knowledge in engineering and new materials.[5] In spite of these differences, the rapid growth of the *aeronautical* industry in Mexico contributed to sophistication of the demand for commercial space products and services, boosting the growth and institutionalization of the *space* sector.[6] The goal of this essay is to identify the advantages that AI clusters operating at the sectoral and regional level generate for Mexico's development.

In 2003, the Ministry of Economy decided to invest in the development of the *aerospace sector* in Mexico, launching a strategy to attract international companies and to facilitate their location in Mexican regions with productive and entrepreneurial maturity. The National Program for Trailblazing Companies boosted by ProMexico sought in conjunction with the Ministry's outreach to develop productive clusters

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[3] In much of Latin America PME stands for *pequeña y mediana empresa* (small and medium enterprise); as in the United States, it represents a business sector with high potential for job growth and innovation, contingent upon effective public policies.

[4] The map for the technological route of AI in Mexico, was elaborated by a group of public and private organizations—ProMéxico, Consejo Nacional de Ciencia y Técnologia (Conacyt) (National Council for Science and Technology), Secretaria de Economia (SE) (Ministry of Economy), Dirección General de Aviación Civil (DGAC) (General Direction of Aviation), Federación Mexicana de la Industria Aeroespacial (FEMIA) (Mexican Federation of the Aerospace Industry), Consejo Mexicano de Educación Aeroespacial (COMEA) (Mexican Council of Aerospace Education) and Fundación Mexico-Estados Unidos para la Ciencia (FUMEC) (U.S.-Mexico Foundation for Science). Casalet, Mónica, "Chapter III-Actores Y Redes Públicas Y Privadas En El Desarrollo Del Sector Aeroespacial Internacional Y Nacional: el Clúster De Querétaro, Una Oportunidad Regional (Public and Private Actors and Networks in the Development of the National and International Aerospace Sector: the Queretaro Cluster)." *La Industria Aeroespacial. Complejidad Productiva E Institucional (The Aerospace Industry. Productive and Institutional Complexity)* (D.F., Mexico: FLACSO and Conacyt, April 2013), p. 105.

[5] Broekel, Tom, and Ron Boschma, "Aviation, Space or Aerospace? Exploring the Knowledge Networks of Two Industries in the Netherlands," *European Planning Studies* Vol. 19, No. 7 (December 2010): 1205-1227.

[6] In 2010 the Agencia Espacial Mexicana (AEM) (Mexican Space Agency) was created to guide the formation and research of the sector, and orient the formation of public-private consortiums.

of aerospace firms specifically at the state level within (federal) Mexico and linked to the world market. The arrival of investments from Canada, France, and Spain created opportunities for Mexican businesses to raise revenue and ascend the sector production chain, stimulating the income of Mexican companies. The installation in the country of world class companies such as Honeywell, Bombardier, Grupo Safran, EADS, and ITP complemented aerospace sector development policies of the national and state governments; this was especially true with respect to industrial groupings in central and northern regions. The modern Mexico Aerospace sector is now formed by companies dedicated to manufacturing, maintenance, engineering repair, design, and auxiliary services.[7] In the most recent data by ProMexico (2013), the sector registered a growth of 17.2% per year since 2004. Nowadays there are 287 companies. 28% are big companies; 43% correspond to medium-sized companies; and 29% to small and micro-businesses.

Although there is interest from companies in acquiring certification (according to international standards such as the 9100 Series), which is necessary to access the global chain of production, not all companies have this seal for quality management of systems in the aerospace sector. The AS9100 standard includes addendums for approval and handling of suppliers. The NADCAP norms managed by the Performance Review Institute (PRI) control special processes and products, besides promoting continuous improvement in industries like automobiles and aerospace. Not all Mexican companies with possibilities of participating in the chain of production have the conditions or interest, or find a viable niche in the aerospace sector, even if they have acquired manufacturing experience in the automobile industry.

Entry into the Aerospace sector requires favorable technical and production conditions for reconversion, and certification demands expenses up front for local companies to be part of the chain of suppliers, which presents an important income barrier. At the same time, Mexico subscribed to international agreements such as the Bilateral Air Security Agreement (BASA) and Wassenaar Arrangement in order to guarantee certification, confirm security of processes, and reduce expenses of local companies in the certification of products and labor.[8]

The hope was that participation in these club-like groups would attract new investments, open access to the latest technology, and increase exports. National and entrepreneurial agencies estimated the number of jobs generated at more than 31,000 professionals. The level of Mexico's exports in 2012 rose to 5.04 billion USD, with 76% of production exported to the United States. According to data from the U.S. Department of Commerce, in 2009 Mexico supplied products for the Aerospace sector in the value of 604 million USD, marking 127% growth compared to 2006.[9] Secondary destinations for exports mapped to Germany and France, then Canada and the United

[7] Secretaría de Economía (Ministry of Economy), *Sector Aeroespacial Mexicano (Mexican Aerospace Sector),* 2011.

[8] The accepted worldwide standard for the aerospace industry is the 9100 Series. Its application is decisive for entering the supply chain of parts and components. The 9100 Series is a model for quality management systems in the Aerospace sector based on the standard ISO 9001:2000 guideline. Its implementation is under the International Aerospace Quality Group (IAQG), which is under the Society of Automotive Engineers (SAE). This guideline emphasizes quality, security, and technology in all stages of the supply chain and is applied in all aspects both military and civilian. SE-DGIPAT, 2012 (Economy Ministry – Heavy Industry and High Technology General Directorate).
In the case of the Aerospace sector, NADCAP (National Aerospace & Defense Contractors Accreditation Program) certification is required by the main manufacturers of motors and planes for the entire network of suppliers. Obtaining NADCAP certification exempts the company from other audits by manufacturers that recognize it (SE-DGIPAT, 2012).
In 2012 Mexico joined the Wassenaar Arrangement (WA). This has two fundamental implications. One is that Mexico adheres to the non-proliferation of conventional arms; the other is it joins the club of high technology countries, which allows it access to new markets and technology. WA membership improves competitiveness and attracts investment from different sectors.

[8] SE, 2011. U.S. Department of Commerce, Bureau of the Census, 2009.

Kingdom. Meanwhile, imports for the same year were a healthy 4.36 billion USD. In 2012, investment in the sector rose to 1.3 billion USD, totaling more than 4 billion USD over the last four years.[10]

Of the strategic pillars of development for the Mexican Aerospace sector, the northeast region (Baja California, Sonora, Chihuahua) stands out: It includes more than half of the national industry specialized in electric-electronic systems and boasts a regional niche in avionics. Meanwhile the central-northern region (Mexico City, Queretaro, and Nuevo Leon) specializes in the assembly of value-added components, located near the main airports of the country, as well as repairs and maintenance of aircraft.[11] More detailed information on aerospace clusters forming in Mexico after the government's economic policy initiatives of 2003 is displayed in Table I, below.

MEXICO AEROSPACE: TOWARD A NEW MODEL OF GOVERNANCE BASED ON INTER-INSTITUTIONAL COLLABORATION

In the creation of productive aerospace clusters across different industrialized countries, a distinct geographic space draws companies, suppliers, research centers, and professional and technical training institutes, together with support undertaken by national and sub-national governments. Intermediary organizations link the various elements of an aerospace cluster, building a mutual field of influence, the strength of which depends upon the density of established links connecting production, research, and training of specialized labor. In Mexico's case, despite a decade of policy efforts to develop the Aerospace sector, the public-private framework is still incipient. Strong microeconomic differences place barriers to learning among companies; some do not have the minimum competitive thresholds to take advantage of positive externalities cultivated by government. Again, from the mid-2000s, public institutions, entrepreneurial partnerships, and state governments promoted technology development and constructive competition, looking to combine relationships of cooperative partnership and market incentives to support the Aerospace sector. In this context, the needs of state and local companies are served when they acquire new knowledge and become part of a high-technology system of production; international companies meanwhile seek new investment opportunities with lower costs of production and competent labor, not to mention the incentive of having the American market close by.

The line of action of public policies since 2003 has been oriented towards mobilizing new instruments created and executed by the 'Secretaria de Economía' (SE) (Ministry of Economy); Conacyt; NAFIN; and Pro Mexico. Meanwhile, international organizations such as BID (Inter-American Development Bank); the OCDE (Organization for Economic Cooperation and Development); and PNUD (UN Development Program) promoted upgrades in production standards, supported decentralization and competition among financial sources for creation of aerospace clusters, and stimulated training of specialized engineers in the sector.

The foresight, at both public and private levels, to plan the growth of a sector, rather than a single firm anointed as aerospace champion for Mexico, was remarkable, perhaps unprecedented in the country's development strategy. Apart from sparking collaboration on framing challenges and determining priorities for the regions among public and private actors, universities, and public research centers, a new, dynamic market for intermediary organizations was created.[12] On the state and sectoral levels this new breed of firm thrived in the interstices between traditional companies, supplying communication channels and negotiating structures to new-style members of the aerospace network-cluster: universities,

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[9] Secretaría de Economía (Ministry of Economy), *Industria Aeronáutica en México (Aeronautical Industry in Mexico),* 2012.

[10] FEMIA, Secretaría de Economía (Ministry of Economy), *Pro-Aéreo 2012-2020 Programa Estratégico de la Industria Aeroespacial (Strategic Program of the Aerospace Industry),* 2012, pp. 99.

[12] Examples include business chambers such as FEMIA, CANIETI, and other linking institutions such as FUMEC.

technology centers, and government officials. In linking the scientific community with the public and private sectors, they performed relationship-building functions that substituted and in some cases surpassed the old efforts of government offices for knowledge transfer.

Table II (below) flows from the Mexican government's strategic decision to construct a structure of governance at the Aerospace sector level that would nurture fundamental networks of collaboration, research, training, and investment. Subsequent public policies mobilized private sector investment across several dimensions (connectivity, collaboration for training and research, financial resources, specialization of small and medium enterprises in supplier development programs) to sustain creation of productive groupings within the sector.

Governmental attention shifted toward collective strategies of intervention that could exploit certain advantages for sector growth: improved standards for competition, targets for critical mass within a cluster, increased R&D to consolidate investment on regional priorities, and preferential tariffs for importing and exporting of goods. Assembly thereby encouraged in Mexico included aircraft, components, machinery, and equipment. The structure of incentives also influenced the location of OEMs and foreign direct investment (industrial parks, improved airport runways to receive heavy airplanes, a loading and passenger terminal, an interior customs house, and the fiscal precinct).

Application of these incentives was sustained by public resources and the contribution of large international integrating companies anchoring the clusters. "Brick and mortar" articulation of sector infrastructure indirectly affected mainstream operations. New paradigms of knowledge, advanced manufacturing, and diffusion of information technologies revealed the next rung of novel challenges in processes of production and in cognitive abilities for workers as well as managers: these are non-trivial problems to resolve in order to expand complex production environments with multidisciplinary platforms.

In general, macro-, meso- and micro-complexity will increase in a fractal pattern so that barriers to production do not get easier as one scales down to subcontractors or even divisions within firms. The need for appropriate state intervention to develop synergies and organize priorities around a vision of educational, relational, and productive growth has been greater than it first appeared from a macro perspective. An example of this complexity would be the sectoral change contingent on transformations in the management of universities to adapt to challenges of knowledge transfer, such as incentivizing progress of research groups toward commercialization of new technology in the Aerospace sector once there is an integrated overall vision linking ICT policies with industrial, educational, and research activity.

AN AEROSPACE CLUSTER WITH HIGH-DENSITY INSTITUTIONAL NETWORKS

In the state of Queretaro, which has experienced robust industrial growth, traditional sectors like the manufacture of parts and metal components coexist with sectors that have greater technological intensity like automobile and electronics manufacturing, specialized chemicals, and food biotechnology.[13]

[13] The state of Queretaro, located in the center of the country, has a total population of 1,827,937, of which 70% reside in urban areas; in 2012-13 it had an education average of 9.2, above the national average of 8.9, and a low rate of illiteracy (5.5%) compared to the national total (6.1%), according to figures from the Instituto Nacional de Estadística y Geografía (INEGI) (National Institute of Statistics and Geography). The value of Queretaro's exports reached an amount of 7.4 billion USD, which represented 2.3% of national GDP; the manufacturing industry stood out as the main activity, and the subsector with the most participation was manufacturing of transport equipment, which represented 54% of manufactured exports (Ministry of Economy, 2012). See also, Daniel Villavicencio, Juana Hernández, and Leonardo Souza, "Capacidades y oportunidades para el desarrollo de la industria aeronáutica en Querétaro- (Capacities and opportunities for development of the aeronautical industry in Queretaro), in Casalet M, *La Industria Aeroespacial. Complejidad Productiva e Institucional (The Aerospace Industry. Productive and Institutional Complexity)* (DF, Mexico: FLACSO and Conacyt, April 2013), pp. 49-92.

The Queretaro State Development Plan, as well as its S&T program established the Aerospace sector as a priority for state development together with the automobile sector. Both sectors received government support through productivity and financial incentives. The prior establishment and high performance record of the Mexican automobile industry provided a solid foundation for development of the Aerospace sector, for it trained engineers and accelerated the pace of industrial production.[14]

Queretaro concentrates production on products and machining processes of complex components, manufacturing of aero-structures, manufacturing of components for engines, manufacturing of brake systems, MRO (maintenance, repair and overhaul) for propulsion engines, manufacturing of landing gear and MRO, and technical treatment and manufacturing of components for complex materials.

In order to stimulate high-tech entrepreneurship, the State of Queretaro set aside the Fund for Competitiveness of SMEs (Ministry of Sustainable Development, 2009); sponsored programs previously mentioned, including ISO 9000 certification, that fostered development of small and medium enterprises; and granted specialized consulting and coaching for business. To maintain the ISO 9000 standards, for example, Queretaro state government still covers 33% of the financial cost; the federal administration contributes another 33%; and the rest is paid by the company that wishes to obtain certification (Council of Science and Technology of the State of Queretaro, 2010).

Relationships with educational institutions are another pillar for consolidation of the aerospace cluster in Queretaro, for those understandings result in a reliable and less expensive supply of qualified labor (technicians, engineers, IT personnel), essential for foreign investors, especially companies that initially demanded coaching or training of Mexico's technicians outside the country. Diversity is manifest in the integration of local companies into development programs of global suppliers. Most local companies first enter AI at a competitive disadvantage in terms of investment capital, infrastructure, and a critical mass of skilled labor to attend the demands of this high-tech market; these deficits present formidable obstacles to fulfilling production deadlines according to international demand and to the new entrants' long-term survival.

Thickening of innovation networks manifests in frequent collaboration between universities, public research centers (PRCs), and companies of the Aerospace sector, which gradually strengthens bonds of trust – building social capital and facilitating acquisition and transfer of new knowledge (Table III, below). The use of diverse channels for knowledge transfer presents peculiarities and, again, added complexity.

Among the most significant challenges are the sheer number of component parts and the technology level of tools for design and assembly. Intriguingly, financial consulting; worker training; information technology; and commercialization support – all with integration of local suppliers – plus linkages of research groups and experienced international partners in exchanges with industry, these opportunities have evolved in some cases from informal relationships based on academic interest of researchers to formal agreements that resolve incentives for long-term, institutionalized transactions.[15]

Market entry of Mexican systems and subsystems supply for transnational AI companies has occurred, and these phenomena are tied to dynamic global value chains on an international scale. Where the geographic proximity of the American market plays a determining role, transport and time costs are reduced; benefits provided by NAFTA and innumerable incentives offered by state and national governments for sector growth also have an impact.

Engineering and manufacturing companies that make up the aerospace cluster in Queretaro actively participate and receive counseling in state

[14] This was included among the *top ten* best producers in the world, putting together 2,261,000 vehicles from January to December 2010.

[15] Casalet, 2013, p. 94.

programs. They also maintain good communication with local research centers (e.g., Ciateq, Cidesi, Cideteq and especially with UNAQ), and most of them have asked for support from national innovation programs within Conacyt (National S&T Council).

The development structure for suppliers has not had the same success however. On one hand, there are not enough trained personnel. Despite having multiple institutions working on it, many potential supply companies from the aerospace value chain do not have appropriate certification, due to the investment costs and trained personnel required up front. In this sense, Mexico is still remote from the market interactions of competitive countries.

Brazilian aerospace companies, for example, receive à *la carte* credits from the Banca de Desarrollo (BNDES) (Development Bank) while smaller companies from Mexico do not have the technological, financial, or managerial capacities to qualify for loans as viable risk partners.[16] Figure 1, below, depicts the ecology of an important support network created with a governmental eye toward specialized worker training, research, and knowledge transfer. This AI network, with its potential for cultivating information exchanges and new products, is a sign of commitment from both state and private actors. It carries the hopes in some sense for future foreign investment and consolidation of the Aerospace sector in Queretaro, Mexico.

FINAL REFLECTIONS

In this work, the efforts of different agents to incorporate and expand the Aerospace sector (AI) in Mexico have been identified. In elaborating this complex web of interests and dynamics among participating actors, two basic claims have been made:

1) On one hand, the process of production and organizational management in AI, which determines the level of international competitiveness reached, has been characterized by mergers, new acquisitions, and continuous international engagement to maintain competitive advantages. In the Aerospace sector, the local entrepreneurial network of suppliers links through an assembler that operates as *leading company* and establishes vital connections to the outside world. This sector leader organization in Mexico allowed companies to enter the aerospace business at multiple access points along the global value chain.

2) On the other hand, the case of Mexico, especially in the state of Queretaro, shows how *national and state policies* combine with the efforts of small companies and larger businesses to create favorable conditions for development and growth of the Aerospace sector, articulating effective networks to link with research and specialized training that can meet international standards.

ProMexico and the Ministry of Economy played an important role as trailblazers of specialized demand, promoting the insertion of anchor companies in a sector of strategic importance for the country. Conacyt, through various national programs, has strived to strengthen the demand for knowledge, together with state-level institutions (UNAQ, CEDIA) and Public Research Centers (Cidesi, Ciateq, Cideteq,CIAT) that, in addition to supporting joint public-private research projects, provided training for highly qualified personnel in AI.

Changes in the design of public policies can support new strategies to promote priority sectors. In the case of Aerospace, ProMexico's studies transcended the macroeconomic dimension, for they included programs and proactive incentives to generate changes in the structural nature of institutions, in the behavior of companies, and in the scientific community. This expanded scope of activity for public policy was nevertheless anchored around strategic objectives:

[16] Flor Brown and Lilia Dominguez-Villalobos, "¿Tiene la industria aeronáutica mexicana las condiciones para integrarse a la cadena de valor internacional de alto valor agregado? (Does the Mexican aeronautical industry have the conditions to become part of the international value chain of high added value?)." In Casalet Monica, *La Industria Aeroespacial. Complejidad Productiva E Institucional (The Aerospace Industry. Productive and Institutional Complexity)*. (DF, Mexico: FLACSO and Conacyt, April 2013), pp. 135-162.

1) Establishing growth priorities in productive sectors.
2) Promoting the proliferation of public-private networks of collaboration on a regional and sectoral level, stimulating the formation of industrial clusters.

3) Favoring the mobility of post-graduate students and researchers in companies within priority sectors such as Aerospace.

4) Generating public support to increase capacity of companies to innovate, improve productivity and quality, and restructure *networks* for transforming educational institutions, public research centers, and technology institutes.

The preliminary success of these initiatives indicates that across-the-board, broad brush policies are not sufficient. Selective policies are necessary, oriented towards defining a specialization profile, or niche, across the global value chain of a high-tech industrial sector. Despite progress in the creation of public programs to support Mexico Aerospace, obstacles persist in systematization of information on results ("sector assessment"), and on the effectiveness of communication and collaboration initiated between companies and specialized researchers.

Improved coordination implies strategic action for the future growth of Mexico Aerospace that goes beyond current innovations in government policy. In this vein, two policy objectives are fundamental: ensuring financial resources for incorporation of local suppliers, and strengthening management of specialized knowledge. For these, it is necessary to have more information to track the different stages of various regional concentrations in AI; the needs for leading companies in each region; and the coincidence among national and regional policies for integrating local suppliers into the global value chain.

Systematized data is lacking to design a comprehensive strategy that fully integrates private companies; the public sector; linked intermediate institutions; educational institutions; and public-private research centers. Such an information-intensive strategy could prove indispensable to diverse actors within the AI support network for resolving specific problems posed by the Aerospace sector in Mexico – and for capturing any lessons beneficial to the cause of international development in general.

Selected References:

Broekel, Tom and Ron Boschma. "Aviation, Space or Aerospace? Exploring the Knowledge Networks of Two Industries in the Netherlands." *European Planning Studies* Vol. 19, No. 7 (December 2010): 1205-1227.

Brown Flor and Lilia Dominguez-Villalobos, "¿Tiene la industria aeronáutica mexicana las condiciones para integrarse a la cadena de valor internacional de alto valor agregado? (Does the Mexican aeronautical industry have the conditions to become part of the international value chain of high added value?)." In Casalet Monica, *La Industria Aeroespacial. Complejidad Productiva E Institucional (The Aerospace Industry. Productive and Institutional Complexity)*. DF, Mexico: FLACSO and Conacyt, April 2013, pp. 135-162.

Chapter III- Actores Y Redes Públicas Y Privadas En El Desarrollo Del Sector Aeroespacial Internacional Y Nacional: el Clúster De Querétaro, Una Oportunidad Regional (Public and Private Actors and Networks In the Development of the National and International Aerospace Sector: the Queretaro Cluster)." *La Industria Aeroespacial. Complejidad Productiva E Institucional (The Aerospace Industry. Productive and Institutional Complexity)*. DF, Mexico: FLACSO and Conacyt, April 2013, p. 105.

FEMIA, Secretaría de Economía (Ministry of Economy), *Pro-Aéreo 2012-2020 Programa Estratégico de la Industria Aeroespacial (Strategic Program of the Aerospace Industry),* 2012, pp. 99.

Roco, M., W. S. Bainbridge, B. Whitesides, "Convergence of Knowledge, Technology and Society," *Science Policy Reports,* 2013.

SE, 2011. U.S. Department of Commerce, Bureau of the Census, 2009.

Secretaría de Economía (Ministry of Economy), *Industria Aeronáutica en México (Aeronautical Industry in Mexico),* 2012.

Secretaría de Economía (Ministry of Economy), *Sector Aeroespacial Mexicano (Mexican Aerospace Sector),* 2011.

Villavicencio Daniel, Juana Hernández and Leonardo Souza, "Capacidades y oportunidades para el desarrollo de la industria aeronáutica en Querétaro (Capacities and opportunities for development of the aeronautical industry in Queretaro." In Casalet, Monica, *La Industria Aeroespacial. Complejidad Productiva E Institucional (The Aerospace Industry. Productive and Institutional Complexity)*. DF, Mexico: FLACSO and Conacyt, April 2013, pp. 49-92.

TABLE I: M*ain Aerospace Clusters in Mexico*[1]

MAIN CLUSTERS	SPECIALTY	MAIN PLAYERS
In Baja California • Mexicali • Tecate • Tijuana	Electric-Electronic Parts manufacturing.	51 companies among which these stand out: • Honeywell • Gulfstream Interiores Aéreos (Air Interiors)
In Chihuahua: • Chihuahua • Ciudad Juarez	Manufacturing of parts and fuselages, electric-electronic, mechanized interiors.	28 companies among which these stand out: • Labinal, de Grupo Safran • Cessna Aircraft • Textron International • Grupo American Industries
In Queretaro • Queretaro	Manufacturing of motor components and landing gear. Assembly of components and airplane fuselages, MRO.	32 companies among which these stand out: • Bombardier • ITP Ingeniería y Fabricación. • SNECMA, from Grupo Safran • GE-IQ • Aernova
In Sonora • Hermosillo • Guaymas • Ciudad Obregon	Manufacturing of components for motors and turbines, fuselage and composite materials.	43 companies among which these stand out: • Goodrich Aerostructures of Mexico • ESCO
In Nuevo Leon • Apodaca • Monterrey • Santa Catarina	Forging and machining, manufacturing of components, assembly of fuselages for helicopters.	29 companies among which these stand out: • Frisa Forjados • MD Helicopters.

[1] Secretaría de Economía (Ministry of Economy), Dirección General de Industrias Pesadas y de Alta Tecnología (General Management of Heavy Industries and High Technology), *Industria Aeronáutica en México (Aeronautical Industry in Mexico),* June 2011, pp. 54.

TABLE II: ***Institutional Framework for Strengthening Mexico Aerospace***[2]

PUBLIC AGENTS	PROGRAM	PRINCIPAL ACTIONS
National/Civil Bodies Ministry of Economy	Sectoral program 2007-2012	Formation of productive chains; Company partnerships; Supply creation; Technological export and reconversion of sectors; Company boosting; Factors
	SME (small and medium sized companies) fund.	Financing. Company management. Technological innovation. Training. Commercialization. Strengthen value chains in Mexico. Link suppliers with supplies in global chains. Increase national supply and exports.
ProMexico.	Productive linking program. National Program for Trailblazing Companies. Alliance model with transnational companies.	Applied in multiple automobile and aeronautical companies. Initiatives to generate prospective studies of industrial sectors.
Dirección General de Aviación Civil (DGAC) (General Management of Civil Aviation), assigned to the Ministry of Communication and Transport.	Aeronautical authority. 1950 first regulations for civil aircraft; Regulation for Aeronautical Telecommunications and Radio Asst.; Regulation for Search and Salvage. 1952 Mexico signed an agreement with the ICAO. Supervises daily operations of the sector.	Verify aeronautical and airport security measures (Safety and Security). Guard airports, issue permits, authorizations, licenses and certificates to air transport companies. Compile information and statistics about air transport.
Conacyt. (National S&T Council).	Programa Estímulos a la innovación (PEI) (Innovation Stimulus Program). Innova SME programs. Pro Innova. Innovatec.	Financial support programs for big companies, SMEs and C.P.I.(Engineering Preparatory Courses) to generate jobs linked to innovation. Support for aerospace and aeronautical sectors.

[2] Based on author interviews and analysis of documents from said institutions.

PUBLIC AGENTS	PROGRAM	PRINCIPAL ACTIONS
	Alianzas estratégicas de redes de innovación para la competitividad (AERIS) (Strategic alliances of networks of innovation for competitiveness).This program ended but it was important to boost the formation of aerospace clusters.	Interinstitutional coordination to stimulate innovation networks. Prospective and market studies.
	Thematic networks.	Exchange platform between researchers, entrepreneurs and the public sector.
	Red Temática de Conocimientos Tecnológicos Espaciales (RTCTE) (Thematic Network for Technological Space Knowledge).	Competitiveness of the mexican aerospace industry UNAM, IPN, Ciateq, Cicese, UABC, INAOE, Global Star Mexico, Satmex, AMC, Cinvestav (Guadalajara).
Agencia Espacial Mexicana (AEM) (Mexican Space Agency)	Law created in 2010	Construction of a work agenda with public and private actors and academics in order to elaborate a state policy in the matter of space, for training, scientific research and space development.
Consejo Mexicano de Educación Aeroespacial (Comea) (Mexican Council of Aerospace Education), autonomous academic body, created in 2007.	1st national academic research network linked with the aerospace sector.	Analysis of the aerospace industry. Determine professional competitiveness. Program for joint updating and training (Comea and Femia).
International Bodies (PNUD) Mexico	Program for supplier development.	Methodology to reduce the learning curve and generate a greater impact in the training of human resources.
	Special processes certification program.	SME integration into the aerospace, automobile, electric and electronic sectors.
	Collaboration agreement with the Programa Integral de Apoyo a las Pymes (Piapyme) (Integral Support Program for SMEs) Mexico-European Union.	Mexican SMEs and European companies collaboration, aerospace sector jointly with Femia. Certification of space processes for SMEs. Nadcap standards, SAE, AS9100.
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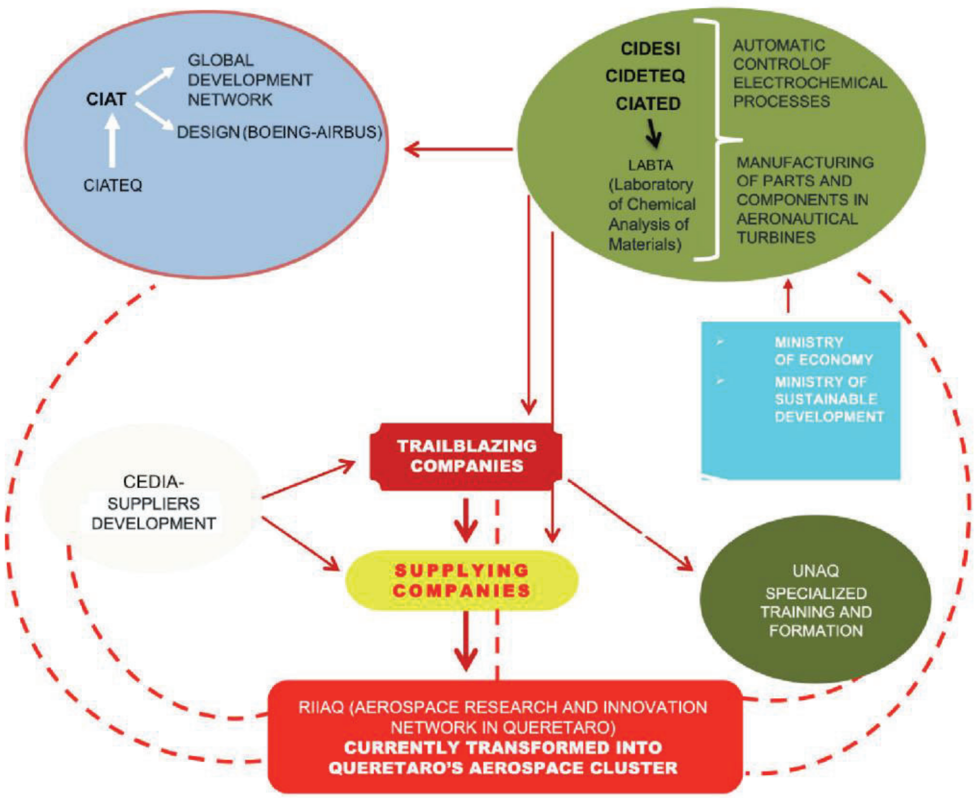
PUBLIC AGENTS	PROGRAM	PRINCIPAL ACTIONS
Entrepreneurial bodies with public/private action.		
Federación Mexicana de la Industria Aeroespacial (Femia) (Mexican Federation for the Aerospace Industry), non-profit civil partnership (2007).	Establish a strategic national aerospace plan. Support integration of the national aerospace industry. Obtain incentives and tariffs for aerospace products. Events and seminars.	Products for maintenance and manufacture. Analysis of legislative trends in the matter. Diagnosis of the sector on an international and national level. Lobbying to organize a sole government agency in charge of acquisitions in the sector.
Intermediate organizations with state and national action		
Fundación México-Estados Unidos para la Ciencia (Fumec)(U.S.-Mexico Foundation for Science.	Programs in emerging niches with high potential.	Support for the aerospace sector: Diagnosis of strengths and opportunities. Financial advice to link companies with investments. Consultancy to advice an international business – ICT, financial plans and manufacturing. Linking with TechBa for business units in Seattle and Montreal.
	TechBa – Business accelerator program (SE) (Ministry of Economy).	TechBa is installed in highly competitive strategic environments: Silicon Valley, Austria, Montreal, Madrid, Michigan, Vancouver, Seattle.

TABLE III: ***Trailblazing Companies in the State of Queretaro***[3]

Trailblazing companies	*Principal products*	*Motives for installation in Mexico*	*Competitive opportunity in Queretaro*
Aernova	Aeronautical structures: design, development, certification test, prototypes and active support. Manufacturing of composite and metal parts. Assembly plant. Metal components plant.	Interest in the American aerospace market. Facility in Mexico as part of FTA. Interest in creating a currency mix dollar, euro, peso.	Precedent of commercial relations of the state of Queretaro with the Basque Country's Autonomous Community, where the company is from. Training of workers; some were sent to Spain. Active exchange with Femia. Uses CENAN's test laboratories in Queretaro. Supports training programs from the UNAQ.
Industrias Turborrectores (ITR)	Air transport, engineering, manufacturing and maintenance of gas turbines.	Closeness of Mexico with the United States' market, Mexico's participation in NAFTA, facility to save on tariffs.	Manufacturing of the first static seal T900 motor in Mexico.
Bombardier: three plants	Manufacturing of regional aircraft, executive jets.	Reduction in production costs. Importance of Mexico's participation in the integration of the FTA, with Japan and the EU.	Work was moved from Toronto to Mexico, manufacturing of harnesses and electric systems for Challenger 300, 605, 850, 870, 890 models. Active relationship with the UNAQ. Integrated few direct Mexican suppliers because of certification problems.
Grupo Safran: eight production and maintenance plants in Mexico. Messier Services Messier Dowty Sncema Sames in Queretaro	Aeronautical propulsion and equipping, defense and security. MRO landing gears with machining and treatment. Generation of biofuels.	Interest because of Mexico's participation in NAFTA. Maintenance of Airbus 320 and Boeing 737 components.	Heads French-Mexican campus of aviation. Active participation in the UNAQ.

[3] From author interviews conducted with said companies.

Figure 1: ***Institutional Network Supporting the Aerospace Cluster in Queretaro***[4]



[4] Information provided by Casalet, M. 2013.

The Centro de Ingeniería Avanzada en Turbomáquinas (CIAT) (Center of Advanced Engineering in Turbomachines) began its activities as an engineering services provider for General Electric (GE), specifically assisting two companies that belong to GE—GE Power Systems and GE Aircraft Engines—with design, drawing, engineering, and analysis activities. The CIAT evolved into the biggest and most important aviation engineering center outside the United States, as part of a global network of development centers from GE.

El Centro de Desarrollo de la Industria Aeronáutica (CEDIA) (Development Center of the Aeronautical Industry) depends on the Tecnológico de Monterrey, Queretaro Campus. Among its objectives are development of the aeronautical industry and training of high-level professionals. CEDIA also offers solutions to technical problems for companies that seek to become part of the chain of production in AI.

The Universidad Nacional Aeronáutica de Querétaro (UNAQ) (The National Aeronautical University of Queretaro): Created in 2007 to respond to the needs of highly skilled labor, it has teaching personnel from aerospace companies (OEM, Tier 1) and the support of Public Research Centers such as the Centro de Ingeniería y Desarrollo Industrial (Cidesi) (Center of Industrial Engineering and Development). Oriented towards electronic and advanced manufacturing, the Centro de Investigación y Asistencia Técnica del Estado de Queretaro A.C. (Ciateq) (Technical Research and Assistance Center of the State of Queretaro) offers technical training to companies and technical assistance services specialized in measuring systems, machinery and equipment design, monitoring and control systems, process engineering, and advanced manufacturing. The Centro de Investigación y Desarrollo Tecnológico en Electroquímica (Cideteq) (Center for Technological Research and Development in Electrochemistry) offers accredited services to the industry in chemical analysis, material analysis, and environmental technologies.

Laboratorio de Pruebas y Tecnología Aeronáutica (LaBTA) (Aeronautical Testing and Technology Laboratory): Created jointly by the Cidesi, Ciateq, and Cideteq, it has support from Conacyt and the State of Queretaro to carry out specialized services for aeronautical companies. LabTA offers laboratory services (chemical analysis of materials and composites, physical-chemical and behavior testing in services of composite materials, vibration diagnosis, and noise analysis) and assistance in product development, including design and manufacturing of testing prototypes and devices (design and manufacturing of process and testing equipment; design of metal, polymers, and composite products; design, manufacturing and activation of testing devices: hydraulics, pneumatics, mechanical, and fatigue).

Red de Investigación e Innovación Aeroespacial del Estado de Querétaro (RIIAQ) (Aerospace Research and Innovation Network of the State of Queretaro) emerged in calls by Conacyt to stimulate the formation of alliances between public and private agents in critical areas of knowledge, research, and creation of productive capacities. RIIAQ led to the formation of the Aerospace Cluster in Queretaro financed by OEMs and made up of companies, public research centers, and intermediate companies in Queretaro (Casalet, 2013, op. cit.).