Thesis for the Degree of Master of Management of Technology

Challenges of Latecomer in Complex Product System: The case study on the Indonesian Aircraft Industry

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(복합 제품 시스템에서의 후발주자의 난관: 인도네시아 항공기 산업의 사례)

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Abstract

For latecomer, the development of complex product system (CoPS) is challenging from the perspective of inherent disadvantage in the knowledge base and the lack of resources to develop capabilities necessary for catch-up and growth. Specifically, even if Indonesia tried to nurture the aircraft industry for a long period, it achieved very limited growth in the industry. What are the capabilities necessary to nurture the CoPS for latecomers? Why did Indonesia fail to nurture the aircraft industry? Based on the review on the study of latecomers' catch-up in CoPS, we suggested the four capabilities are necessary conditions for the catch-up, i.e., networking, technology and production, institution and policy leveraging, and market development capability. Interestingly, even if PTDI, Indonesia's the only state-owned aircraft firm, succeeded to develop networking and institution and policy leveraging capabilities, it failed to acquire technology and production capability in terms of self-reliant design and project management in production. Consequently, due to the challenges in technology and production capability, PTDI could not fully nurture market development capability and achieved limited performance. Our findings contribute to the extension of 'CoPS' discussion by achieving analytical generalization of the case study.

복합 제품 시스템에서의 후발주자의 난관:
인도네시아 항공기 산업의 사례

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요약

후발주자를 위해 복잡한 제품 시스템 (CoPS) 개발은 지식 기반의 고유 한 단점과 추격 및 성장에 필요한 역량 개발을 위한 자원 부족의 관점에서 도전적입니다. 특히, 인도네시아가 장기간 항공기 산업 육성을 시도했지만, 산업계의 성장은 매우 제한적이었습니다. 후발주자를 위해 CoPS 를 육성하는 데 필요한 역량은 무엇입니까? 왜 인도네시아는 항공기 산업 육성에 실패 했습니까? 후발주자의 CoPS 연구에 대한 검토를 토대로 4 가지 능력은 추격, 즉 네트워킹, 기술 및 생산, 제도 및 정책 활용 및 시장 개발 역량에 필요한 조건이라고 제안했습니다. 흥미롭게도 인도네시아 유일의 국영 항공기 회사 인 PTDI 가 네트워킹 및 기관 및 정책 활용 역량 개발에 성공 했음에도 불구하고 자체 생산 설계 및 프로젝트 관리 측면에서 기술 및 생산 능력을 확보하지 못했습니다. 결과적으로 기술 및 생산 역량의 문제로 인해 PTDI 는 시장 개발 능력을 충분히 육성하지 못하고 제한된 성과를 달성했습니다. 우리의 발견은 사례 연구의 분석적 일반화를 달성함으로써 'CoPS'토론의 확장에 기여합니다.

I. INTRODUCTION

Complex product system (CoPS) is known as a high cost (value), high customized, engineering-intensive capital goods based on a temporary project or small batch-based production (Hobday, 1998). In this perspective CoPS are challenging to apply for latecomers in terms of CoPS have a greater in-depth knowledge base and higher managerial capability for highly integrated projects (Choung and Hwang, 2007). It is important to latecomer to increase their knowledge and capabilities to developed CoPS in term of to achieve a remarkable competitive advantage in exporting commodity goods. Latecomers' initial weakness also in CoPS highly politicized, market of CoPS, high entry barriers and risks, uncertain and low trade volumes (Milter et all., 1995). The role of government as a policies maker is crucial to develop CoPS in latecomer industry. Many success cases of CoPS studies came from the strong and highly recommended government roles. CoPS Product life cycle of CoPS tends to remain in the fluid phase of product innovation and its rate can remain consistently high (Davies, 1997). In other words, CoPS does not give latecomers a chance to show their abilities in process innovation.

The previous study form Lee and Yoon (2015) discuss the latecomers; technological learning from the perspective that the learning is facilitated by technology acquisition strategies and policy initiatives. They explained the determinants and patterns of technology acquisition modes, in terms of knowledge-base and technology accusation modes and role of foreign partnership and technology acquisition. For the perspective of the role of foreign partnership and technology acquisition, South Korea and Brazil had stable and favorable collaborations with their Western

partners. The main difference between Brazil and South Korea's technology acquisition lies in the fact whereas the former relied on several foreign actors including research institute and universities; the latter was somehow dependent on foreign suppliers. In another side, China into a self-sufficient defense partner. For instance, China purchased Soviet fighters to arrange co-production agreements and resolve technical constraints.

The case study by one of the latecomer' industries (Indonesian Aircraft Industry) known as PT Dirgantara Indonesia (PTDI) that failed in sustained in a CoPS market. This article focuses on the strategies and policies settings to nurture the CoPS industry as a latecomer. Within the latecomer CoPS context, Indonesia aircraft industry is an interesting case, why PTDI do not achieve the global competitiveness in the global market even if PTDI got supported by the Indonesian government for this a whole year.

Before the previous studies explained about Indonesian Aircraft industry, PTDI managerial weakness was not the only obstacle to improved performance at PTDI according to McKendrick (1992). Later on, he explained that PTDI greater competence in skill (both in personal and organizational) which are conceptually distinct from scientific and engineering-based knowledge could have improved PTDI's performance, making it cheaper both to assimilate and adapt new product and process technologies and to adjust to market changes through endogenous technological development. Another study by Hill and Fong (1988) explained that there are three grounds for concern regarding the company's financial performance such as, PTDI has captive domestic market, and the project that PTDI took has lack public accountability as

well as the company's remarkable progress. Goldstein (2002) discussed PTDI achieved quit impressive progress in mastering advanced technical operations and in pool qualified Indonesian technicians and engineers. But, the managerial constrain have greatly reduced the scope for exploiting such technological advanced. Eriksson (2003) also explained the creation of PTDI is an example of how one influential person, in conjunction with the state can play an important role in establishment and development of high-tech aircraft production. Which is work of Dr. Habibie with strong and direct support from former president Suharto. These previous studies gave the present research a strong motivation to dig in to the phenomenon of Indonesia challenges to achieve the global competitiveness in the global market specifically in perspective of CoPS. Though the previous studies show the challenge to PTDI develops their aircraft industry but among these studies did not expalined the complex product system that could be the crucial contrivance of Indonesian aircraft industry to achieve their success.

■ **Specific Problem Identified**

In accordance with the background that has been stated, the writer could conclude that the problem that will be further discuss are about what kind capabilities are needed for latecomers to develop their capabilities in term of CoPS

Research question:

1. What are the capabilities necessary to nurture the CoPS for latecomers?
2. Why did Indonesia fail to nurture the aircraft industry in perspective of CoPS studies?

■ Scope and Limitations

This study only discusses about CoPS for latecomer especially the case of Indonesian aircraft industry. The data had been collect only limited to the aircraft and helicopter production. This study also, derive the capability of CoPS for Indonesian aircraft industry.

■ Research Objectives

The objectives of this thesis are:

1. To derive capabilities that necessary to nurture the CoPS for latecomers
2. To investigate reasons Indonesian aircraft industry was fail in perspective of CoPS
3. To contribute more knowledge in the term of CoPS studies for latecomer industries

II. LITERATURE REVIEW

2.1 Innovation in Complex Product System (CoPS)

The idea of Complex product system (CoPS) has featured in a number of recent studies (Miller et al. 1995; Rycroft and Cash 1999; Hobday, Rush and Tidd 2000). CoPS can be defined as any high-cost. Engineering-intensive product, subsystem, system network, software system, high-technology service, capital good or construct supplied by a unit of production, i.e. a single firm, production unit, group of firms or temporary project-based organization (Davies and Hobday, 2015). The term 'complex' reflects complexity from the perspective of the supplier rather than as perceived by users of the system (Thota and Munir, 2011).

According to Park (2012), he indicates the CoPS innovation pattern is different from mass-produced goods (MPG) in term of product development and market development. He divided into six factors to differentiate in development, innovation process and engagement, product development of components and the degreed of standardization, the predictability of the product design variation, buyer involvement in innovation and market structure. In term of the product development, there are four factors integrated such as the development of CoPS is based on Project-base and multi-firm alliances; in term of the innovation process and engagement CoPS tends to remain in product innovation and large actors are engaged in innovation; in term of components and the degree of standardization. CoPS are high level of unit production cost and not standardized means, many alternatives design routes for particular components may exist; as well as the low predictability of the product

design variation. In the other hands, for market development CoPS is initiate to high degree of buyer involvement in innovation and order-based production; also, the market structure in CoPS is institutionalized or politicized and heavily regulated by the government and small and few transactions.

Choung and Hwang (2007), developed countries have an advantage over NIEs, in the development of CoPS because they have a greater in-depth knowledge base and higher managerial capability for the highly integrated project. Latecomers' initial weakness in CoPS highly politicked market of CoPS, high entry barriers and risky, uncertain and low trade volumes (Miller et al., 1995). Also, Davies in (1997) argue the product life cycle of CoPS tends to remain in the fluid phase of product innovation and its rate can remain consistently high. In other words, CoPS does not give latecomers a chance to show their abilities in process innovation.

Jun (2011) emphasizes two capabilities determine in CoPS the intra-path Integration is the capabilities that determine and combine the knowledge and perspective of firms, government agencies, legal actors and other stakeholders. It is important, during the process of technology commercialization and diffusion, socio-economic factors influence the success of a technology by selecting and directing technological options. The other hand, the Inter-Path Reconfiguration capabilities, it will coordination and aligning a new path with the existing one, directly point out the path of leaders. Later on, Park (2012) suggested the 3 major capabilities for latecomer to require developing CoPS. Networking their capabilities among various actors. Further, the participating firms all need to integrate their capabilities. Also, the buyers are more influential than

suppliers in CoPS; thus, suppliers also require the ability to collaborate closely with buyers. Broad, deep and integrated knowledge and skills. In other words, the high complexity and emergent and unpredictable properties need a board and deep knowledge and skill for understanding CoPS. Lastly, leveraging intuitions and policies. Institutionalized or politicized and heavily regulated or control the market. By that, the actors in CoPS should leverage instructions and policies to be able to foresee future trends.

Kiamehr, Hobday and Kermashah (2013) developed a new framework named Latecomer Systems Integration Capability (LSIC). They divided this framework into 3 constituent part, such as functional LSIC, constructed around the core technical field of systems engineering, design and engineering and services such as training, maintenance and finance required for delivering partially or fully integrated solutions; project LSIC, it conduct of the project management skills required for the management of design, procurement, installation, testing and commissioning activities during a project, permits suppliers to engage with clients to identify and analyze their needs, configure a proposal and secure resource such as finance and subcontractors' capacity as well as the life cycle of complex capital goods project is often extend into provision of some services during the operation; the last part is referred to a collection of attributes required for deciding on the position (strategic focus) in the industry value chain, the extent of outsourcing, choosing partners to work with withdrawing from unattractive markets and gearing capabilities toward new markets. Later, Nagizadeh, Manteghi and Ranga (2016) developed a framework for researching integration of a CoPS project within an innovation network structure and integration

mechanisms as well as integrator capabilities. This provides guidance in studying different aspects of integration in CoPS innovation network, especially in a developing country, by gathering evidence on the integration challenges and tools adopted to solve them, the contextual factors facing the players, especially the integrator, and the available data over time.

According to Davies, et. Al (2011) CoPS research has shown how to enact competitive strategy and branch out in new directions of innovation. To achieve the strategic business, firms should move beyond the traditional discipline and mindset of project management which focusses on operational efficiency. Project are not merely part of operational side of business, they are central to business innovation, capability building and corporate strategy.

According to Park (2012) CoPS innovation pattern is different from mass-produced goods, in term of product development there are four criteria, such as development; innovation process and engagement; components and the degree of standardization and predictability of the product design variation. In term of development, CoPS is project-based multi-firm alliances, means to deal with CoPS project are crucial because have to do collaboration with other alliances and it could implies to the market structure.

In CoPS is designed by project based with multi firms' alliances, so it needs a good collaboration and must works harmoniously each other. Because in CoPS it based on project management, by that latecomers need to deep knowledge and advanced technology to fulfill their success performance. Also, they could fully nurture their market development capability and achieved a better performance.

As mention above, CoPS is very critical to develop, but for latecomers it difficult to catch up with developed countries. By that, this study will explain the challenges for latecomers in CoPS.

2.2 Capabilities for CoPS Accumulation

In this study, we combined various data collection such as, review many kinds of international and domestic paper and journal, elaborate case studies, news and knowledge articles about the Indonesian aircraft industry. We selected about 22 papers and used as a background references for Indonesian case. These 22 papers divided into, 2 papers about Complex Product System (CoPS), 10 papers about Latecomers' CoPS, 4 paper about Aircraft Cases and 6 papers about Indonesian Aircraft Cases.

By summarizing some literatures concerning latecomer in complex product system (CoPS), we derived capabilities for CoPS accumulation as follows, (Table 2-1):

- ***Network Development Capabilities***, Capability to elaborate with networks, project with the other firm alliances to do innovation and production. There are also, government intervention and role of foreign partner that influence the network capabilities. The role of government to supervise the firms to integrate capabilities harmoniously with other firms. Also, the role of foreign partner to improve the technological and productivity
- ***Institution and Policies Leveraging Capabilities***, to enter market is needed a heavily regulated for the market control. Policies by the related instantiations should be leveraging to meet the future trends

- ***Technology Development and Production Capabilities***, Capability in relation to a specific and increasingly important technology development (mastering technology) and increase the productivity performances. To integrated knowledge and skills to deal with high-craft based and project
- ***Market Development Capabilities***, the capabilities to assign the potential customer that have interest to target to sign the contract. Also, the capabilities on penetration market to potential customer that have interest to the products.

<Table 2-1>

Capabilities CoPS Accumulation

Capabilities	Sub-Capabilities	Definition
Network Capabilities	• Integrate and collaborate the capabilities among actors	• Capability to elaborate with networks, project with the other firm alliances to do technology innovation and production. • The role of government to supervise the firms to integrate capabilities harmoniously with other firms • The role of foreign partner to improve the technological and productivity performance

Capabilities	Sub-Capabilities	Definition
Institutional and Policy Capabilities	• Leverage the capability and policies • Policy-making and regulation	• Leverage of institution and policy for entering market, which is highly regulated as well as developing market condition favorable for a firm. • Leverage of institution and policy for transforming business to meet the changing industrial trends
Technology and Production Capabilities	• Engineering and design capability • Advanced research capability • Project management capability	• Integration of knowledge and skills to deal with high-craft and complex project (Project Capability) • Capability in relation to a specific and increasingly important technology development (mastering technology) and increase the productivity performances.
Market Capabilities	• Acquiring new customers • Retaining existing customers	• The capabilities to acquire new customers that have interest to PTDI aircraft's target to sign the contract

III. METHODS

3.1 Case Study: The Development History of Indonesia Aircraft Industry

Before established as PTDI the National Aviation Industry was pioneered in 1946 at Yogyakarta by the formation of *Planning and Construction Bureau* through the Indonesian Air Force led by Nurtanio. In 1953, cost of only 15 personnel they built and tested three prototypes of a single-seat all metal aircraft at Andir Airport in Bandung. In 1957, The *Experimental Section* graduated into The *Inspection, Trial, and Production Sub-Depot* based on Decision Letter of Indonesian Air Force Chief of Staff number 68. Later in 1958, a light training aircraft prototype named *Belalang 89*, or *Grasshopper 89*, was flown. The design was later produced as *Belalang 90*. Five *Belalang 90* were built and used for military training. Within the same year, a sport plane, "Kunang 25", was also built and flown (Amir, 2007).

On 1 August 1960, by the order of Indonesian Air Force Chief of Staff, The *Aviation Industry Preparation Agency* was to be formed to establish the National Aircraft Industry. By 16 December 1961, the new body, known as LAPIP (Lembaga Persiapan Industri Penerbangan), was actively negotiating for technological transfers and contracts. LAPIP was able to secure a joint licensing and production contract with Poland. Within the same year, Indonesia was producing the PZL-104 Wilga or locally named *Gelatik*. 44 were produced for agriculture, transport, and aero club purposes. In September 1974, Pertamina's Advanced

Technology Division signed a license contract with MBB and CASA for producing Bölkow Bo 105 and CASA C.212 Aviocar.

On 26 April 1976, mandated by Government Act No. 15, in Jakarta, PT. Industri Pesawat Terbang Nurtanio was officially established with Dr. BJ. Habibie as the President and CEO. The infrastructure was completed and inaugurated on 23 August 1976 by President Suharto. The new body was a merger between Nurtanio Aviation Industry Institution (*Lembaga Industri Penerbangan Nurtanio*/LIPNUR) and Pertamina's Advanced Technology Division. Initially, PTDI manufactured the NBO 105 (MBB Bo 105), under license by MBB – followed by the NC 212 (CASA C-212 Aviocar), under license by CASA. On 11 October 1985, the name PT. Industri Pesawat Terbang Nurtanio was changed to the PT. Industri Pesawat Terbang Nusantara or PTDI.

Later on, PT. Industri Pesawat Terbang Nusantara or PTDI was changed to PT Dirgantara Indonesia (PTDI) is involved in aircraft design and the development of the manufacture of civilian and military regional commuter aircraft. This company was the only one Indonesian Aircraft Industry in Indonesia, owned by Indonesia ministry of state-owned enterprises as a state-owned company. PTDI has developed its capability as an aircraft manufacturer and diversified into another area. Table 2.1 shows the development stage of PTDI from 1976 until now divided into three stage.

<Table 3-1>

The Development stage of Indonesian aircraft industry

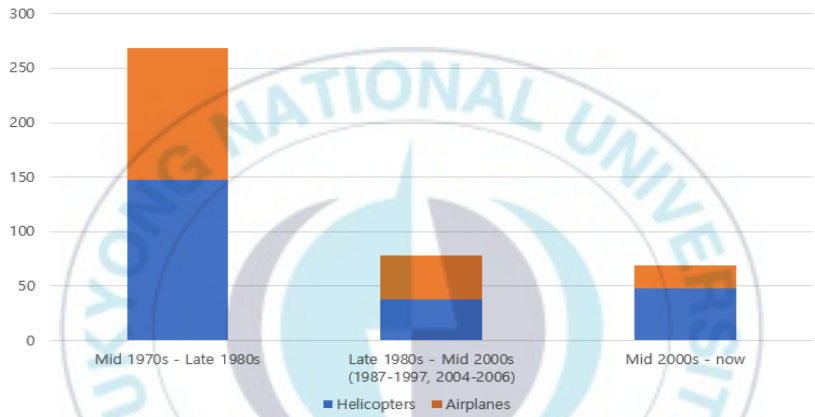
Stage	Focus
Stage 1: The New Order phase 1 – Development (middle 1970s – late 1980s)	• The licensed manufacture of aircraft from existing designs • Industry entered the co-design and manufacturing Establishment of Indonesian aircraft industry • Industry's advancement to autonomy the design and production • Collaboration with foreign partner
Stage 2: The New Order phase 2 – The Economic Crisis (early 1990s – middle 2000s)	• Developing of passenger's aircraft in Indonesia • The first Indonesian aircraft for passenger's aircraft • The crisis of economy and politic
Stage 3: The Reformation Era (middle 2000s – now)	• Development program incorporates advanced R&D • Restructuring programmed • Developing the next generation of fighter aircraft • Opportunities to service Indonesian military as well as countries broad • Improving aircraft safety

In the beginning stage of Indonesian aircraft industry, PTDI achieved quit impressive progress in mastering advanced technical operations and maintain good qualified Indonesian technicians and

engineers. But later on, PTDI couldn't achieve the global competitiveness in the global market. Also, the managerial constrain have greatly reduced the scope for exploiting such technological advanced. Table 3.1 shows that the production of helicopters and aircrafts of PTDI.

<Figure 3-1>

Time Series Delivery Aircrafts of PTDI



Source: Hill and Fong (1988); Kompas.com (2018); Indonesian state own company organized by Ministry of Enterprise (2018)

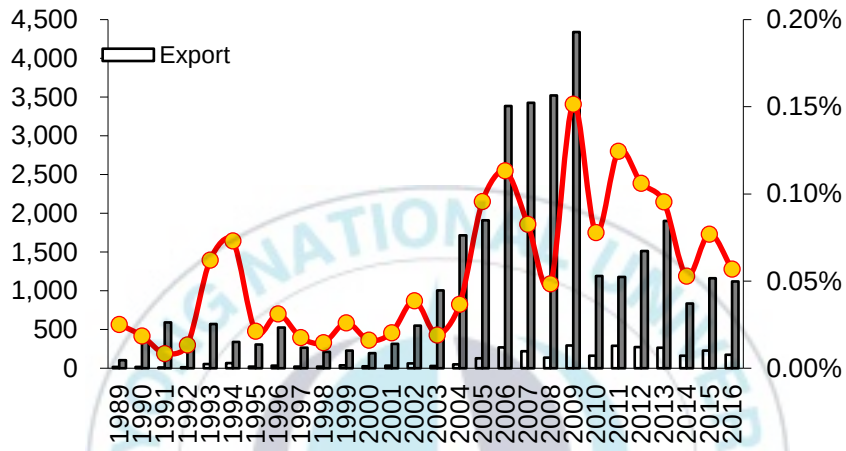
**)Note: From 1997 to 2003, due to the financial crisis of Indonesia and its government, PTDI had not produced aircrafts and helicopters any more*

Figure 3-2 shows Indonesian eager and passion of PTDI to developed aircrafts and helicopters in a big production to deal with not only in national market not also international market. Figure 3-2 also shows that Indonesian products are highly demand in international market. But, regarding PTDI got highly intention in international market, there is main problem where they cannot sustain their productivity which is the company has not been able to fulfill the airline's *on-time*

delivery commitment and the unbalance of utilization of production facilities (*manufacturing* and *assembly*).

<Figure 3-2>

Indonesian Aircraft Industry – Export and Import



Source: UN Comtrade Harmonized System Code on the Aircraft industry

IV. RESULTS

4.1 Challenges of Indonesian Aircraft Industry: from the perspective of capabilities accumulation

As mention before in figure 2 there are four capabilities for CoPS development that could influence the successful in CoPS. Flight simulators, aircraft engines, aircraft carriers are a complex product system according to definitions of Hobday (1998). The term "aircraft industry" is specially used to mean aircraft and helicopters only.

4.1.1 Network Development Capabilities

In the Indonesian aircraft industry, there are three major actors, such follows government, foreign partner that include the regulating institutions.

- **Role of Foreign Partners**

In the beginning, PTDI under supported by Indonesian government produced under license MBB's BO-105 helicopters and CASA's 12-passenger C-212 Aviocar. It took 3 years for PTDI technicians to learn how to construct an aircraft down to its smallest parts. This process required both technical and administrative skills, for every part had to be drawn and documented.

During the first decade, PTDI grew rapidly in terms of employee numbers and projects. Several joint ventures with Western corporations were signed. In addition, PTDI and French Aerospatiale agreed to produce

the PUMA SA 330; PTDI and Bell Helicopter Textron manufactured 100 Bell-412 helicopters.

In 1986, PTDI succeeding in getting an order from General Dynamics to manufacture F-16 components EADS. EADS will play an advisory role in the process through a joint venture, which fits Indonesia's government strategy of seeking to attract foreign direct investment and boosting high value manufacturing industries. Later in 2014, the private sector, PT Regio Aviasi Industri is developing R80 aircraft which is able to carry 80-90 passengers and was initiated by former President B.J. Habibie. They collaborate to design and develop R80 aircraft.

However, joint venture not always ended up with a good story, the record with the CN-235 project with Spain's CASA has so far been mixed, and the plan was to obtain airworthiness approval form the U.S Federal Aviation Administration (FAA). On December 3, 1986, the US FAA certified CN235 but only Spain's CASA prototype because all of CN235's flight hours witnessed by the FAA used Infanta Elena. This unexpected result was especially disappointing to PTDI because the Indonesian civil aviation authority had no bilateral agreement with FAA. In the end, PTDI had to go to another regulating institutions to get certification for the Indonesian-made CN235s, later PTDI obtained an airworthiness certificate from the British aviation authority, making Indonesia's CN235s marketable in certain countries.

■ **Role of Government**

PTDI is a state-own company, that directly fostered by Ministry of State-Owned Enterprises (MSE). The task of MSE for PTDI are:

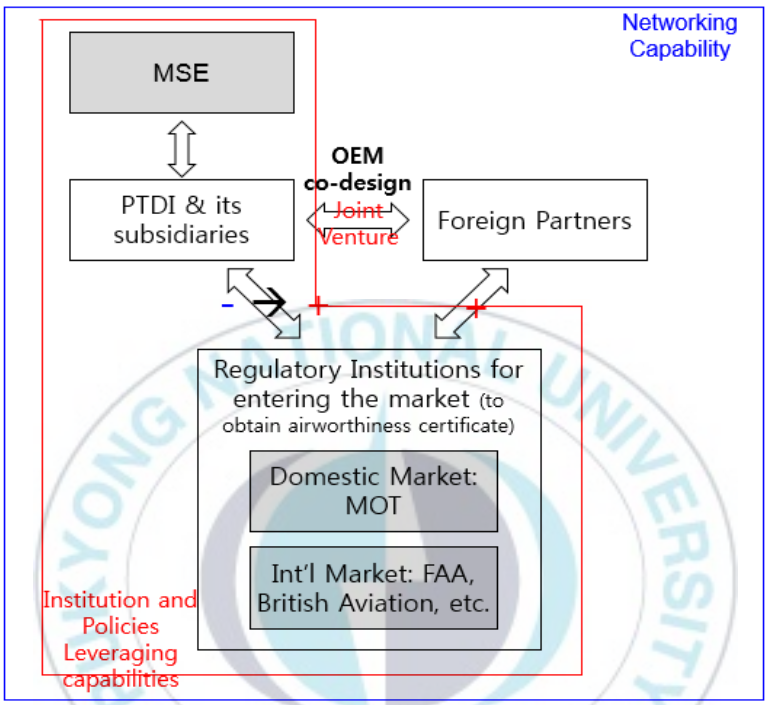
1. Formulation and stipulation of policies in the field of development of state-owned enterprises;
2. Coordination and synchronization of policy implementation in the field of development of state-owned enterprises;
3. Management of state property / wealth which is the responsibility of the Ministry of State-Owned Enterprises

The role of MSE is currently become a bridge for PTDI employees with management and all functions related to PTDI. MSE also creating an atmosphere and direction for achieving solutions that are win-win solutions, so that conductive situations and conditions can be realized. Beyond that, MSE could make a business unit located for PTDI in upstream area of an industrial circuit line and in downstream areas, thereby increasing the capacity of local content support and reducing dependence on supply from abroad, while increasing the industry's national endurance.

PTDI got fully support by the government to develop the Indonesian Aircraft industry by actively support in PTDI and keep looking for the advance technology countries in advance to mastering the Western technology. By doing the joint venture with another partner could lead to success for the other player not PTDI as the main player. Therefore, it can be concluded in “networking development capabilities” was one of the challenges of PTDI’s poor international standing.

<Figure 4-1>

Integration of Network and Institutional and Policy Capabilities



Source: Eriksson (2003); Hill and Fong (1988); Amir (2007); Kompas.com (2017); McKendrik (1992)

In sum, PTDI got could be successful in term of their networks among actors by partnering with foreign countries and the relation with the government. After all, PTDI could do the collaboration with the foreign partners that gave benefits to PTDI in term of technology acquisition and marketing development.

4.1.2 Institution and Policies Leveraging Capabilities

Indonesian government fully support to PTDI sales of their product in the global market through a joint venture with the advance technology countries to get the approval of the institutions to need. The

CN235 project taught PTDI valuable lessons, not only technical but political. The certification mishap was just one among several. Although PTDI and CASA made equal contributions to the project, PTDI eventually benefited less than its Spanish partner. Despite a market-sharing agreement between the two, many customers preferred to purchase CN235 s from CASA because of the backward image of developing countries associated rather than PTDI. Habibie as the president and CEO that time believed the time had come for PTDI to develop its own technology independently, and he felt certain PTDI engineers were capable of carrying out such a future vision.

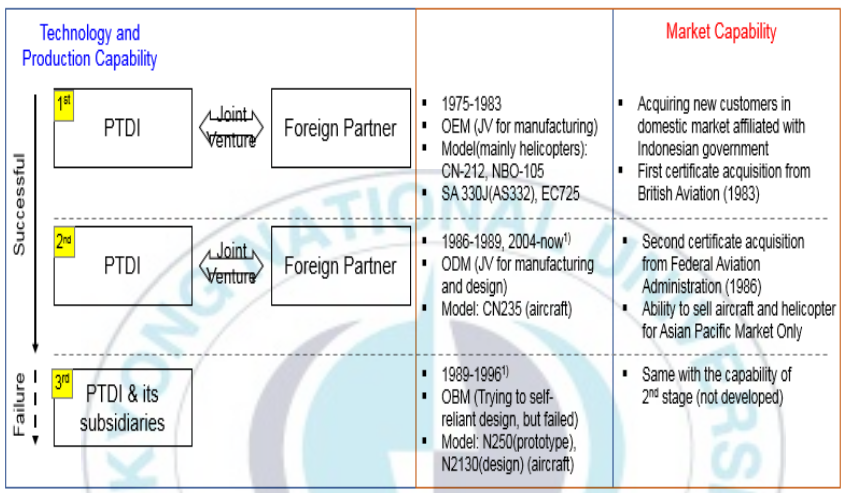
According to the Chudnovsky (1986), he found out by comparing the capital goods in 3 countries could not have taken place without explicit government policies aimed at fostering the domestic manufacturing of capital goods. Industrialization strategies and evert socio-political systems are different ever countries, but still the recent development of indigenous manufacturing of capital goods was made possible not through market force but through explicit government decision.

The successful through the institutional and policies capabilities in PTDI was clear. The Figure 4-1 explain the PTDI as one of a state-own company, that directly fostered by MSE. Together, MSE and PTDI make a collaboration in making the policies in aircraft industry. Also, the Ministry of Transportation (MOT) also have an important role as a domestic institution that give the aviation certification for PTDI products that want to commercialize. Furthermore, as part of a complex product system, the aircraft sectors is characteristically strongly influenced by politics and institutions regulations.

4.1.3 Technology Development and Production Capabilities

<Figure 4-2>

Integration of Technology and Market Capabilities



1) From 1997 to 2003, due to the financial crisis of Indonesia and its government, PTDI had not produced aircrafts and helicopters any more
Source: Eriksson (2003); Hill and Fong (1988); Amir (2007); Kompas.com (2017); McKendrik (1992)

Indonesia opted immediately for full assembly. Although the country had virtually no machine and capital goods base in the mid-1970s. In brief, there is four stage of PTDI development process in technology and production. According to the Jakarta Globe (2011) Stage 1, which called for the licensed manufacture of aircraft from existing designs, got underway with two agreements concluded in 1975, one with Construcciones Aeronáuticas S.A. (CASA) of Spain to build the CN-212 Aviocar 26-seat twin turboprop, and the other with Messerchmitt-Bölkow-Blohm GmbH (MBB) of Germany for the licensed production of the NBO-105 helicopter. One year later PTDI obtained a licensed to assemble the French SA 330J Puma helicopters from the Aerospatiale Company (Hill and Fong, 1988) later PTDI produced another series in 1983 AS332

Super Puma helicopters (AntaraNews.com, 2012). The twin-engine EC725 helicopter is a member of Eurocopter's Super Puma/Cougar family. Next stage, stage two industry entered the co-design and manufacturing stage, with the second arrangement with CASA to develop and coproduce the CN-235, a 35 to 44 seat multi-purpose turboprop, under the 50-50 joint venture Aircraft Technology Industries (Airtech). On December 3, 1986, the US FAA certified CN235. Stage 3 of the industry's advancement, calling for complete autonomy in the design and production of an indigenous aircraft, is represented by Indonesia's first nationally produced civil aircraft, the N-250 regional turboprop incorporating flyby-wire technology, which emerged as a prototype in November 1994. The final stage of Indonesia's aerospace development program incorporates advanced R&D for the design and manufacture of a regional jet. Indonesia's aircraft industry entered this fourth stage with plans to develop a family of aircraft starting with the N-2130 jet-powered airliner (Global Security, 2018).

Later, there are almost 80 Bell helicopters of various models operating currently in Indonesia. 31 of these are the variants of the Bell 412 EP. All of Bell 412 SPs & 412 HP helicopters were manufactured under license from Bell Helicopter by PTDI in the 1980's and 1990's. Since 1984 PTDI had been manufacturing under license NBell 412 SP/HP from BHTI, USA. PTDI has continuously improved their R&D for design and manufacture helicopters and aircraft.

In previous studies, Prencipe, A (1997) describe three characteristics of product-systems briefly outlined of what business firms must develop in order to manage their success. First, managing product-systems requires firms to have different skills, notably component

knowledge, knowledge about the ways in which the components are linked together and interact as a system, and knowledge about the system as a whole. Second, given the multi-technological nature of product-systems, firms develop competencies in multiple knowledge bases. However, due to financial and managerial constraints, they usually stick to those competencies regarded as crucial and contract out peripheral ones. Third, innovation can arise from existing and new technological paradigms and undermine static components' hierarchies. In fact, the product-system's evolution hinges on the joint dynamics of several technological trajectories. This poses severe demands on the R&D activities carried out in-house.

In some phenomenon, PTDI could be categorize as a successful firms that could manage product-system, where PTDI keep increase their skills, knowledge and integrated all that as a system by doing the knowledge transfer. This refers, also to the Lee and Yoon (2015) knowledge transfer mechanisms, which consisted of formal and informal mechanism and commodity trade to explain latecomers' learning with foreign support. The theoretical literature that exists on these strategies stresses the choice between internal development and external development is "make" or "buy" approach. Whereas "make" corresponds with indigenous development (build) option, "buy" is preferred by latecomers with limited technological capabilities. These two options are closely related with the very first stage of the aircraft industry development and the focus of latecomers' knowledge-based determined by industrial policies. Where PTDI got their knowledge transfer 'make' by development or build option. It shows, where PTDI developed many

kinds or aircrafts and helicopters form the output of learning with foreign support.

4.1.4 Market Development Capabilities

The market of PTDI depends on the project and cooperation with other institutions to meet the market development in term of the national and international market. The market policy by the government, it is hardly to find the evidence that regulated the market procedure in the aircraft industry. In other words, there is no significant regulation that made by the government to utilize the market development in Indonesia aircraft industry.

This figure 4-2 explain the relationship of technology and production capability was quite significant for market capability in PTDI. In early of stage, PTDI was quite good by doing the collaboration with foreign partners by the designed. At that time, the market only significant to the domestic market. Because, PTDI couldn't have any certificate accusation with the international institution.

Later on, in the second stage when PTDI do the joint venture with foreign partners (CASA) by doing the 50:50 design and assembly aircraft, the results not quite good. Because PTDI only got the certification by British Aviation that only limited the market into the Asian Pacific. While, the CASA who got certification by FAA could expanse their international market.

The market of PTDI depends on the project and cooperation with other institutions to meet the market development in term of the national and international market. For PTDI they had a major problem to face their project management in time, the company is has not been able to fulfill

the airlines on time delivery commitment and the unbalance of utilization of producing facilities.

One of the examples, when PTDI delays in the delivery of aircraft for the C212-400 aircraft to Thailand. PTDI contract with Thailand for the C212-400 aircraft was carried out in August 2011 with a delivery target of 12 October 2013. The contract value was 8.34 million US dollars, PTDI has to pay a penalty of 13.52 million US dollars because it was just sent on January 19, 2016 (Kompas, 2017).

In the last stage, when PTDI couldn't enter any market foundation because their self-design product couldn't enter any market.

4.2 Alternative Discussion: Windows of Opportunity

Also, we investigate whether the windows of opportunity have indirectly or directly affected the growth of PTDI. We found that, in term of the technological windows the specific set of innovation production is critical in other words, the diffusion of innovation of airlines, big companies had to develop innovation to produce. For example, of jet airlines, PTDI tried to develop this kind of airlines but failed in term of their lack production and development.

In term of demand windows, changes in market preferences is significant, the transition from turbo prop to jet airlines machines, PTDI also tried to design a new engine of airlines but failed during the attacks of global financial crisis.

In addition, we can summarize that in spite some existing of windows of opportunity, PTDI cannot fulfill the opportunity due to their lack of project managerial and some issues in Indonesia.

4.3 Discussion

Despite from the perspective of CoPS accumulation capabilities that we already analyze in PTDI, there are some evidence too that shows why the PTDI couldn't maintain their success in CoPS industry.

In the early stages of PTDI according to Eriksson (2003) Indonesia through their government was so tempestuous to invest in aircraft manufacturing industry because, the political isolation/national independence where Indonesian want to develop their own potential industry for the economic growth and technology development (more and less there are 10 industries have been targeted as strategic industries, such as: aerospace, shipbuilding, railways, telecommunication, electronics, explosive steel and machine goods). This study was investigating Indonesian aircraft industry because, aircraft industry can be analyze using CoPS studies. The other reasons were the import substitution/export promotion and also the national prestige.

After the establishment of Indonesian aircraft industry PTDI could achieved a significant learning process and technology absorb by doing the collaboration with foreign partners but they were failed in term of management and marketing. The reason why they were failed because PTDI was focusing only on technology without any thought about the business, management and marketing. PTDI was also had a major problem to enter the international market dues to their lack of foreign certification, the company lacked experiences in sales and marketing of such advanced products.

After PTDI thought that strong enough to develop their own products, PTDI decided to go alone, which must be rather complicated. Amir (2017) explained, PTDI clumsy handling management by

developing N250 programs led to ballooning costs (Initial budget US$600 million rising to the US $ 1.2 billion). To celebrate 50th Indonesian Independence Day. In 1994, Suharto as the second president of Indonesia allowed PTDI to take loan US$200 million from Reforestation fund. In return, 5% loyalty will go to forestry department. Scandalous use of reforestation fund bring criticism to file a lawsuit against Suharto, but because President is accountable only to People's Consultative Assembly (MPR) the case was closed.

After the first flight of the N250 in 1995, the 1997 monetary and economic crisis made PTDI shaky. In an increasingly deteriorating situation, the Indonesian government was forced to borrow funds from the International Monetary Fund (IMF) on the condition that it should stop PTDI operations. Thousands of employees are laid off and a wave of demonstrations rocked the aircraft industry.

V. CONCLUSION

This study illustrates the capabilities CoPS development that reflect the Indonesian aircraft industry challenge to success in complex product system and suggests the necessary capabilities for CoPS development. The study first examines the previous studies regarding the Indonesian industry phenomena and their challenges. It also contributes to integrate the previous studies of latecomer in CoPS capabilities' frameworks. The paper contributes to the four capabilities of CoPS, such as network development capabilities, technology development and production capabilities, institution and policies leveraging capabilities, market development capabilities.

The evidence indicates of initial approximate challenge in achieving technological accumulation and market performance globally the case of Indonesian aircraft industry. We found the importance of market development and the role of government as the critical issues. As the evidence shows, in "networking development capabilities" was good enough for PTDI's by doing the collaboration with international companies and got fully supported by Indonesian government. In the "technology development and production capabilities", PTDI achieved a good performance in term of mastering the western technology and PTDI have continuously improved their R&D for design and manufacture helicopters and aircraft. In the term of "the institution and policies leveraging capabilities" furthermore, as part of complex product system, the aircraft sectors are characteristically strongly influenced by politics and institutions regulations. For the market policy by the government, it is hardly to find the evidence that regulated the market procedure in Indonesia aircraft industry have existed. By the "market development

capabilities", the market of PTDI depends on the project and cooperation with other institutions to meet the market development in term of the national and international market. The critical issues were the certification that make barriers for PTDI to expanse their international market.

For the future suggestion for PTDI in term of CoPS development, we suggest that PTDI should reflect to their performances carefully in term of their technology and production also their market performance. Because PTDI is state-owned company, the relationship with government as the owner of PTDI should be growing very well.

Government as the key holders for PTDI succeed in term to gain collaboration with the foreign partner to absorb the technology and knowledge also to enter the global market aggressively. PTDI also, should change their project management so it could acquire the technology and production capability and could fully nurture the market development. Because the crucial issue is PTDI couldn't maintain their performance to project management.

In the future PTDI should try to do more collaboration with foreign countries to expand their technology acquisition to increase their production also to market creation

Also, the collaboration with domestic private company to build an aircraft so prefer to PTDI, by that PTDI could open a great potential for increase the national prestige. It could reflect when PTDI tried to do collaboration with regional manufacturer company to develop new turboprop airline R80.

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APPENDIX

CoPS Capabilities Analysis Summary in PTDI

Capabilities	Explanation in PTDI conditions	Results
Network Capabilities	• PTDI is a state-owned company. By that PTDI is shaded by Ministry of State-Owned Enterprises (MSE) of Republic of Indonesia. MSE have a role to do collaboration with PTDI to create their policy • PTDI also have a strong relationship with foreign partners in term of technology and knowledge transfer also the potential market creation • In term of the market enter, PTDI must get a certificate by the regulatory institution. To enter the market PTDI must obtain the airworthiness certificate. 1. Domestic market, PTDI had certified by Ministry of Transportation (MoT) to sales their aircrafts/helicopters in Indonesia 2. International Market, PTDI had certified by FAA, British Aviation to sales their aircrafts or helicopters in international market.	**Success**

Capabilities	Explanation in PTDI conditions		Results
Institutional and Policy Capabilities	• MSE have a strong role for PTDI to do collaboration and synchronization of policy implementation in the field of development of PTDI • Ministry of Transportation (MOT) also have an important role as a domestic institution that give the aviation certification for PTDI products that want to commercialize. • International Market, PTDI had certified by FAA, British Aviation		**Success**
Technology and Production Capabilities	Stage 1	▪ 1975-1983 ▪ OEM (JV for manufacturing) ▪ Model(mainly helicopters): CN-212, NBO-105 ▪ SA 330J(AS332), EC725	**Failed**
	Stage 2	▪ 1986-1989, 2004-now[1)] ▪ ODM (JV for manufacturing and design) ▪ Model: CN235 (aircraft)	
	Stage 3	▪ 1989-1996 ▪ OBM (Trying to self-reliant design, but failed) ▪ Model: N250(prototype), N2130(design) (aircraft)	
Market Capabilities	Stage 1	▪ Acquiring new customers in domestic market affiliated with Indonesian government	**Failed**

Capabilities	Explanation in PTDI conditions		Results
		▪ First certificate acquisition from British Aviation (1983)	
	Stage 2	▪ Second certificate acquisition from Federal Aviation Administration (1986) ▪ Ability to sell aircraft and helicopter for Asian Pacific Market Only	
	Stage 3	▪ Same with the capability of 2nd stage (not developed)	

PT Dirgantara Indonesia (PTDI)

PT. Dirgantara Indonesia or *Indonesian Aerospace* (PTDI) is the first and only aircraft industry in Indonesia in the Southeast Asia region. This company is owned by the Indonesian Government. Established on April 26, 1976 with the name of PT. Airplane Industry Nurtanio and BJ Habibies as President Director. The Aircraft Industry Nurtanio later changed its name to Nusantara Aircraft Industry (IPTN) on October 11, 1985. After restructuring, IPTN then changed its name to Dirgantara Indonesia on August 24, 2000. Indonesian Aerospace did not only produce various aircraft but also helicopters, weapons, providing training and maintenance services (maintenance service) for aircraft engines. PTDI also has a variety of products in other fields such as information technology, automotive, marine, simulation technology, turbine industry, service engineering, and a sub-contractor for major aircraft industries in the world such as Boeing, Airbus, General Dynamic, Fokker etc.

In its production, PTDI has produced more than 300 units of aircraft and helicopters, defense systems, aircraft components and other services. PTDI has 4 business units that were previously 18 business units. The four business units are:

1. Aircraft Integration - Assembly and Integration

-CN235-220 (produced and shipped as many as 57 units, returned 5 units)

-NC 212-200 (produced and shipped as many as 102 units)

-NBO-105 helicopters (produced and shipped as many as 122 units, and stopped production in 2008)

-Helicopter BELL-412 (produced and shipped 33 units)

-Helicopter NAS-332C1 (produced and shipped as many as 20 units)

-ILS and customer support

2. Aerostructures - Producing aircraft equipment and components

- Airbus A380 / A320 / A321 / A340 / A350
- Boeing B-747 / B-777 / B-787
- Eurocopter MK-2 (EC225 / EC725)
- Airbus Military CN235 / C295 / C212-400

3. Aircraft Services - Provides maintenance, repairs, changes and improvements

-Products: CN235, NC-212-100 / 200, NBELL-412, NBO-105, NSA-330 and NAS-332

-Non-products of PT DI: B737-200 / 300/400/500, Cesna172, Enstrom 480B, BK-117 and Bell-212

4. Technology and Development

- As one of the directorates under PTDI which has the ability and experience in the field of product engineering and development, simulation technology, integration of systems and maintenance for defense and security systems, information technology and a training facility and laboratory.

In 2012 was a moment of the rise of Indonesian Aerospace. In the beginning of 2012 Dirgantara Indonesia managed to send 4 CN235 aircraft ordered by South Korea. PTDI is also exploring to build C295 aircraft (CN235 jumbo version) and N219, as well as cooperation with South Korea in building KFX pilot aircraft.

Vision

"To be the world class aerospace company based on high technology and cost competitiveness in the global market"

Mission

1 As the center of competence in aerospace industry for both commercial and military mission, as well as for non-aerospace application.

2 As a major player in the global industries. which has strategic alliance with other world class Aerospace Industries,

3 Cost competitive business.

4 Delivering cost competitive products and services

Company Logo's

Figure Logo of PT Dirgantara Indonesia

Source: PTDI archived (2018)

On PTDI Logo,

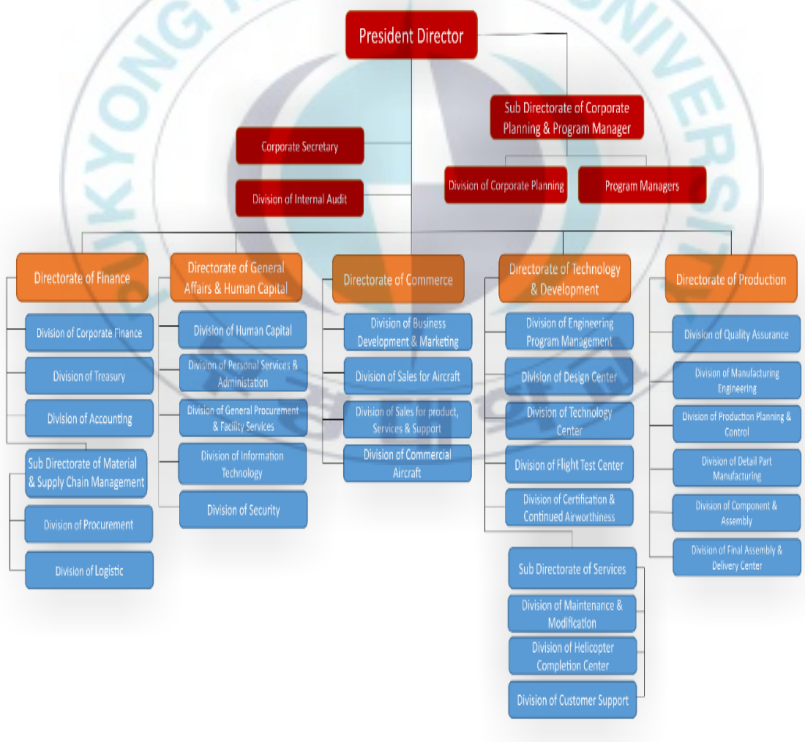
1. Space blue symbolizes the sky where the airplane is.
2. Airplane wing as much as 3 pieces, which symbolizes the phase of PT Indonesia Aerospace, namely:
   a. PT Aircraft Industry Nurtanio
   b. PT Nusantara Aircraft Industry

c. PT Dirgantara Indonesia

3. The size of an increasingly enlarged aircraft symbolizes the desire of PTDI to become an aerospace company which is getting bigger in each phase.
4. The circle symbolizes the globe where PTDI wants to become a world-class company.

Organizational Structure

Figure Organizational Structure



Source: PTDI archived (2018)

Table of Development Technology of Indonesian Aircraft Industry

Stages	Foreign Partners (Year)	Role of PTDI and Foreign Partners	Model developed
Stages 1 the licensed manufacture of aircraft from existing designs (OEM)	Construcciones Aeronáuticas S.A. (CASA) of Spain (1975)	■ CASA: The CASA C-212 Aviocar is a turboprop-powered STOL (short take-off and landing aircraft) medium cargo aircraft for civil and military use. ■ PTDI: PTDI builds the CN-212, a further-400 upgrade, with new digital avionics and autop ilot, and a cabin for up to 28 passengers.	CN-212 Aviocar 26-seat twin turboprop aircraft
	Messerchmitt-Bölkow-Blohm GmbH (MBB) of Germany (1975)	PTDI under license from MBB since 1976 manufacture and assembly; in total there are 123 helicopters of this type produced in Bandung and are used for domestic and export purposes. Of all aircraft, only rotors and transmissions are supplied by Germany.	NBO-105 helicopter

Stages	Foreign Partners (Year)	Role of PTDI and Foreign Partners	Model developed
	French SA 330J Puma helicopters from the Aerospatiale Company (1976)	Variants of this helicopter are also manufactured, assembled or licensed by *Atlas Aircraft Corporation from South Africa as Atlas Oryx, ICA from Romania* and **PTDI from Indonesia.**	SA 330J Puma helicopters
	The twin-engine is a member of Eurocopter's Super Puma/Cougar family (1983)	PTDI manufactured both the SA 330 and AS 332 under license from Aerospatiale for domestic and some overseas customers. NAS 332 - Licensed version built by PTDI	AS332 Super Puma helicopters
	The twin-engine is a member of Eurocopter's Super Puma/Cougar family	In November 2014, the Indonesian Air Force took delivery of the first six EC725s for Combat Search and Rescue (CSAR) operations. PTDI performs the maintenance, repair and overhaul activities upon Indonesia's EC725 fleet; the tail booms and airframe	EC725 helicopter

Stages	Foreign Partners (Year)	Role of PTDI and Foreign Partners	Model developed
		assemblies for EC225s and EC725s worldwide.	
Stage 2 industry entered the co-design and manufacturing stage	CASA under the 50-50 joint venture Aircraft Technology Industries (Airtech) (1986)	The CASA/PTDI CN-235 is a medium-range twin-engined transport aircraft that was jointly developed by CASA of Spain and Indonesian manufacturer PTDI, as a regional airliner and military transport. Its primary military roles include maritime patrol, surveillance, and air transport. ■ CASA: to handle the centre wing-box, fuselage mid-section and Electric ■ PTDI: to be responsible for production of the outer wing, rear fuselage and stabilizer	the CN-235, a 35 to 44 seat multi-purpose turboprop aircraft
Stage 3 the industry 's effort to achieve	PTDI (1994)	The N-250 development plan was first revealed by PTDI at the Paris Air Show in 1989, but was first introduced in 1986 when the Indonesian Air Show 1986	the N-250 regional turboprop incorporating flyby-wire technology

Stages	Foreign Partners (Year)	Role of PTDI and Foreign Partners	Model developed
own design (ODM)		was held. The first prototype, serial number PA-1 with a capacity of 50 passengers, flew on 10 August 1995. The Second prototype, a stretched variant with a capacity of 70 passengers named N250-100, was planned to have its first flight on May 1996, but this was delayed, and the plane was instead first flown on 19 December 1996. The third and fourth prototypes were planned to first fly on July 1996 and September 1996 respectively, but construction for both aircraft were halted due to the financial meltdown in Asia the following year.	(Prototype)
	PTDI (1995)	President Soeharto invited the Indonesian people to make the N-2130 project a national project. N-2130 after the N-250, which is	N-2130 jet-powered airliner (prototype)

Stages	Foreign Partners (Year)	Role of PTDI and Foreign Partners	Model developed
		estimated to cost two billion US dollars. PT Dua Satu Tiga Puluh (PT DSTP) was formed to carry out this large project. When the 1997 financial crisis hit Indonesia, PT DSTP Tbk, which had been registered was baffled. For this aircraft preliminary design, PTDI has spent a lot of energy, thought and money. Funds that have been spent more than 70 million US dollars in accordance with the resolution of the EGMS, these funds are then considered to be sunk-cost.	

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