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APPLICABILITY OF PERFORMANCE-BASED LOGISTICS TO BRAZILIAN ARMED FORCES' CONTRACTING PROCESSES IMPROVEMENTS

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APPLICABILITY OF PERFORMANCE-BASED LOGISTICS TO BRAZILIAN ARMED FORCES CONTRACTING PROCESSES IMPROVEMENTS

June 2020

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13. ABSTRACT (maximum 200 words)

In recent years, the Brazilian Armed Forces (BAF) has started the adoption of Performance-Based Logistics (PBL) contracts for maintenance of defense systems such as operational aircraft and frigates. It was a migration from the traditional method of using in-house capability to outsourced maintenance structure with performance requirements. The life cycle of a system is costly, and may span decades. Hence, the correct contractual choices made during all phases of a program may represent a significant amount of savings to the Brazilian branches.

This research had as the main issue finding out how BAF can optimize its performance-based contracting processes by identifying best contractual practices developed by the U.S. Department of Defense (DoD). This study identified several best practices distributed in different phases of the Contract Life Cycle that can promote cost reduction and system performance improvement.

Finally, even though there are differences between the DoD and the BAF contracting cultures, financial capacity, and number of defense systems, this study concluded that the PBL best practices could be used in the BAF and also made recommendations on how to apply them in the Brazilian Defense Sector.

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APPLICABILITY OF PERFORMANCE-BASED LOGISTICS TO BRAZILIAN ARMED FORCES CONTRACTING PROCESSES IMPROVEMENTS

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LIST OF ACRONYMS AND ABBREVIATIONS

AM	Materiel Availability
AOA	Analysis of Alternatives
BAF	Brazilian Armed Forces
BN	Brazilian Navy
PROSUM	Brazilian Submarine Development Program
CMBOK	Contract Management Body of Knowledge
CAPE	Cost Assessment and Program Evaluation
DAU	Defense acquisition University
DP	Development Plan
DCA	Brazilian Air Force Command Directive
DoD	Department of Defense
DLS	Development or Definition of Logistic Support
EMD	Engineering and Manufacturing Development
FAB	Brazilian Air Force
FMS	Foreign Military Sales
FRP	Full-Rate Production
GAO	Government Accountability Office
IPS	Integrated Product Support
ICD	Initial Capabilities Document
JCIDS	Joint Capabilities Integration and Development System
LCC	Life Cycle Costs
LCM	Life-Cycle Management
LCSP	Life Cycle Sustainment Planning
LSC	Logistical Support Contract
LRIP	Low-Rate Initial production
MDAP	Major Development Acquisition Program
MDD	Materiel Development Decision
MR	Materiel Reliability
MSA	Materiel Solutions Analysis
MILCON	Military Construction

MILPERS	Military Personnel
NTT	Nationalization Technology Transfer
NYOGB	Navy Total Ownership Guidebook
NATO	North Atlantic Treaty Organization
OSD	Office of the Secretary of Defense
OPTEMPO	Operational Tempo
O&M	Operations and Maintenance
O&S	Operations and Sustainment
PBL	Performance-Based Logistics
PBLG	Performance-Based Logistics Guidebook
PSI	Personnel Security Investigation
PSP	Personnel Security Program
PDR	Preliminary Design Review
PSMG	Product Support Management Guidebook
PSM	Product Support Manager
PM	Program Manager
QDR	Quadrennial Defense Review
RFI	Request For Information
RFP	Request For Proposal
R&D	Research and Development
RDT&E	Research, Development, Test, and Evaluation
SRR	System requirements review
TMRR	Technology Maturation and Risk Reduction
TLCSM	Total Life Cycle System Management
TOC	Total Ownership Cost
VTC	Verification, Testing and Certification
WBS	Work Breakdown Structure

I. INTRODUCTION

In recent years, the Brazilian Armed Forces (BAF) has adopted Performance Based Logistics (PBL) contracts for maintenance of defense systems such as operational aircraft and frigates. These contracts represented a migration from the traditional structure of in-house maintenance to an outsourced maintenance structure with performance requirements such as operational availability. This application still has a low level of maturity with regard to relatively few PBL cases in the Brazilian Defense Sector.

This study uses the term Armed Forces to facilitate the reader's understanding of how the Brazilian military services work with this method of contracting, but it does not take into account the PBL practices carried out by the Brazilian Army. Unlike the American model, where the DoD has a centralizing, guiding, and unifying role in the military's contracting processes, the Brazilian branches have greater independence in decision-making. Consequently, there are significant differences between the procedures of the branches of the Armed Forces. For this reason, and for time constraint, the Army approach to PBL is not discussed in this study.

In the process of acquiring or developing a new weapon system, it is important to think about its capabilities, requirements, operational needs, etcetera. These are critical factors to observe, especially from the perspective of the warfighter, because the end user has to manage a critical risk for the system utilization. Considering that in a system life cycle, about 70–80% of the cost occurs in the sustainability of the system, the relevance of the study of PBL increases because it may represent concrete gains or losses in cost, performance, and availability.

The life cycle of a system is costly, and the system may last decades. The correct contractual choices made during all phases of the cycle of the system may represent a significant amount of savings to the Brazilian branches. Performance-based contracts are not just associated with the acquisition of a new system. As long as a viability analysis indicates that the application can be beneficial, the methodology can be applied in already used systems at some point in their life cycle.

A PBL contract brings the opportunity for the client to increase performance level and reduce costs, so its extensive utilization should increase in BAF. Hence, to facilitate the applicability and create more incentives for the BAF to implement PBL contracts, this research proposes how the Brazilian military services can optimize their performance-based contracts, extracting the good contractual practices during the twenty years of experience of the U.S. Department of Defense (DoD) and other relevant studies and policies in performance-based contracting.

Chapter II starts by giving some foundation about a system's Life Cycle. It gives an overview of all process phases from the conception of the project, through its production, operational maintenance, and deactivation. This chapter shows that PBL is present in all phases, and the solid understanding of its concepts is important.

Chapter III presents a literature review on PBL contract to help the reader understand the concepts and applicability of PBL.

Chapter IV introduces the Brazilian industry of defense, which plays a significant role in the execution of the PBL contracts. If PBL is done with the national industry, it is beneficial for the national economy. The Brazilian industry has been through a significant transformation over the last three decades. The chapter demonstrates the evolution of the sector that has now achieved the capabilities to take charge of PBL contracts from the Brazilian Navy and Air Force.

Chapter V explains how the BAF has been maintaining their systems recently and which strategies are being used.

Chapter VI analyzes successful cases of PBL implementation, publications, guides, and manuals developed by the DoD. Based on that, the Chapter VII presents a management guide with best practices to implement in the contracting processes in the BAF, and offers recommendations based on the current situation of PBL contracting in Brazil.

This study answers the following primary research question and some subsidiary research questions:

- Primary research question
    - How can the BAF apply the good contractual practices developed by the DoD during the past twenty years to their own PBL contracts in an effort to achieve cost reductions and operational improvements?
- Subsidiary research questions:
    - Which are the best practices developed by the DoD in PBL contracts?
    - Which areas of the BAF should be the focus for PBL contracts implementation?
    - In which situations should PBL be the preferred contracting method? (Only when in-house maintenance is not possible?)
    - How can the PBL application improve the Brazilian defense system's performance?
    - What is the cost of PBL in comparison to in-house maintenance?

This study has some limitations:

- There is a lack of material related to PBL contracts in the BAF to analyze the application of this methodology.
- There is a lack of publications of case studies of PBL implementation in Brazil.

- There are differences in regulations used by the U.S. and Brazilian branches of the military about acquisition and contract management that can make it difficult to implement DoD best practices in the Brazilian context.

Finally, this study uses the investigative research of several publications about the utilization of PBL contracts used mainly by the DoD. The research method includes a collection of actual and historical data about DoD's contracts with logistic support, and descriptive analysis to identify best practices developed. This study also collects actual data related to the PBL utilization by BAF.

II. LITERATURE REVIEW ON LIFE CYCLE MANAGEMENT

Performance-Based Logistics (PBL) contracts are evaluated within the context of the Life Cycle. The theoretical basis of the Life Cycle is fundamental for the understanding of PBL. Its correct knowledge has significant influence on the successful development of a PBL contract. This chapter provides the knowledge foundation of Life Cycle to support this thesis's PBL study.

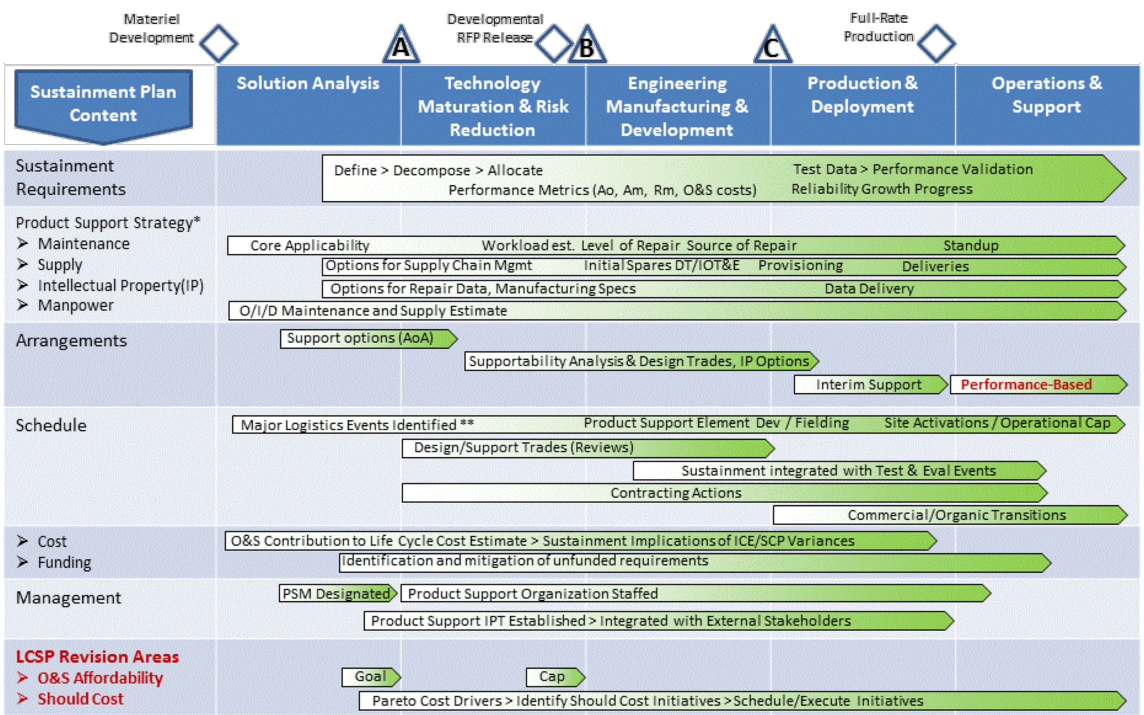
The chapter utilizes the *Brazilian Air Force Command Directive DCA 400–6* (2007), which regulates the Life Cycle of Brazilian systems, and certain U.S Department of Defense (DoD) publications to support this understanding. Due to the Foreign Military Sales Program (FMS), which allows Brazilian military officers to study in American Military Schools, Brazil has learned and followed the best practices of U.S Life Cycle policies. For this reason, Brazilian policy legislation has the same flow of ideas as the American, and this study assumes that all doctrine of the U.S DoD applies to Brazil.

According to *DCA 400–6*, Life Cycle is a set of procedures that starts with the detection of the operational need, development or acquisition, employment, operational evaluation, and their timely modernization or revitalization until deactivation. To be applied to a given system or material, Life Cycle must be linked to operational needs, operational requirements, and technical, logistic, and industrial requirements.

According to the *Defense Acquisition Guidebook* (Defense Acquisition University [DAU], 2017), Life Cycle sustainment planning (LCSP) is a key function of the defense acquisition system for the development of military capabilities. The guide highlights that the goal of Life Cycle sustainment planning is to maximize readiness by delivering the best possible product support outcomes at the lowest operational and support cost (DAU).

To put performance-based logistics (PBL) in practice, planning needs to begin long before the production phase. The same university explains that, while weapon system sustainment does not begin until the first production units are fielded, sustainment planning begins at the earliest stages of the defense acquisition system. Successful post-fielding sustainment performance depends on critical thinking during requirements development and solution analysis (DAU, 2017).

Figure 1 describes an overview of the Life Cycle sustainment activities according to the *Defense Acquisition Guidebook*. It shows the activities during the milestones of the Life Cycle beginning with the Sustainment Plan, followed by the Solution Analysis, Technology Maturation and Risk Reduction, Engineering, Production and Deployment, and finally, Operations and Support.



Ao/Am/Rm = Operational Availability/Materiel Availability/Materiel Reliability; AoA = Analysis of Alternatives; Dev = Development; DT = Developmental Testing; Est = Estimate; Eval = Evaluation; ICE = Independent Cost Estimate; IOT&E = Initial Operational Test & Evaluation; LCSP = Life-Cycle Sustainment Plan; Mgmt. = Management; O&S = Operations & Support; O/I/D = Organizational-/Intermediate-/Depot (Levels of Maintenance); PSM = Product Support Manager; RFP = Request for Proposal; SCP = Service Cost Position; Specs = Specifications.

Figure 1. Overview of Life Cycle Sustainment Activities.
Source: Defense Acquisition University (2017).

One of the factors to be considered in a Life Cycle is the total ownership cost (TOC). AcqNotes explains that, "TOC includes the elements of a program's life-cycle cost, as well as other related costs not necessarily attributed to the program in the context of the defense acquisition system" (AcqNotes, 2017, para. 1). TOC is broader than Life Cycle cost, given that it includes other costs.

AcqNotes mentions that the "Major categories of infrastructure are support to equipment, support to military personnel, and support to military bases (installations and communications/information infrastructure)" (AcqNotes, 2017, para. 2). *The Product Support Management Guidebook* (PSMG) explains that "the weapon system must be designed to deliver the required warfighting capability and be affordable" (Product Support Management Guidebook [PSMG], 2019, p. 2). It explains that the product support solution needs to reduce the demand for logistical support and meet the warfighter's needs. In the implementation and development of a product support strategy, it is important to balance these two needs. According to the same guidebook, life-cycle management (LCM) is:

> the implementation, management, and oversight, by the designated Program Manager, of all activities associated with the acquisition (such as development, production, fielding, sustainment, and disposal) of a DoD weapon system across its life-cycle. LCM bases major system development decisions on their effects on life-cycle operational effectiveness and affordability. (PSMG, 2019, p. 2)

In both Brazilian and American military policies, Life Cycle consists of similar concepts, but each country adopts different names for them. Acquisition programs in the United States are structured in phases separated by milestone decisions (A, B, C) by the Life-Cycle Management System established in DoD Instruction 5000.02. Brazil has a similar structure, but its phases are named differently. Brazil adopts the following phases: conception, viability, definition, development or acquisition, production, deployment, use, revitalization, modernization and improvement, and decommissioning (DCA 400–6, 2007). The names are different in each country, but when reading both contents, conceptually, the ideas are very similar. This chapter intends to make an integrated overview of the Brazilian and the American Life-Cycle with common theories.

Notice that for developing countries like Brazil, the development of technology is not the first option. The first option is to buy a “shelf” product. Because development demands significant financial resources, BAF typically buys products that have been successfully produced in other countries, with the technology transference. This policy has been successfully displayed, and the Brazilian industry can already build aircraft to compete with Lockheed KC-130 (Flight Global, 2019). After 2024, the Brazilian industry will own knowledge to build its own attack aircraft (ECB, 2019) and after 2028 its own Tamandaré Class frigates (Marinha, 2020).

The U.S., as an enormous military power, tirelessly seeks to develop new technologies to create a competitive advantage to face other countries (Deterrence Operations—Joint Operating Concept, 2006). The development of a powerful and technologically advanced weapon, for example, undoubtfully increases dissuasion power.

Figure 2 demonstrates the milestones A, B, and C of the system’s Life Cycle in the DoD. The steps necessary to the development of a new system, either in the U.S. or Brazil. For example, this refers to the creation of a new weapon or an aircraft. It also introduces decision points during the system development. Decision points are steps where the decision-maker decides whether or not to move forward with the system development. (R. Jones, class notes, October 21, 2019). The decision points begin with the materiel development decision, and pass through the capability development document, request for proposal release decision, full rate production decision, initial operational capabilities, and the full operation capability document.

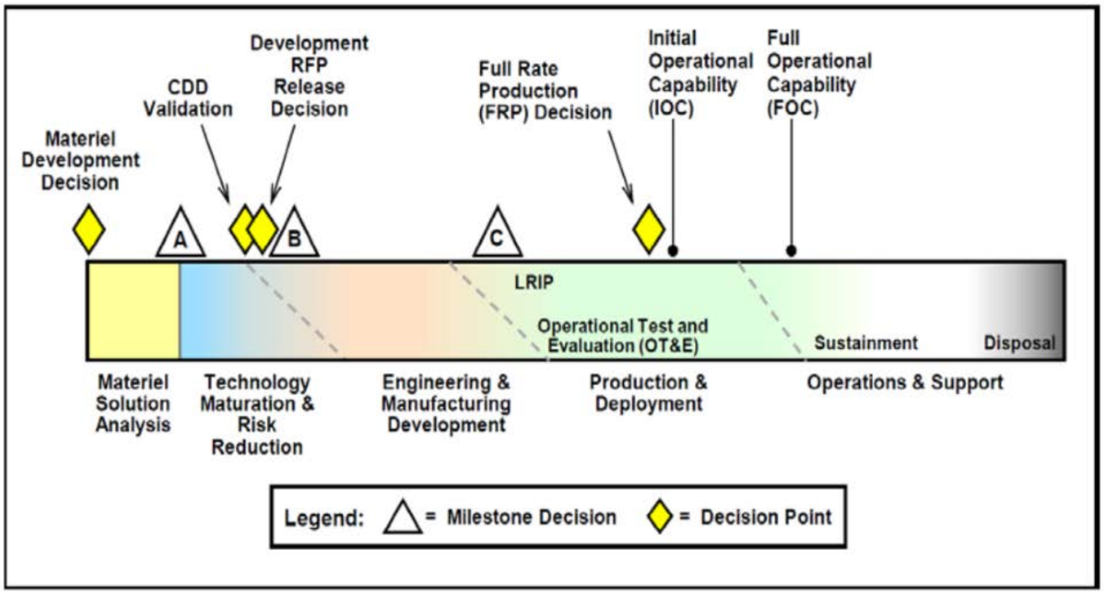


Figure 2. Hardware-Intensive DAS Process. Source: DoD 5000.02 (2017).

According to the *Contract Management Body of Knowledge* (2019), in a contracting perspective, the Life Cycle consists of three contract phases with five domains: pre-award (develop the solicitation and the offer), award (form the contract), and post-award (perform and close contract) (NCMA, 2019b).

During the Life Cycle, the contracts tend to transit from cost-reimbursement contracts, in the beginning, prior to the production phase, to firm-fixed price in the production phase. The idea is to, in the initial phase of the development process, transfer most of the business risk to the government, making the defense industry companies interested in participating in the development of new technologies. After the technological developments are completed, the risk migrates to the private sector (R. G. Rendon, class notes, January 6, 2020).

A. PHASES OF DEVELOPMENT

1. The Conception Phase

According to *DCA 400–6* (2007), the process of acquiring or developing equipment begins with the understanding and identification of a deficiency or an operational or logistical need. In Brazil, this phase commonly begins with a technological or economic "opportunity." Sometimes a country's agency orders the production of equipment, and for some economic, political, or other reason gives up buying the product, thus creating the "opportunity."

To the DoD, the conception of a system begins with the materiel development decision (MDD). AcqNotes (2018) claims, "the MDD is the point in time where the Joint Capabilities Integration and Development System (JCIDS) analysis has identified a capability gap/need, and a MDD Review has determined a materiel solution is needed. The MDD is the formal point that initiates the Materiel Solutions Analysis (MSA) Phase" (AcqNotes a, 2018 para. 1).

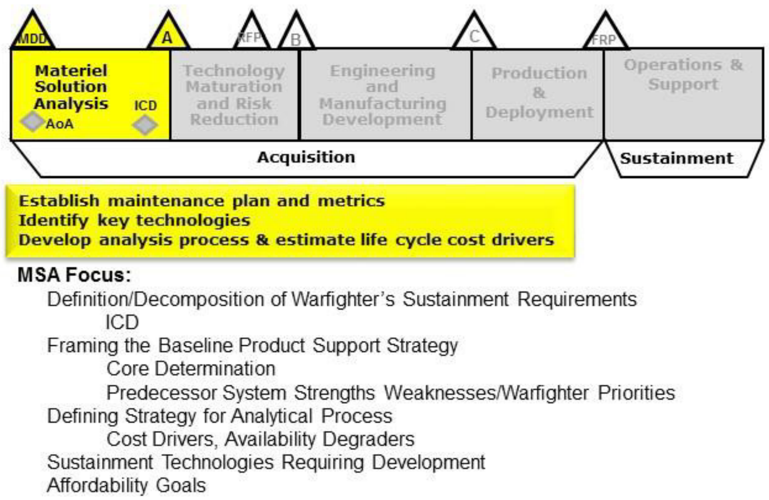
According to the DoDI 5000.2T (2020), the capability requirements change during the product Life Cycle. As the guidance states, "As knowledge and circumstances change, consideration of adjustments or changes may be requested by acquisition, budgeting, or requirements officials" (p. 8).

After understanding that a materiel solution is needed, or that a deficiency or a necessity exists, it is necessary to understand the possibilities and technologies available on the market shelf and the development possibilities to overcome the deficiency. This process is called material solution analysis.

2. The Viability/Material Solution Analysis

The material solution analysis initiates with an approved MDD. This phase corresponds to the analysis and evaluation of the various alternatives (AoA) for meeting the operational shortage or taking advantage of a technological or market opportunity, where these factors are considered: the political aspects of the program (desired degree of independence about the operation and maintenance of the system or material, technological development, maintenance of workload in industry and others); technical, economic and financial aspects and deadlines, with their various associated risks, as well as a forecast of the time required for the availability of the resources involved (human, financial and material) (DCA 400–6, 2007). The directive explains that, "the cost of the Life Cycle should be evaluated for each of the alternatives considered viable" (p. 29). AcqNotes explains that, "the Analysis of Alternatives (AoA) process is expected to contribute to the selection of a preferred materiel solution that satisfies the capability gap/need documented in the approved Initial Capabilities Document (ICD)" (AcqNotes b, 2018, para. 2).

Figure 3 describes the MSA primary focus activities. Starting with the definition of the warfighter's sustainment requirements, followed by framing the baseline product support strategy, analysis of the predecessor system strengths and weaknesses, cost drivers of the Life Cycle as well as the affordability goals of the system.



AoA = Analysis of Alternatives; FRP = Full Rate Production; ICD = Initial Capability Document; MDD = Materiel Development Decision; MSA = Materiel Solution Analysis RFP = Request for Proposal.

Figure 3. Material Solution Analysis Phase. Source: DAU (2017).

Some people may wrongly think that the Life Cycle cost analysis does not begin in the initial phases of a program, but in fact, it does. According to the *PBL Guidebook* (PBLG, 2016), the MSA phase is the first moment were the supportability and affordability of weapon systems can be influenced. The guide mentions that the MSA is the opportunity to balance the "warfighter requirements and desired operational capabilities with support and cost considerations. The Analysis of Alternatives (AoA) is completed at this time, which includes a comparison of the Life Cycle support approaches and costs" (PBLG, 2016, p. 22).

According to the *Navy Total Ownership Guidebook* (NYOGB, 2014), the analysis of alternative study of the total ownership cost should be “sufficiently detailed that it produces a differentiation of viable material solution candidates, in terms of likely life-cycle ownership cost” (p. 17, para 2). The guidebook also explains that the AoA helps to improve technical requirements, assigning a range of threshold for each requirement and performance metrics. It mentions that the AoA starts analyzing data related to ownership cost of an existing system that needs to be upgraded or replaced by the new system (NYOGB, 2014, p. 17, para 4).

It is critical in the AoA that the comparison between the Life Cycle cost of performing an-organic maintenance x outsourcing to a contractor (e.g., compare in-house maintenance versus a PBL contract). The comparison also needs to relate to the possibility of using existing infrastructures for saving cost (NYOGB, 2014, p. 17, para 4).

According to the *Defense Acquisition Guidebook*, the AoA cost estimate study should have at least:

- Maintenance strategy
- System/component weights
- Number of systems to be sustained
- Fuel usage/energy consumption
- System complexity
- Operational tempo (OPTEMPO) constraints
- Required manning to operate/maintain/support
- Transportation requirements, including storage and environmental requirements
- Planned/required future upgrades
- Software refresh schedules/licensing agreements

- Hardware refresh cycles
- Projected service life (DAU, 2017, p. 20, para. 2).

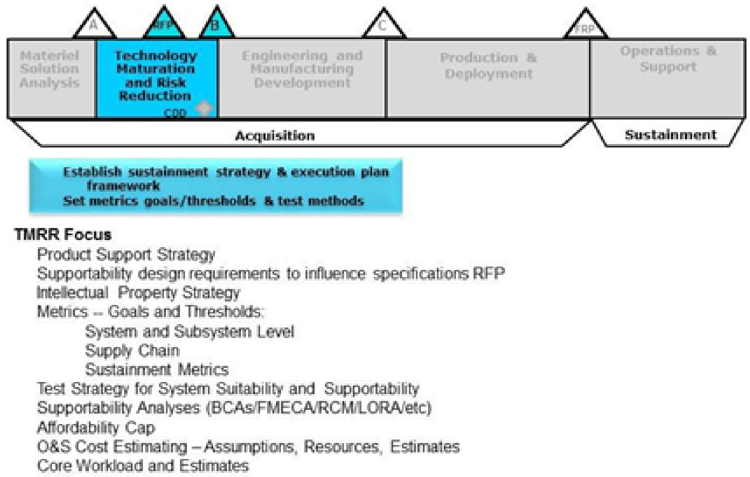
This phase ends with Milestone A, which is a go-no-go point of the process. It is considered a risk reduction moment, and the point where it is decided whether the investment is going to be made. In some cases, after analyzing all alternatives possible and the risks involved, the decision-maker may understand not to proceed with the development or acquisition of the solution.

3. Technology Maturation and Risk Reduction

The technology maturation and risk reduction (TMRR) phase is important during the Life Cycle of the project. In this phase the product that is going to be manufactured is defined, prototypes are tested, and requirements are refined or redefined (AcqNotes c, 2018).

The intent of the TMRR is to mitigate the risk of high cost Life Cycle and to place the decision-maker in a good condition to decide whether or not to take the project to the next level, which is the manufacturing development. Even though there has been a large amount of money invested in the project to this point, it is still possible to give up on the investment made and give up producing. The damage to proceed to an unstructured project or a bad project design will probably be much greater than the investment already made (R. Jones, class notes, November 18, 2019).

Figure 4 describes the major activities during TMRR. They start with creating the product support strategy, followed by supportability design for RFP, undertaking the intellectual property strategy, defining metrics, creating test strategies, doing a supportability and affordability analysis, and ending with cost and workload estimates.



BCA = Business Case Analysis; CDD = Capability Development Document; Failure Modes and Effects Criticality Analysis; FRP = Full-Rate Production; LORA = Level of Repair Analysis; O&S = Operations & Support; RCM = Reliability-Centered Maintenance; RFP = Request for Proposal; TMRR = Technology Maturation and Risk Reduction".

Figure 4. Technology Maturation and Risk Reduction Phase.
Source: DAU (2017).

The PBL Guidebook (2016) explains that,

> During the Technology Maturation and Risk Reduction Phase, supportability design features (e.g., reliability, maintainability) are incorporated in the overall design specifications, as reflected in the system requirements review (SRR) and preliminary design review (PDR). This phase is critical for establishing the life-cycle costs of the program. Maintenance and logistics support planning are coordinated with design (levels of maintenance, repair skills, support equipment, etc.). (p. 23).

In this phase, Project Management Teams are designated, offer requests are provided, bid analysis is performed, and price negotiation is performed. The selection of companies and or governmental entities are made, both for development and production, and commercial compensation requirements are elaborated (DCA 400–6, 2007). Management teams must be involved with the PBL contract requirements and metrics from the beginning of the process (R. Jones, class notes, November 21, 2019).

One important point of the TMRR is the possible simplification of complex performance requirements. According to the *Defense Acquisition Guidebook*, Chapter 4, "Life Cycle Sustainment": "The PM's focus throughout TMRR should be on mitigating the more challenging technical performance requirements (e.g., weight, power, etc.). If the program can emerge from TMRR with sufficient performance margin, the program design will be much lower risk" (DAU, 2017, p. 22).

Plans for the nationalization and technology transfer plan are also drawn up, especially for countries with little capacity for developing their technologies, such as Brazil. These are included as objects of contracts. In this phase, financing studies are also carried out (DCA 400–6, 2007). Given the complexity of the project, the government may hire companies and/or government entities to prepare the definition study, whose purpose is to determine the best option among possible alternatives.

The TMRR includes sustainment planning, which is composed of the sustainment strategy, framework and plan for analysis, product support package development, product support integrators and providers, core workload, Life Cycle sustainment plan reviews, maintenance plan, financial resource management plan, design interface, and RFP release (DAU, 2017, p. 60–81). The sustainment planning must consider if the maintenance will be performed in house, organically, or for instance, outsourced in a PBL contract (NYOGB, 2014, p. 17, para 4).

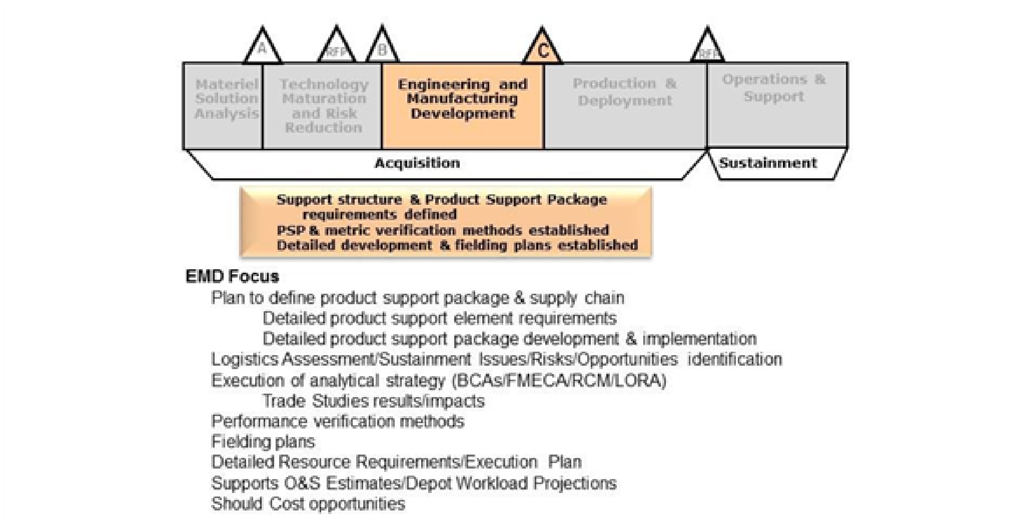
TMRR ends with Milestone B. According to the *Defense Acquisition Guidebook* (2017), many activities in the product support planning affect the Life Cycle sustainment cost directly. It also mentions that Milestone B is the "critical decision point in an acquisition program because it commits the organization's resources to a specific product, budget profile, choice of suppliers, contract term, schedule, and sequence of events leading to production and fielding" (DAU, p. 96).

4. Engineering and Manufacturing Development

This phase assures that the development or acquisition of a new system or material, or significant changes to an existing system or material follow standards that allow the delivery and implementation of a reliable system with adequate maintenance and support (DCA 400–6, 2007, p. 35).

According to the *Defense Acquisition Guidebook* (2017), the sustainment focus in the EMD phase is planning for development, testing, and delivering the product support package. The guidebook also explains that the program manager's (PM) work is not static: "As the system design matures, the PM continues to influence the design to reduce risks in reliability, maintainability, availability, and O&S Cost. The PM also conducts additional analyses to refine the Product Support Strategy" (DAU, p. 112).

Figure 5 describes the primary focus and activities of the EMD phase. It proceeds from the definition of the support package and supply chain, followed by logistics assessments, sustainment issues, risks and opportunities identification, analytical strategy, performance verification methods, fielding plans, resources requirements, execution plan, operational and support estimates, and should cost opportunities.



BCA = Business Case Analysis; EMD = Engineering and Manufacturing Development; FMECA = Failure Modes and Effects Criticality Analysis; FRP = Full-Rate Production; LORA = Level of Repair Analysis; O&S = Operations & Support; RCM = Reliability-Centered Maintenance; RFP = Request for Proposal; TMRR = Technology Maturation and Risk Reduction.

Figure 5. Engineering and Manufacturing Development Phase.
Source: DAU (2017).

EMD is the phase where all the plans and drawings start to take form. Prototypes are built and all teams involved try to finalize the project with the intent to produce in scale. Integration of different systems is also developed and refined in this phase. The integration is important to guarantee interoperability of the system and make the new system interact with other existing systems. According to the *PBL Guidebook*:

> this phase includes the establishment of initial product baseline for all configuration items. One of the PM/PSM's objectives in the EMD Phase is ensuring the program develops an integrated product support (IPS) solution that meets readiness requirements, Materiel Availability (AM) and Materiel Reliability (RM), while taking advantage of Should Cost opportunities to reduce projected O&S costs (PBLG, 2016, p. 24).

According to the DCA-400, in this phase, four major plans previously made in the Technology Maturation and Risk Reduction are executed. They are:

> 1) Execution of the Development Plan (DP) (Components, Equipment and Subsystems) where the technological research, development and product and process engineering are made, aiming the manufacture of prototypes.
>
> 2) Execution of the Nationalization and Technology Transfer Plan.
>
> 3) Execution of the Verification, Testing and Certification (VTC) plan. In cases of less complexity or for reasons of economy, this plan can be replaced by a Verification and Acceptance Plan. Prototypes are evaluated technically and operationally to verify compliance with technical and logistical requirements.
>
> 4) Development or Definition of Logistic Support (DLS) plan. This plan intends to establish how logistics will meet the operational performance requirements of the material, supporting it with the best cost-benefit ratio throughout its Life Cycle, from its entry into operation until its decommissioning" (DCA 400–6, 2007, p. 39–40).

Because of the technological dependence in Brazil, a nationalization technology transfer (NTT) plan is a prevalent practice in Brazil's acquisition strategy. Particularly for Brazil, this is one of the most critical aspects of the acquisition negotiation (DCA 400–6, 2007). Receiving the know-how to produce is a step to develop the Brazilian defense industry. This policy has been successful as this study demonstrates in Chapter IV.

Time and costs are necessary for operational tests, and charges for modifications must be considered. It is recommended for economic reasons that the initial performance-based support contract be negotiated with the development process (R. Jones, class notes, November 21, 2019).

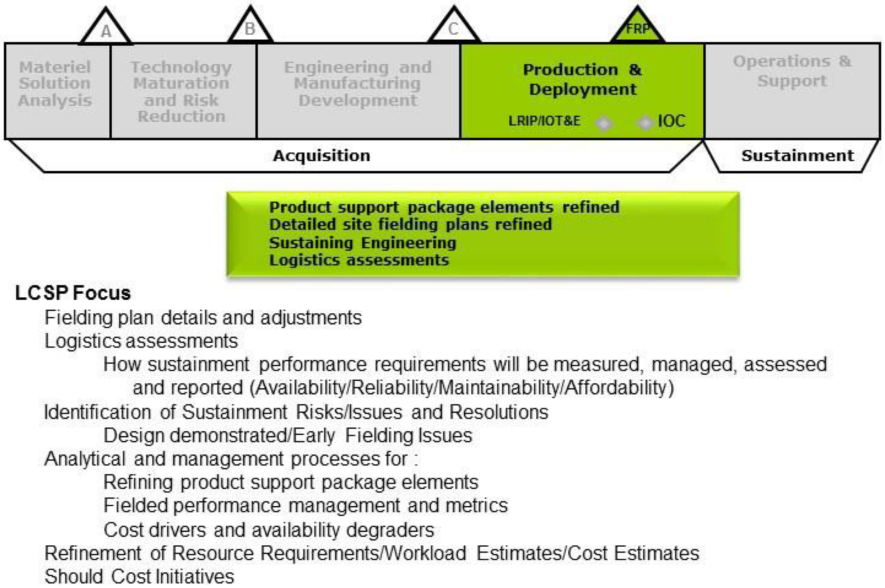
EMD ends with Milestone C, where the designs for product support elements and the support packages are finalized. Everything is ready for production.

5. Production Phase and Deployment

This phase applies to systems and materials developed explicitly for the armed forces and to systems and materials already available on the market. Special attention is given to “incorporating every lesson learned from the initial phases of implementing the product support package, refining the fielding plan, and contracting for sustainment” (DAU 2017, p. 143). According to the DAU, this is the moment where the PBL and the logistics support contract is ultimately refined.

According to the Defense Acquisition University, “the Program Manager uses the Life Cycle Sustainment Plan-LCSP during this phase to manage the program’s fielding efforts and to execute the required product support infrastructure, including PSAs, maintenance and supply capabilities, and sustaining engineering and logistics functions” (DAU 2017, p. 143). The guidebook states that during the production and deployment phase, the PM updates the LCSP according to the logistic evaluation reports (DAU, 2017).

Figure 6 describes the major focus on the production and deployment phase. It starts with fielding plan detail, followed by logistics assessments, identification of the sustainment risks, analytical and management process for support packages, performance, costs, and metrics. It concludes with the cost estimates.



FRP = Full-Rate Production; IOC = Initial Operational Capability; IOT&E = Initial Operational Testing and Evaluation; LCSP = Life-Cycle Sustainment Plan; LRIP = Low-Rate Initial Production; O&S = Operations & Support; RFP = Request for Proposal

Figure 6. Production and Deployment Phase. Source: DAU (2017).

It is reasonable to understand that the real parameters and metrics for the PBL contracts need to be adjusted when the field tests start. Before fielding tests, all actions are based on reports and technical manuals. Incentive cost types of contracts are also vital to improve the equipment's performance and the system's reliability in this phase. According to the *PBL Guidebook*:

> as products are fielded, and logistics demand can be reasonably forecasted, performance-based arrangements can be implemented. Early in this phase, shorter-term cost-type incentive arrangements are appropriate until sufficient cost data and technical data on failure modes and rates and field reliability data are accumulated in conjunction with design stability. This approach allows cost visibility through the use of a cost-reimbursable contract. It shares cost-risk via gain (or pain) share and allows for the incremental transfer of risk to the PSI/PSP. Later arrangements may use a combination of fixed-price contracts with incentives and other consideration as the design stabilizes, tailoring the contract type to the appropriate level of design maturity and stability. Longer-term fixed price-type arrangements that incentivize continuous process and product

> improvement at a reduced cost are appropriate with a reasonable ability to forecast demand and assess risk and cost impacts (PBLG, 2016, p. 17).

The production phase may also take on a more direct aspect if the country buys an aircraft, or a battleship currently produced. The production phase, in this case, will aim at a contract for the acquisition of the system or material with an offsetting clause for technological transference (DCA 400–6, 2007).

This phase may be simplified, in the case of a revitalization, modernization, or improvement of a system or material existing in the collection of the national armed forces, depending on the complexity of the necessary modifications. The technical and administrative actions are triggered to contract the execution of the activities required to manufacture the necessary tools to support the serial production of the system or material.

The production begins in what is called low-rate initial production (LRIP), in order to avoid issues in the full-rate production (FRP), where the cost of a mistake is increasingly harmful. Production phase industries receive full support, in the form of technical and managerial guidance, aiming to reach the levels of contractual quality and their certification. Such guidance may include technical assistance, technology transfer, and training, with the program officer involvement. (R.G Rendon, class notes, January 15, 2020). Each phase of the process may rely on a specific type of contract. Industrialization may be the subject of a specific contract as well, with cost estimates and forms of costs raised during the development and acquisition phase, in preparation for launching the production phase.

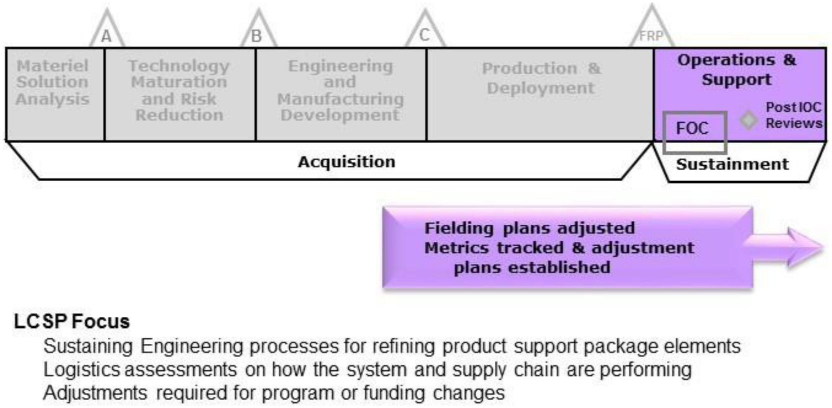
According to Perez, Urbina, and Damiani, "when the deployment starts, all measures are taken to ensure that the new material is received, stored, distributed, used, and maintained in operation, within the conditions foreseen for its performance" (Perez, et al., 2009, p. 32). The sectoral implementation plans must be executed in the following order: employment support plan, supply and maintenance plan, infrastructure plan, operation plan, human resources adequacy plan, and human resources training plan (DCA 400–6, 2007).

6. Operations and Support

This phase comprises operational and logistical activities, covering the monitoring of the system or material performance throughout its Life Cycle, from its warranty period, or logistical support contract (LSC), until its deactivation (DCA 400–6, 2007). During this period, actions are taken to standardize the operation, record the parameters necessary to assess performance and life expectancy, and view future proposals for revitalization, modernization, or improvement. It is always important to understand the focus of the Life Cycle planning, which is to support the warfighter with desired capabilities in an affordable manner.

The operation phase is when all involved in the system are using and monitoring the capabilities and performance. The PM has high responsibility and needs to act fast to provide the changes necessary to achieve the mission goals. According to the DAU, "after production, as the product support strategy is executed, the PM monitors the performance of the operating system and identifies risks and issues to continue to achieve the warfighter's sustainment goals affordably" (DAU, 2017, p. 159). The PM analyzes data, monitors performance, opportunities, risks, and conduct analysis to find the best action to improve the system continuously (DAU, 2017).

Figure 7 demonstrates the primary focus in the operation and support phase. This phase starts refining the product support package to the field reality, accessing the system and the supply chain, and making program and funding adjustments.



FOC = Full Operational Capability; FRP = Full-Rate Production; IOC = Initial Operational Capability; LCSP = Life-Cycle Sustainment Plan; O&S = Operations & Support

Figure 7. Operational and Support Phase. Source: DAU (2017)

In this phase, actions are carried out to monitor the performance of the items under the manufacturers' warranty or supported by the contracted logistic support based on performance (PBL). Because systems typically last many years or decades, the PM plays an important role in keeping the system operating and sustainable. According to the PBLG, "the Operations and Support phase of a system or product Life Cycle is the most extended phase of the Life Cycle. It generates the most significant portion of LCC—approximately 60–75 percent depending on the weapon system category" (PBLG, 2016, p. 25).

In cases where new technologies are used, whose reliability is not known, a model for monitoring the reliability of the material should be required in the contract. It is necessary for close monitoring during contractual execution to verify that the technical-logistical requirements and supplies are consistent.

Reliability has a vital priority on systems development because a reliable system reflects a high system's availability. If reliability increases, the cost with maintenance during the Life Cycle decreases. On the other hand, it is exponentially costly to increase reliability during project development (i.e., creating redundancy or using better-quality materials). It is a trade-off. (E. Dahel, class notes, January 16).

It is expensive to keep availability at high rates. Close monitoring in the contractor's activities is important because the contractor may relax the standards and metrics to reduce cost. According to the U.S. Government Accountability Office (GAO), the work performed in the previous phases of the system development also has a direct impact on the operational availability of the system operation. It mentions that "Programs can achieve operational availability by building reliable weapon systems or, if the systems are not reliable, supporting them with an extensive logistics system that can ensure spare parts and other support items are available when needed" (GAO, 2020, p. 11).

In PBL contracts, the performance metrics, and other indicators that can assist in the decision of contract extension or migration to organic maintenance must be carefully monitored.

7. Revitalization, Modernization or Improvement Phase

This phase's objective is to introduce or change technical and logistical characteristics in the systems or materials in use in the armed forces. It can also update them or adjust their performance and specific requirements that did not exist at the time of the acquisition of these materials or systems (DCA 400–6, 2007).

According to Perez, Urbina, and Damiani, "from the identification of an operational need arising from the exhaustion of the useful life of a Material or System, obsolescence of components, or the appearance of a technological or economic opportunity, a new list of operational needs is considered" (Perez et al., 2009, p. 36). Then, the process for modification or modernization starts, and it follows the steps already mentioned in the previous phases.

According to the DAU:

> During the O&S Phase, a program may require modifications to meet emerging requirements, improve performance, address safety issues, reduce operating costs, or extend operational. Additionally, modern acquisition programs are dependent on technology and thus may require technology refresh and insertion at a higher rate than legacy systems. Across DoD, the definition of modification varies from the replacement of a component to an MDAP-sized investment. (DAU, 2017, p.192)

8. Deactivation Phase

This phase includes studies and actions for withdrawal from service and the disposal of the system when they are close to end of the Life Cycle. If there is economic viability, the system can be sold. Procurement and maintenance work is reduced to the minimum necessary. At the beginning of this phase, the substitute material or system, when applicable, will already be available in the Production Phase. If there is economic viability, the system can be sold. If the Material is not subject to disposal, proceed to its destruction.

B. LIFE CYCLE COST

One of the goals of using PBL is making a positive impact in the Life Cycle management, especially reducing the cost incurred for the maintenance of the systems. It is not an easy task to evaluate the maintenance costs across the life of a system, and it requires expertise and knowledge related to cost management and Life Cycle management, already detailed in this chapter.

According to the *Defense Acquisition University* (DAU):

> ASD (L&MR) chartered a study in the fall of 2010 to analyze the impact of PBL on Life Cycle Costs (LCC), as compared to non-PBL sustainment arrangements. The "Proof Point" study concluded that, when properly structured and executed, PBL arrangements reduce the Services' cost per unit-of-performance while simultaneously driving up system, subsystem, or component readiness. The study further estimated that an average annual cost savings or avoidance of 5–20 percent is possible for programs with generally sound adherence to the PBL tenets. (DAU, 2017, p. 6)

The Defense Acquisition University (DAU) defines Life-Cycle cost as the direct cost of the acquisition program, as well as the indirect cost that can be logically attributed to the program over the entire Life Cycle ("Life Cycle Cost," n.d.). Therefore, all costs should be considered, including acquisition costs, operational costs, support costs, and disposal costs.

The U.S Navy typically looks to Life Cycle cost in a broader way, which is important to highlight. Instead of focusing on the Life Cycle cost management, their approach is to the total ownership cost. The Navy *Total Ownership Cost Guidebook* clarifies this idea. It explains that, "For program management, TOC should be viewed as an expansion of the earlier Total Life Cycle System Management (TLCSM) decision-weight paradigm, since the goals of TOC and TLCSM are the same" (NYOGB, 2014, p. 7). The idea is that the total ownership cost (TOC) is related to enterprise-wide governance, and the focus in cost control is not only inside the government, but with the outside stakeholders (NYOGB, 2014).

As there are many stakeholders involved in the Life Cycle of a system, there are many perspectives to analyze the life cycle cost (LCC). According to George and Ledbetter (2019), "These multiple perspectives have led to three different methods of breaking down and displaying LCC" (p. 10). These authors mention that the first method is the preferred one for the Congress to use in the budgeting process. It is divided into five different appropriation categories ("Life Cycle Cost," n.d.): research, development, test, and evaluation (RDT&E); procurement; operations and maintenance (O&M); military construction (MILCON); and military personnel (MILPERS).

George and Ledbetter (2019) also explain that the second method uses the work breakdown structure (WBS), and program managers prefer it. DAU describes a WBS as a framework that displays "the total system as a product-oriented family tree composed of hardware, software, services, data, and facilities" ("Life Cycle Cost," n.d., para. 5), and this method details the relationship between the different components of a system and their costs (George & Ledbetter, 2019).

Finally, the third method is defined by the U.S. Office of the Secretary of Defense (OSD) for cost assessment and program evaluation (CAPE) in its *Operating and Support Cost-Estimating Guide* (OSD CAPE, 2014). For them, the LCC should be divided into four phases: research and development (R&D), investment, operating and support, and disposal. Figure 8 presents a graphic of the organizations of LCC using this method (George & Ledbetter, 2019).

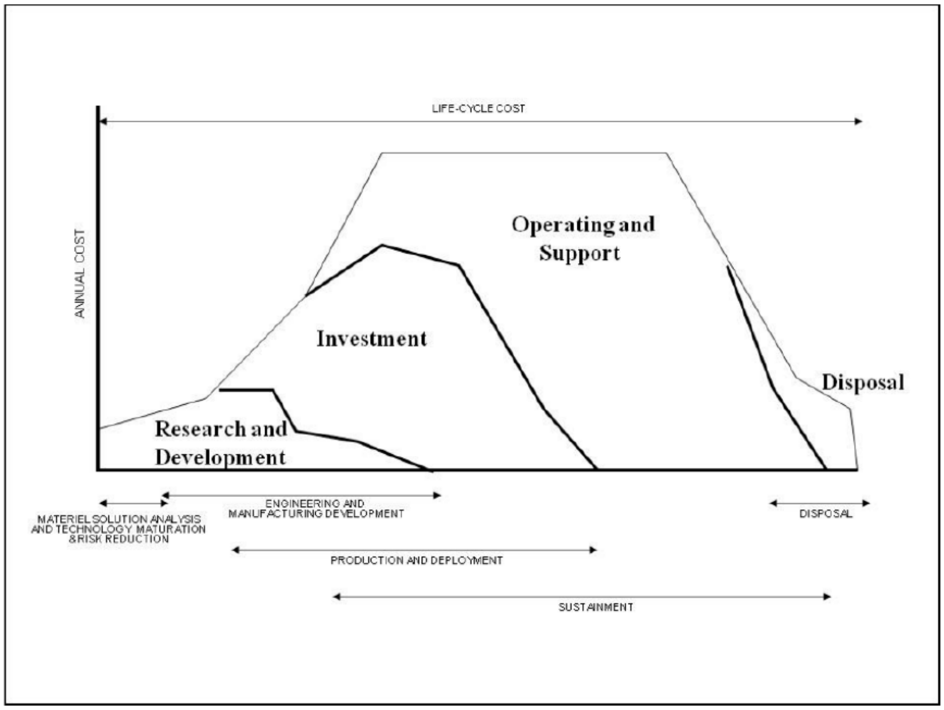


Figure 8. Notional Profile of Annual Program Expenditures by Major Cost Category over the System Life Cycle. Source: OSD CAPE (2014).

The Navy *Total Ownership Cost Guidebook* describes the four phases of the Life Cycle cost, fitting them on the Life Cycle time very well. First, it explains that R&D costs consist of all expenses from the conceptual phase through the end of the system development and demonstration phase. It mostly gets into the LRIP (NYOCG, 2014, p. 8). It explains that R&D typically includes costs of:

> concept refinement trade studies and advanced technology development; system design and integration; development, fabrication, assembly and test of hardware, and software for prototypes and/or engineering development models; system test and evaluation. System engineering and program management; peculiar and common support equipment; peculiar training equipment/initial training; technical publications/data and initial spares and repair parts associated with prototypes and/or engineering development models/ (NYOCG, 2014, p. 8)

It follows explaining the important aspects of the investment phase. It mentions that Investment costs involve all the production and deployment expenses from the LRIP through completion of deployment (NYOCG, 2014, p. 9). According to the NTOGB, typically investment costs include costs associated with:

> producing and deploying the primary hardware; system engineering and program management; peculiar and common support equipment; peculiar training equipment/initial training; technical publications/data; initial spares and repair parts associated with production assets; interim contractor support that is regarded as part of system production and is included in the scope of the acquisition program baseline; and military construction and operations and maintenance associated with system site activation. (NYOCG, 2014, p. 9)

This same guidance also gives details about the operating and support phase. It explains that O&S costs involve all expenses from initial system deployment through the end of system operations (NYOCG, 2014, p. 9). It includes the operating costs, maintenance, and field supporting cost. In greater detail, according to the NYOCG, the O&S consist of the cost related to "personnel (government and contractor), equipment, supplies, software, environmental costs including environmental permits and hazardous materials management, energy expenses including acquisition, storage and transportation, and services associated with operating, modifying, maintaining, supplying, training and supporting a system in the DoD inventory" (NYOCG, 2014, p. 9).

The same document finally explains the costs associated with disposal. It notes that disposal costs are all costs related to the demilitarization and the disposal of a military system when it reaches the end of its operational life (NYOCG, 2014). It mentions that, commonly, the costs related to the execution of the demilitarization are not well estimated. It is important to be done well because, in some cases, it represents a significant amount of money. (NYOCG, 2014). "Costs associated with demilitarization and disposal may include disassembly, materials processing, decontamination, hardware, collection/storage/disposal of hazardous materials and/or waste, safety precautions, environmental considerations and transportation of the system to and from the disposal" (NYOCG, 2014, p. 10).

The third phase, operating and support, represents the majority of the LCC because, according to George and Ledbetter (2019), "it consists of all of a system's operation and sustainment costs from initial deployment to the end of its operational life" (p. 17). It is in this phase that PBL plays a significant role. At this point, PBL contracts generally reflect considerable cost savings, because it is possible to use contractual incentives to improve metrics, consequently improving the maintenance process (R. G. Rendon, class notes, January 6, 2020).

Finally, although the third phase represents the major costs, the second phase, the investment, which accounts for the costs of procurement, also has a positive impact by the utilization of PBL. The positive reflects typically occurs when the purchase of a new system is integrated with a logistical support contract, based on performance Life Cycle, for the first years of operation.

III. LITERATURE REVIEW ON PBL CONTRACTS

A. PERFORMANCE BASED CONTRACTS

In the contracting environment, there are various methods and tools available for contracting personnel, and the decision of which to use depends on the type of product or service that is necessary for the organization. Those responsible for the contracting processes have to be aware of the tools available to optimize the process and achieve the best results for the organization. One of these tools is performance-based contracts (PBC). According to Comello Machado, in *A systems approach to performance-based logistics (PBL) applied to warships support* (2018):

> Performance Based Contracting is defined as a product support strategy utilized by Program Managers (PM) to achieve measurable war-fighter selected performance outcomes for a weapon system or subsystem. PBC utilizes performance outcomes such as availability, reliability, maintainability, supportability and total ownership cost. The primary means used to accomplish this end are incentivized, long-term performance-based contracts with specific and quantifiable levels of operational performance as defined by the user. (p. 4)

Brown, Potoski, and Van Slyke (2009) specify the logic of performance-based contracting as offering bonus payments to incentivize the seller to perform beyond what is explicitly stated in the contract. For these authors, the situations that require this contracting method are when it is possible to have lower costs or improve performance.

According to Lucyshyn, Rigilano, and Safai (2016), under traditional sustainment strategies, the buyer is responsible for purchasing spare parts, tools, repairs, and data in individual transactions. However, using PBL contracts, the buyer transfers the inventory management, supply chain management, and technical support to a contractor, which will have to perform according to predetermined levels to meet desired outcomes. One of the primary goals of the contracting team is to reduce the downtime of the system and increase its reliability.

The *PBL Guidebook* (DoD, 2016) mentions three necessary primary arrangements that the PBL contract must have to achieve the desired outcomes. First, the requirements must be described in terms of outcomes instead of the methods that the contractor should adopt. Second, it is necessary to use measurable performance standards in regard to time, quality, quantity, and other factors, and they must be achievable and independently verifiable. Finally, some penalties must exist when the services are not performed according to the expected levels.

Kratz and Buckingham (2016, p. 21) have a similar approach for this type of contract. They define outcomes-based service contracting (OBSC) as "a contracting mechanism that allows the customer to pay only when the contractor has delivered outcomes, rather than merely for activities and tasks." Therefore, the focus of this strategy is to incentivize the contractor to invest and improve its capabilities, which will make it able to deliver the best outcome for the buyer.

By achieving a win-win type of relationship between government and contractor, there are several benefits of the OBSC's utilization. According to Kratz and Buckingham (2016, p. 21), "OBSC has an ability to produce preferred performances arising from the incentives within the contract, consequently reducing the long-term cost of the contract for the customer." In the same article, these authors also provide a summary of the benefits of OBSC use for the DoD and the industry. Figure 9 shows that it is possible to emphasize lower servicing and transaction cost for the DoD side, and opportunities for greater control, efficiency, and innovation for the industry side.

Outcomes Based Service Contracting	
DoD/Services Benefits	**Industry Service Provider Benefits**
Efficiency and predictability gains from paying for outcomes: By only paying for a measurable specified outcome that is predictable, DoD and the Services will able to make more accurate cost projections.	**Effectiveness, which breeds efficiency and security:** If payment of service providers is dependent on delivering measurable outcomes, there is greater motivation for service providers to perform high-quality work.
Lower servicing costs: OBSC lowers total contract costs as both the DoD and industry contribute complementary resources toward a joint outcome.	**Opportunities for greater control and efficiency:** OBSC involves a closer relationship between industry and the DoD. As a result the industry is more able to optimize and control outcome delivery, maximizing opportunities to reduce the cost of performance while still achieving acceptable outcomes.
Lower transaction and monitoring costs: Better alignment between the interests of the DoD/Services and industry and guaranteed outcomes means that less scrutiny of industry is required and internal DoD costs related to ensuring the outcome may be cut or reallocated.	**Opportunities for innovation:** Industry can use their first-hand experience of working alongside the DoD to drive innovation that meets DoD/Services' changing requirements. New processes required to deliver OBSC may also prompt internal innovations, such as the empowerment of cross functional service teams spanning multiple organizations.
Increased motivation of industry service providers to provide high quality outcomes: If payment to industry is dependent on delivering measurable outcomes, there is greater motivation for service providers to perform high-quality work.	**Sustainable competitive advantage:** Managing customers to optimize co-creation and co-production effectively is an integral part of successful OBSC. Service providers that become adept at customer management can develop a unique competitive advantage, providing more opportunities for the service provider to win contracts.

Figure 9. Benefits of the OBSC`s Use. Source: "Future Contracting for Availability." Source: Kratz and Buckingham, (2016).

B. PBL CONTRACT DEFINED

According to Comello Machado (2018), in PBL contracts, by purchasing the outcomes instead of the assets or services themselves, the supporting activity becomes a problem to be dealt with by the supplier/contractor. The contractor now should have all the incentives necessary to perform in the most efficient way possible, being unable to ignore the through-life support of what they deliver.

Different from traditional approaches, PBL contracts incentivize (and demand to work well) the co-creation of value (Ng & Nudurupati, 2010). A study from Nullmeier, Wynstra, and Raaij (2016) shows that the customer assumes more roles than just monitoring, rewarding, and punishing the contractor's performance(e.g., by giving access to important assets to perform the required services). This role and others performed by the customer make it a very different approach when compared to the traditional paradigm, where the customer is basically the end user of the product or service.

The *PBL Guidebook* (DoD, 2016) presents the definition and emphasizes the importance of the outcomes instead of "how" the services will be provided:

> A PBL arrangement is not synonymous with Contractor Logistics Support (CLS). CLS signifies the "who" of providing support, not the "how" of the business model. CLS is the support provided by a contractor, whether the arrangement is structured around Warfighter outcomes with associated incentives or not. PBL arrangements, on the other hand, are tied to warfighter outcomes and integrate the various product support activities (e.g., supply support, sustaining engineering, maintenance, etc.) of the supply chain with appropriate incentives and metrics. Besides, PBL focuses on combining best practices of both Government and industry. (p. 6)

C. PBL APPLICABILITY

The first question that contracting officers ask about performance-based logistics contracts probably is, "in which situations should we use them?" It is possible to use PBL contracts in a wide range of services with simple and complex contracts. An example of the usage of PBL with a simple contract is the service of cleaning the air base bathroom. It can be easily set as a PBL with well-defined inputs, outputs, and outcomes. On the other hand, at the same air base, the PBL contract can be used in a complex contract like the development of a nuclear weapon, with not well-defined inputs, outputs, and outcomes.

It is possible to notice the benefits of using this contracting approach in various situations. One type of situation is when the product or service is not complicated, but the market can have more efficient solutions not limited to just purchasing. Lucyshyn and Rigilano (2019) mention a case where the U.S. Navy had an aircraft tires inventory but preferred to make a PBL contract to reduce the cost of buying them. Compared with the traditional support, the PBL contract had a lower raw material level. Besides the cost reduction, the contract reduced lead-times and increased availability of the items. This case was not a contract just for delivering tires, but instead for several supply chain services, including demand forecasting, order fulfillment, inventory management, and commercial carrier management.

PBL contracts are just one type of performance-based contracting, and even though this tool applies for simple and complicated contracts, generally, this contracting type is a tool to deal with complex purchases. In those situations, it is common not to know precisely the requirements of what is being purchased. It is possible to know the outcomes to be achieved, and the performance measurements help to evaluate the level of achievement.

Identifying whether a contract is simple or complex is not an easy task, because many factors will help to differentiate them. Knowing how to identify them is the first step, even before the decision of using or not using performance-based contracts. Therefore, the next topic of this chapter focuses on the several differences between simple and complex contracts.

D. SIMPLE VS. COMPLEX CONTRACTS

Discussing the complexity of contacts, it is possible to classify them as simple or complex, in terms of products, exchanges, and the written contract itself. Simple products are the products that are well defined, and the cost, schedule, and performance targets are easy to identify. Simple exchanges have a high level of certainty, low specialized investments, and there is no lock-in relationship between buyer and seller. The written contacts themselves are complete, with the full description of the trades, with a win-win type of relationship and with low flexibility for changing.

On the other hand, complex products are not well defined. Brown, Potoski, and Van Slyke, in *Complex Contracting* (2013), mention that complex exchanges lack certainty, that both parties do not know all the product's requirements and details, and therefore have difficult communication about the product. The purchaser may know what the product needs to do or perform, but does not know how to design it properly. It is necessary for specialized investments by both parties to develop the product. After the initial investments, both parties are locked into the agreement because the cost of leaving the business is too high.

Brown, Potoski, and Van Slyke (2013) also say that the complex written contracts are incomplete, because many things are going to be agreed upon during the development, and because it is impossible to forecast all steps of the process (it would be costly). These facts lead the contract to be more flexible. There is also a low probability of win-win, which represents one of the most considerable difficulties in dealing with complex contracts.

As discussed in Chapter II, if we are on the left side of the Life Cycle, in Milestone A, we will probably be discussing a complex contract. As we go to the right of the life cycle, in Milestone C, contracts become simpler, typically firm fixed price contracts.

The challenge of a complex contract, with the lock-in dependence, is to keep both parties motivated to adopt win-win behavior. With the conditions of complex contracts, there is a low probability of a win-win relationship because of the asymmetric information each party has. The contractor typically better understands many details of the product, especially the production process. The DoD understands better issues related to the budget and internal processes. In a complex contract, it is impossible to cover everything. As a result, there is a lot of gray area that makes it possible for both sides to have discretionary behavior.

Brown, Potoski, and Van Slyke (2013) mention that to avoid unwanted behavior and make the contract valid, the primary tool used in complex contracts are the governance rules, which is a set of standards describing what are consummate or cooperative behavior and perfunctory or non-cooperative behavior. To be successful, according to Brown, Potoski, and Van Slyke, governance rules must accomplish a few goals. First, they must determine conduct standards that makes it possible for both parties to identify perfunctory and consummate behavior. Second, they must present means for both parties to diagnose whether the behavior is perfunctory or consummate. Finally, they have to create an arrangement of incentives and sanctions to motivate consummate behavior.

E. INFLUENCE OF THE AGENCY THEORY IN PBL CONTRACTS

There are several theories that influence the performance and outcomes of contracts and an important one is the agency theory. Rene G. Rendon, in *Critical Success Factors in Government Contract Management* (2010), explains how this theory is applied to contracts:

> A contract between the government and a contractor reflects a principal-agent relationship. The principal (government) contracts with the agent

> (contractor) to perform some level of effort. In this relationship, the government's objectives include obtaining the product or service at the right quality, right quantity, right source, right time, and at the right price. Contractors, on the other hand pursue the objectives of earning a profit, ensuring company growth, maintaining or increasing market share, and improving cash flow, just to name a few. Agency theory is concerned with the conflicting goals between the principal and agent in obtaining their respective objectives and is focused on mechanisms related to obtaining information, selecting the agent, and monitoring the agent's performance. (p. 04–05)

PBL contracts have some challenges to overcome. One of these challenges is how to deal with the agency theory, this critical economic theory is related to resolving conflicts between the government (principal in this theory) and contractor (agent in this theory). Therefore, the purchaser must design the contract with conditions that incentivize the contractor to share all the necessary information, and also create transparency for both parties. There is a more substantial need for adequate internal controls and capable surveillance of the provider.

Brown, Potoski, and Van Slyke (2013) mention that in complex contracts a discretionary area appears and there is no assurance about all the level of accomplishment of the performance metrics during the contract execution. Hence, a good PBL contract must be well designed with useful logistics metrics, proper cost evaluation, and incentives and sanctions to avoid that both parties enter in a conflict of objectives.

F. RISK MANAGEMENT IN PBL CONTRACTS

One of the most significant differences between a PBL contract and a traditional contract is that the risk management works differently. Comello Machado (2018) summarizes this difference and explains the reason that PBL represents a shift of risks:

> Although PBL presents itself as a great opportunity for contractors to increase profit margins, such attractiveness comes at the cost of increased risk for them. As opposed to a traditional contract (where after the purchase of an equipment, the client is accountable for dealing with the consequences of its usage, e.g., deterioration, obsolescence), when under a PBL agreement, the client pays for a set of desired outcomes. It is then the contractor's job to find the best way to deliver these and to solve the problems that might occur along the way. (p. 11)

Because both parties are locked in with each other, potential risks can influence the performance of the contractor and also the customer's outcomes negatively. According to Comello Machado (2018), it is possible to consider PBL as a creator of risk shifting, and the risks can arise due to the nature of outsourcing and affect both client and contractor. These risks can be grouped into three classes: operational risks, related to the decrease of quality or the increase of costs, strategic risks (e.g., security issues, loss of privacy), and composite risks, related to the long term consequences of such an approach (e.g., loss of proficiency in the outsourced activity).

The solution for this complicated risk management can be the increase of frequency of measurements and evaluations in the performance of the contract. Both parties must be in the same place and transparent with each other, which would make both of them able to react when a potential risk becomes real and can influence the contract outcome. Efficient surveillance will be responsible for monitoring the risks, and an action plan has to be developed by both parties to mitigate the risks.

G. SOME ADVANTAGES AND OBSTACLES

According to Jester, Ferguson, and Bussier (2010), one of the differences between the PBL type of contract and the standard approach relates to the payment. They used the terminology "pay me now, pay me later" to differentiate the moment and amount of money spent in both situations.

As the authors state: "In the standard approach to contract writing, services and spares are purchased post-production as needed. Because the costs for future services and parts are not added to the contract's overall cost, the starting contract cost is reduced. This, in turn, lowers the budget allocated to the contract and allows the unused money to be spent on other program needs." (p. 08). This factor causes short-term money availability in the standard approach, which represents a disadvantage for the PBL contract.

However, in PBL contracts, the money spent upfront can turn to a long-term advantage, due to the contractor's obligation to support and provide a system's spares for the full life cycle. Jester et al. (2010) mentioned that "the money (and perhaps the time) that would have to be spent in the future is eliminated because it becomes the contractor's responsibility to determine how the system will be supported. The contractor can manufacture a large surplus of spares and stockpile them for the future, maintain (or mothball) a small production line to satisfy future demand, and build a reliable product that minimizes (or eliminates) the need for the first two options."

According to the *PBL Guidebook* (DoD, 2016), another advantage is the possibility of one PBL contract replacing several traditional contracts. It can represent a reduction of bureaucracy, decrease administrative costs, and can increase the control over the contractor. The centralization of several contracts in one requires a capable and bigger team to manage all the phases of contracting, pre-award, award, and post-award phases.

Although PBL contracts have various benefits, they also have several obstacles to be overcome due to the complexity of this method of contracting. Comello Machado (2018) pointed out five significant issues that can appear:

- the resistance of the client to change paradigm, who often tries to micromanage the contractor;
- the lack of specific PBL training;
- the contractor's difficulty in correctly assessing the involved risks;
- the high amount of risks involved in relying on the contractor;
- the client's loss of expertise, leading to the dependency on the contractor. (p. 13)

Another concern is the application of PBL contracts during wartime. According to Comello Machado (2018), war and crisis situations in general require the support of defense equipment to be delivered by military personnel, because there are practical or legal obstacles for civilians to perform such support. Besides, even when civilians are allowed to act for specific activity, they might require protection from the military, being an additional burden to manage.

This chapter mentioned some general characteristics of PBL contracts, including the benefits and disadvantages of its utilization. To complement the understanding and the best ways of using this contracting tool, Chapter VI of this project addresses best practices that can be used to avoid the issues mentioned and others that can appear during the execution of a PBL contract.

IV. BACKGROUND ON BRAZILIAN DEFENSE SECTOR

The Brazilian defense industry differs from that of the United States. It is important to familiarize the reader with Brazil's dependence on the development of technology outside the country, and to highlight the advances achieved in recent years to reduce this dependency. The use of PBL contracts depends on national or international industries for their execution, and Brazilian domestic defense industry is an important stakeholder in this process.

From the 1990s through the 2010s, the Brazilian defense industry has had several different momentum shifts, with changes caused mainly by political instability and the difference between the goals of the various administrations. Some challenges and opportunities remain the same and depend on financial investment and government focus.

Different from Brazil, the United States has traditionally incentivized the defense industry and the industry has written this concept into their guidebooks. For example, the *PBL Guidebook* (PBLG, 2016) explains that the U.S. government and American industry share mutual interests. The *Guidebook* discusses the interdependence between government and industry. As the *Guidebook* states, "The contractors depend on the DoD for a substantial portion of their business, while the DoD depends on this specialized group of industry providers (weapons, telecommunications, information, etc.) to support the Warfighters. This relationship is simultaneously cooperative and adversarial" (PBLG, p. 18).

Although, in Brazil, this relationship works the same way, the industry is not as developed as the American. According to Gouvea (2018), one of Brazil's significant challenges is to force foreign defense companies to transfer technology to Brazil and to use local domestic companies to produce and assemble defense hardware and software. Another challenge for Brazil lies in redirecting the expenditures to invest more in new defense systems or modernize the current ones and spend less money by operating with fewer personnel. To illustrate, while Brazil uses more than 64% of the defense expenditures with personnel and staff and less than 10% with investments, the United States spends only 25% of the defense budget, with personnel around 16% in investment (Gouvea, 2018).

The Brazilian technology dependence appears in the development of new military defense systems. The challenge of importing technology or developing the national industry is that it needs substantial financial resources. The Brazilian government is trying to overcome dependency and trying to develop the national industry by investing in the acquisition of new submarines and aircraft with technological transference (Marinha, 2018).

In the Brazilian Navy, the development and construction of the nuclear propulsion submarine SN-BR, with French technology, is the result of a technology transference contract. The Brazilian Submarine Development Program (PROSUB) includes the construction of four other submarines with conventional propulsion, a Metal Structures Manufacturing Unit and Shipyard, and a naval base (Marinha, 2020).

The nationalization of production encompasses 104 sub-projects. It represents €400 million in offsets including the transference of technology, know-how and training (Marinha, 2020). Orders of systems, equipment, and components for the construction of conventional submarines with the national industry total €100 million. This same amount is the minimum expected for the nationalization of equipment and components for the SN-BR (Marinha).

Another important project is the acquisition of four Tamandaré-class corvettes, which will have the German ThyssenKrupp Marine Systems leading the consortium to build the ships under a transfer of technology agreement (Marinha,2020). The Brazilian companies Atech and Embraer Defense & Security are the principal national manufacturer receiving the technology. Based on this transfer, the BN and the national industry will have the technology to produce its next-generation corvettes (Marinha). The delivery of the first corvette will be in 2024 and the last in 2028.

For the projects mentioned, the Brazilian industrial segment was called upon to evaluate what could be produced in the country, including engines, electric propulsion systems, compressors, batteries, radars, periscopes, and components. Metal structures and civil engineering was also involved (Marinha, 2020). In some cases, the product was already available on the national market. In others, similar products were found, and the supplier was able to make the necessary adaptations. However, there were situations in which Brazilian companies needed specific training to meet the program's demand (Marinha, 2020). For the construction of the Metal Structures Manufacturing Unit and the Shipyard Naval Base, more than six hundred Brazilian companies were involved, which guaranteed the nationalization of 95% of the components and systems leveraging the national industry (Marinha, 2020).

In the Brazilian Air Force, the most recent acquisition with transference of technology is the Swedish-made combat aircraft Gripen. The ability to design and build fighters will be transferred (FAB, 2019). Embraer will assume a leadership role in the transference of technology, becoming the national manufacturer able to produce competitive combat airplanes. There will also be other Brazilian companies, such as AEL, Akaer, Atech, and SBTA, in the manufacturing process. It will be a technology leap, not only for Embraer but for the Brazilian industry in general (EBC, 2019).

Brazil will also participate in the development of the Gripen NG, a different version of the aircraft, and be responsible for the development of the version for two pilots. The Brazilian order involves 28 single-seater units (for one pilot) and 8 aircraft of two-scatter airplanes (for two crew members) (Infodefesa, 2020).

Despite the difficulties, the Brazilian industry has evolved over the years with the development of Embraer. This state-owned company was born in 1969 and privatized in 1994 (BBC, 2018). After privatization, the Brazilian government retained interest through possession of golden shares, which gives it veto power in critical decisions. The company has continued to win government contracts (World Bank Group, 2006).

Just over ten years ago, on April 14, 2009, the Brazilian Air Force and Embraer signed a contract for the development of the KC-390 aircraft (ASAS, 2019). The project was born from the desire to develop an airplane on Brazilian soil capable of replacing, with advantages, the Lockheed C-130 Hercules, one of the most successful aircraft in the history of aviation, with more than 2,500 units sold to more than 60 countries (Flight Global, 2019).

In 2013, after four years of project development, Embraer and Brazilian Air Force (FAB) concluded the critical review of the project (when the aircraft design is effectively approved, as well as details of its architecture and systems). In addition to Embraer, eight other Brazilian companies engaged in the development of the freighter: AEL Systems, Eleb, LH Collus, Aerotron, Aernnova, Alestis, Sobraer, and Akaer (ASAS, 2019). One of the main challenges was Fly By Wire, a system where the aircraft is controlled by software. The KC-390 has no cables, springs, and rods to transfer the movements that the pilot commands on the plane to the control surfaces. All information is processed on computers that send the displacement orders directly to the actuators on these surfaces (ASAS).

On October 21, 2014, the prototype was publicly presented in Gavião Peixoto, Brazil. The ceremony called “roll out” marked the completion of a project and the start of real test phases, ranging from a simple run on the track to a high-performance landing (Defense Aerospace, 2014). The first flight took place on February 3 of the following year. At that stage, more than 50 Brazilian companies participated in the initiative, in addition to companies from Argentina, Portugal, and the Czech Republic (ASAS, 2019).

On October 9, 2019, the first series-production unit flew, which was delivered to the Brazilian Air Force in September 2019. The aircraft was extensively tested in Brazil and abroad. At the current stage, there are about 100 companies involved in the aircraft production chain. The partnerships already brought financial results to Brazilian companies, both for the contracts with the Brazilian Air Force and for other countries (FAB, 2019).

In July 2019, Portugal announced the purchase of five planes and a flight simulator for €827 million. The first will be delivered in 2023 and the last in 2027. The Portuguese Air Force will use the KC-390 on NATO missions. Today, the Brazilian government is working on expanding the aircraft market (Asas, 2019).

Unfortunately, in recent years, frequent cuts to the defense budget have prevented a more significant advance of the national industry. Past governments adopted the strategy of reducing investments instead of reducing personnel. The rigid rules and regulations about military personnel make it difficult to make short-term changes in the number of active-duty military personnel in all the three Brazilian branches, the Navy, Army, and Air Force. Even with the investments mentioned above, the total amount of investments in R&D by the Brazilian government have been meager, reducing the Brazilian defense industry's capability to innovate and develop new technologies on a larger scale. The new government has signaled changes in the defense investments. According to the Ministry of Defense, the investment expenses will increase from 10% of the defense budget to 14%, increasing the expenses in the modernization of the fleet, in 2021. This will undoubtedly develop the national industry (Lupion, 2020).

According to the Brazilian Defense Ministry (2020), the development of the national defense industry brings several supportability advantages to the Brazilian military defense systems. The nationalization of the production and maintenance processes helps lower unemployment rates, increasing protection and security of the defense system's secret information, and lowering the system's supportability costs (Brazilian Defense Ministry, 2020).

The PBL contract, in this scenario, is a tool for improving the reliability of the Brazilian systems and protecting the national industry with secure revenues in long PBL contracts (E. Dahel, class notes, January 16). Additionally, this movement favors the export of defense products, with positive effects on the country's trade balance.

Finally, the efforts undertaken by the defense sector aim, beyond the defense strategy, to develop new ways of incorporating science, technology, and innovation in goods and services for the country (Brazilian Defense Ministry, 2020).

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V. BRAZILIAN NAVY AND AIR FORCE ACQUISITION STRATEGY

A. BRAZILIAN NAVY AND AIR FORCE APPROACH TO ACQUISITION

The literature review mentioned the lack of project centralization in acquisition and maintenance by the Brazilian DoD. Each branch develops its acquisition projects independently, causing a series of negative consequences, such as lack of systems integration in joint operations, and the loss of economics of scale in purchases (Luiz Saint-Pierre, 2010).

The development of the acquisition strategy in the Brazilian Armed Forces is marked by the identification of an operational or logistical deficiency, or a technological or economic opportunity. The Brazilian Ministry of Defense assesses whether the needs presented are in accordance with the country's national and defense strategies and budget availability (DCA 400–6, 2007). The project management team should be previously appointed, with the participation of future members of this team already in the phase of setting operational requirements (Federal Acquisition Institute, 2015).

An essential part of the acquisition strategy is the analysis and evaluation of the various alternatives for meeting the operational shortage or taking advantage of a technological or market opportunity. According to DCA 400–6 (2007), the following aspects are considered:

- The political aspects of the program (desired degree of independence about the operation and maintenance of the system or material; technological development; maintenance of workload in industry and others).
- The technical aspects of the program.
- The economic and financial aspects of the program.
- The deadlines of the program, with their various associated risks.

- The human resources involved.

The Ministry of Defense evaluates the Life Cycle cost of each of the alternatives considered viable.

In some cases, a Request for Information (RFI) is released, aiming to collect data to improve the requirement. Solving the deficiency at the Defense Ministry level involves several actions. The strategy comprises the planning of actions located in three fields: the political, the technical and the economic-financial (Perez, Urbina & Damiani, 2009).

The companies that manufacture ships and aircraft, which are engaged in engineering, consultancy, and other related industry, participate in the studies of this phase, whenever necessary, through contracted or formal consultations (PND, 2012).

During the acquisition process, the different alternatives are analyzed based on the systems or materials existing in national and world markets. The creation and development of systems may occur with or without international cooperation. As mentioned in Chapter IV, describing the Brazilian defense industry, it is typical to acquire equipment and develop technologies with other countries because the national industry is in technological development.

If the Brazilian government decides to acquire the system in the international market, the interactions between government agencies and foreign entities are made by the Ministry of Defense. According to Perez, Urbina & Damiani, the interaction includes "co-participation in development, technology transfer, national production under license, export of national production, participation of national industry in systems integration, and training of personnel" (Perez, Urbina & Damiani, 2009, p. 42).

During the planning of the Life Cycle of a system or material, all future expenses to be incurred in the different phases of the Life Cycle must be considered by the Brazilian government. The respective administrative measures must accompany these expenditure forecasts, so that budget allocations are guaranteed. This ensures the body responsible for the project has the necessary means to maintain the logistical support for the material (DCA 400–6, 2006).

According to the DCA-400-6 and in agreement with the *Defense Acquisition Guidebook*, the survey of possible alternatives to meet operational needs must be based on:

1. Analysis of the material within the armed forces as to its possibility of satisfying operational requirements through actions of revitalization, modernization or improvement.

2. Analysis of the national and world markets, evaluating the systems or materials to understand their capacity to meet the operational requirements.

3. Estimate of costs and terms of alternatives. Based on the information collected, viable alternatives are selected, and cost and time estimates for the entire Life Cycle are carried out for each of the considered alternatives.

4. Risk assessment. Based on the studies carried out, the Ministry of Defense should proceed to assess the risks of each of the possible alternatives.

5. In the case of developing economies such as in Brazil, this phase seeks "opportunity purchases" by taking advantage of a technological or economic opportunity offered by the market. In some occasions, the purchase of a product by another country is abandoned in the production phase, giving rise to the "opportunity" to buy below market price (DCA 400–6, 2007).

Regarding the budget constraint of a developing country like Brazil and the elevated expenditures with personnel, a reduced amount of financial resources is available for investment. In previous governments, the BN and the FAB employed strategies to deal with low budgets, such as purchasing of secondhand ships or aircraft or "opportunities purchase."

Secondhand ship purchase occurs when the Navy needs to renew their systems. If the system matches the Brazilian Navy's requirements, a negotiation is conducted. If successful, the acquisition may occur (Tenório, Gomes, Santos, Araújo, 2019). In previous decades, it happened several times, mainly for acquiring warships and aircraft.

The "opportunity purchase" is characterized by the waiver of a buyer of an acquisition, and the seller offers the product already built or almost finished for a reasonable price and payment conditions. The BN and the FAB have identified these opportunities several times (Portos e Navios, 2019). If the products had the necessary capabilities, and it was possible to make adaptations for the military environment in Brazil, the acquisition was accomplished.

The Ministry of Defense makes considerations for evaluating the alternatives, and the steps that may be fulfilled by the product's existence on the market may be suppressed or simplified (DCA 400–6, 2007).

B. BRAZILIAN NAVY AND AIR FORCE MAINTENANCE STRATEGY—PBL UTILIZATION OVER TIME

Most of the systems' maintenance in the Brazilian Navy is conducted in-house. Within the system's warranty period maintenance is contracted directly with the producer or developer (DAC 400–6, 2007). However, several challenges exist. In most Brazilian large defense systems, spare parts for aircraft and frigates are not produced in Brazil. This issue adds steps to the purchasing process and may increase the system's downtime (E. Dahel, class notes, January 16).

Although the number of systems increased in the previous decades, with new medium or large ships, the in-house maintenance infrastructure did not grow proportionally (Moura, 2015). Most ships are old. The lack of maintenance planning, or not following the plan, may cause a substantial decrease in their operational availability (Moura).

The BN has just started to use a logistical support contract (LSC) and performance-based logistics (PBL) (Marinha, 2020). In 2017 the BN signed its first contract using this tool with the acquisition of four new Tamandaré-class corvettes, which will have the German ThyssenKrupp Marine Systems leading the partnership of companies responsible for the project. The ships are still being built and these vessels already have an initial logistical support and performance-based maintenance contract, with 90% availability of the fleet for each ship's first five years (Marinha, 2020). BN leveraged expertise from the Brazilian Air Force to write this PBL contract.

According to the literature review, during the last ten years the Brazilian Air Force has moved its structure from in-house maintenance to outsourcing the aircraft's maintenance, mostly using performance-based contracts. The change was adopted with the acquisition of new aircraft.

In 2011, the Brazilian Air Force signed the logistical support contract for a fleet of EC-725 helicopters for the Armed Forces. The agreement, in the amount of U.S. $50 million, provides materials and services to support EC-725 aircraft operation for five years (Defesanet, 2011). The logistical support contract was structured to ensure the EC-725 helicopter fleet's availability is kept above 80%. The "Time and Material" logistical concept was adopted, under which the contracted company is responsible for managing and keeping the repairable items owned and used exclusively by the contractor in its facilities. Inspection services, repairs, and technical assistance are included throughout the national territory, in order to meet the demand of the Armed Forces' operation.

In 2013, FAB signed a logistical support contract for the AMX fighter fleet to ensure 90% availability for three years for €58 million (Defesanet, 2013). The contract has been renewed for five additional years. The contract included the following activities: on-site engineering support and permanent technical staff from Alenia Aermacchi, logistical support services, component supply, maintenance, and overhaul. The contract also established, within the scope of the program initiated by the FAB, the guarantee of full operational capacity for the AMX fighter fleet for 20 years, and integrated the fleet update program called A-1M carried out by Embraer and supported directly by Alenia Aermacchi (Defesanet, 2013).

In 2014, the FAB signed an order for the development and production of 28 KC-390 aircraft and initial logistical support (ASAS, 2019). They are being produced in São Paulo, Brazil. According to the ASAS, "FAB and Embraer signed a comprehensive five-year for logistical support contract package including service spare parts." (ASAS, 2019, pa. 9). In 2019, the first unit was delivered (ASAS).

In 2021, when the first of 36 units of FAB's newest fighter will be delivered, the F-39E Gripen will already be covered by a logistical support contract (EBC, 2019). The support included within the total value of the project (kr 39.8 billion SEK and $245 million) is expected to cover the fleet for a total of 26,400 flight hours or a maximum period of five years of operation. The numbers appear in the presidential message sent to the Senate to approve the project's financing. The contract also provides performance-based logistics and operational indicators.

Even though it has passed ten years since the introduction of PBL in the Air Force for the acquisition of new aircraft, there is not even one aircraft in the FAB fleet which has migrated from in-house maintenance to an outsourcing PBL contract. The contract officers still believe that the five years of PBL contract is a time for learning the "how to make the maintenance." After this period, the FAB should migrate to in-house maintenance because the PBL contract is "expensive." Even though the Navy has just begun with PBL, the belief is the same. We disagree, as explained in the following chapters.

VI. BEST PRACTICES OBSERVED AT THE DOD IN PBL CONTRACTS

According to the *PBL Guidebook* (DoD, 2016), PBL has been the preferred sustainment strategy since the 2001 Quadrennial Defense Review (QDR), stating, "DoD will implement PBL to compress the supply chain and improve readiness for major weapons systems and commodities" (p. 06). Since 2001, when DoD began to stimulate the use of PBL contracts, many best practices were developed with regard to lessons learned after the management of many contracts and the evaluation after their conclusion.

These best practices were developed with different types of products and services, different types of contracts, and in different phases of the acquisition and contract management process. Therefore, in this chapter, some of these practices are identified and aligned according to the contract Life Cycle phases and domains specified in the *Contract Management Standard* (NCMA, 2019a). This organization aims to facilitate the application of the best practices by the contract managers in the Brazilian Ministry of Defense.

Figure 10 shows the phases and domains of the contract Life Cycle.

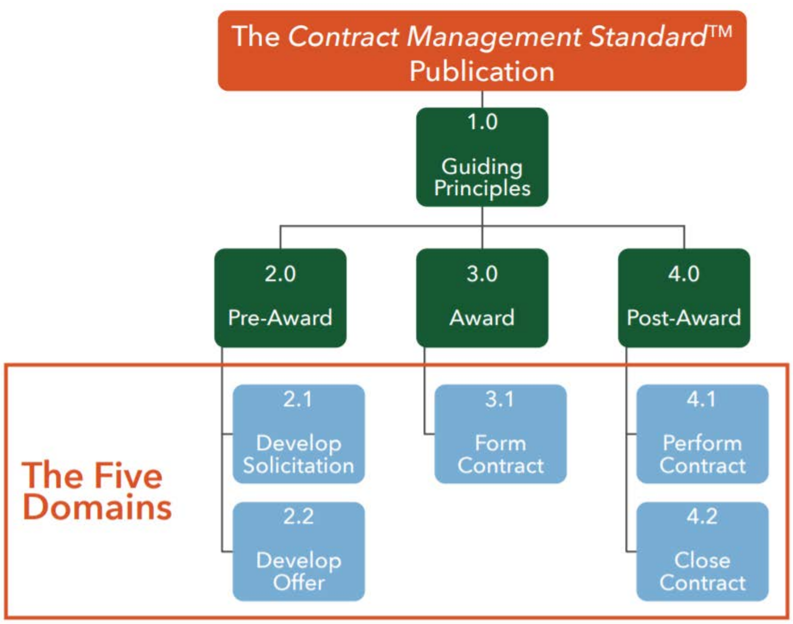

Figure 10. Contract Life Cycle Phases with Associated Domains. Source: NCMA (2019a).

The best practices are also associated with specific tasks, according to the same reference, and detailed in the Figures 2, 3, and 5, presented in the beginning of each Domain explanation, that follow below.

A. PRE-AWARD: DEVELOP SOLICITATION

The Contract Management Standard (NCMA, 2019a) defines the pre-award phase:

> The pre-award process for the buyer includes assisting the customer in defining the requirement. Additionally, the process includes developing a comprehensive plan for fulfilling the requirement in a timely manner at a reasonable price. This is accomplished by developing and executing an overall strategy for the purchase, which is accomplished through researching the marketplace, developing contracting strategies, preparing solicitations, and requesting offers. (p. 9)

Following are the best practices developed in the domain develop solicitation, which is performed by the buyer. The other domain, develop offer, is performed by the seller. Hence, the best practices in this area do not have a significant influence on the government side.

This domain has two main competences, plan solicitation and request offers, and each of them has several tasks to be performed, aiming to achieve an excellent level of contract performance. The majority of the best practices identified are located in this phase mainly because the plan solicitation in a PBL contract has various distinct characteristics compared to the traditional type of contract. Figure 11 lists all job tasks that have to performed in the develop solicitation domain, and the level of importance of each task varies depending on the type of contract.

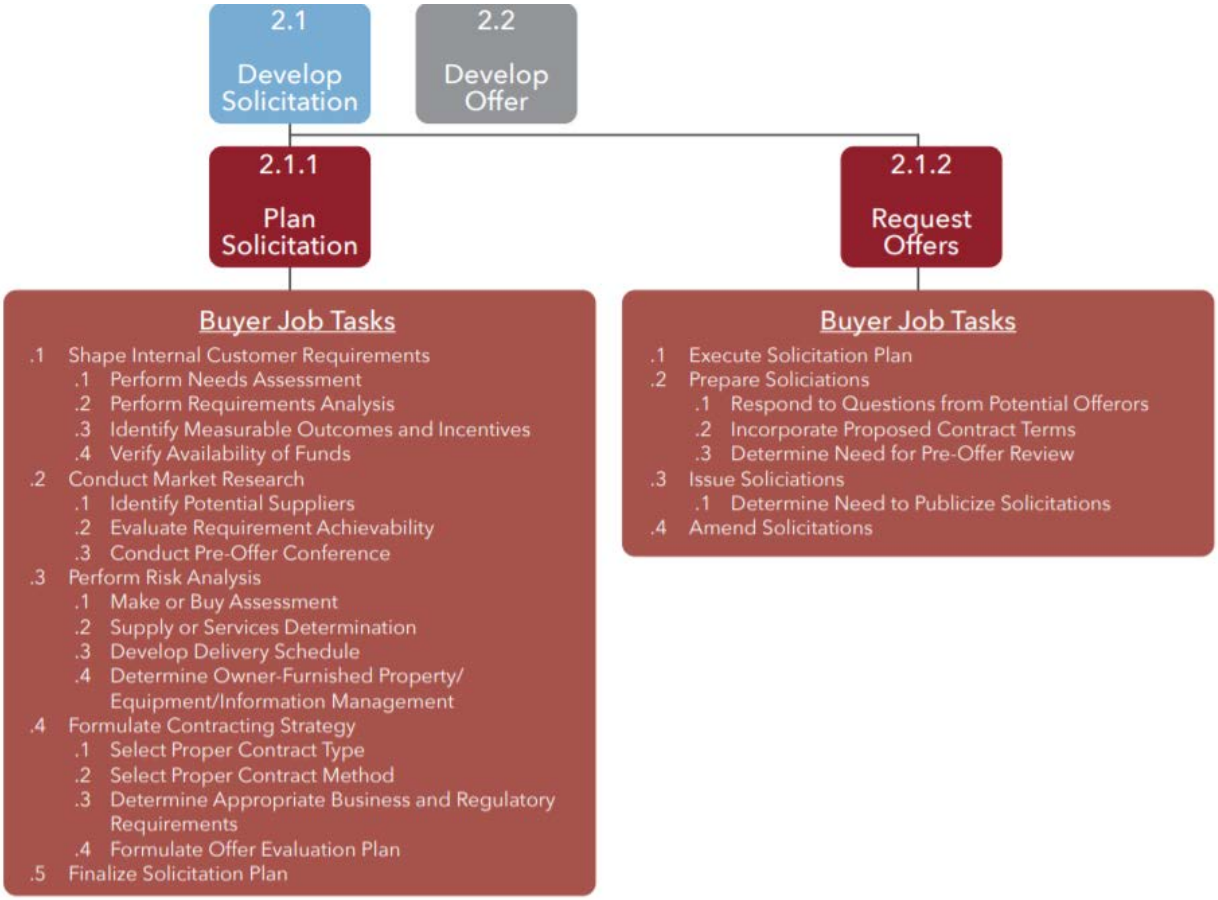

Figure 11. Competences and Tasks of the Domain Develop Solicitation. Source: NCMA (2019a).

1. PBL Strategies Involving Part of a System should have Integrated Weapons System Analysis

This best practice is applied in the plan solicitation competence and is related to the task of shaping internal customer requirements.

According to the *PBL Guidebook* (DoD, 2016), reliability is a measure of "the probability that the system will perform without failure over a specific interval, under specified conditions" (p. 127). More than one reliability metric may be specified for a system as appropriate. Hence, if a PBL contract is focused on a particular component instead of the whole system, it is complex to evaluate the outcome of a better performance of the component inside the system as a whole. For example, maybe the PBL is increasing the reliability of an already reliable item, and another non-reliable component is keeping a high failure rate of the system.

Hence, it is important to be effective when analyzing and determining the requirements of the product or system. The influence of a unique component improvement may not be worthwhile. So, the exact influence that a specific component makes in the system's reliability, and just moving forward with the PBL if the outcome in the system is clear and beneficial (Doerr & Eaton, 2004).

2. Effective Analysis of the Private and Public Sectors Conditions before the Decision to Use PBL

This best practice is applied in the plan solicitation competence and is related to the task, conducting market research.

The decision to use PBL is relevant and intricate, and many factors should be analyzed before a contracting officer moves forward with the contracting process. One of the primary factors to consider is whether the private sector is expected to be more efficient than the public sector in achieving desired outcomes.

According to Bendick (1984), four aspects evaluate the condition of the private sector and a nonmarket solution:

- In producing the services, do the private sector's production processes and input costs allow it to generate output at a lower total cost than could the public sector?
- Are the administrative costs incurred by government to mobilize and control the private sector less than the cost savings from more efficient production?
- Is the supply side of the market sufficiently responsive that private firms enter markets rapidly and smoothly?

- Are purchasers sufficiently rational and careful, and the quality of the service sufficiently definable and measurable, that effective, informed consumer sovereignty can be exercised? (Bendick, 1984, pp. 153–154).

According to Doerr, Eaton, and Lewis (2004), "each of these considerations is potentially problematic when examining PBL initiatives." (p. 06) Therefore, if the result of this evaluation is unfavorable, the execution of a PBL contract can harm the cost to be paid and the performance of a service provided by the contractor.

3. Application for Simple Items and Individual Components if the Private Sector Is More Capable of Providing the Support

This best practice is applied in the plan solicitation competence and is related to the task of conducting market research.

Chapter III mentions some applications of PBL contracts, especially for complex contracts. Chapter V adds that there is a false interpretation by the Brazilian Armed Forces that situations with a lack of complexity do not require PBL use, usually caused by not considering other factors such as lower cost or higher capacity of the private sector.

Hence, the contract strategy should also consider the cost-benefit of using PBL for simple items, such as aircraft tires. It is possible to contract using PBL even for in-house capabilities to achieve cost reduction and better-quality products (Lucyshyn & Rigilano, 2019).

Therefore, it is important to conduct useful market research to identify whether the private sector can provide support with better performance or lower cost. It was the case of a situation involving the U.S. Navy's aircraft tires. "In May 2000, NAVICP issued an RFP for a PBL contract to manufacture and deliver naval aircraft tires to all U.S. Navy, Marine Corps, and foreign military sales customers (NAVICP, 2000)" (Lucyshyn & Rigilano, 2019).

According to Lucyshyn and Rigilano (2019), in this case, "before this PBL contract, tire availability was 81%." After PBL application, "backorders dropped from 3,500 to zero, and logistics response time dropped from 60 days to under two days in continental United

States (CONUS) and under four days outside the continental United States (OCONUS). As of 2011, the average customer wait time was 32.1 hours CONUS and 59.5 hours OCONUS, and on-time performance rates were 98.5%—well exceeding the contract requirement of 95% on-time" (Lucyshyn & Rigilano, 2019).

4. Effective Cost Analysis before Make or Buy Decision

This best practice is applied in the plan solicitation competence and is related to the task of performing risk analysis.

When undertaking the perform risk analysis process, the first step is the make or buy assessment, and a detailed and embracing cost analysis is determinant for the success of this process. The cost of the defense industry is typically compared with the costs when utilizing in-house capabilities. In some situations, the increase in the performance level can justify a higher cost. Therefore, all those performance and cost factors are usually considered before the program manager or contracting officer making the make or buy decision.

The NAVSUP WSS correctly applied this factor in the Navy's aircraft tires case. According to Lucyshyn and Rigilano (2019), at that time, NAVSUP WSS only used to "enter into a PBL contract after assessing the costs and concluding that a PBL contract cost would be equal to or less than traditional support. Overall, NAVSUP WSS PBL contracts have reduced costs by 3.9%." (p. 16).

5. Useful Measurement of the Operational Risk before the Decision for PBL Utilization

This best practice is applied in the Plan Solicitation competence and is related to the task Performing Risk Analysis.

> According to Doerr and Eaton (2004), some military activities have high operational risk involved, according to the nature of the system's operation. In those cases, it is hazardous to transfer the performance of the service for the commercial sector, consequently causing a vulnerability of not having the support when it is needed. More than that, in such situations, the organic support will not be prepared to act in replacement because it is not used to do the support. Doerr and Eaton also claim, "when the operational risk is

high or difficult to measure, PBL strategies should seek less commercial sector involvement.” (p. 13)

It is important to determine whether all the support should be organic, with no PBL contract, or whether a hybrid situation is applicable when depending on the level of operational risk, with each part assuming a bigger whole in the support, with the detailed activities that will be performed by each part clarified in the contract. The result of the organic support assuming more responsibility in those situations of high operational risk is the reduction of the PBL contract terms because the financial rewards must be proportional to the risk assumed by the private sector.

6. Negative Monetary Incentives Are Effective, Even Down to the Subcontractor Level. Positive Monetary Incentives Usually Are Not Useful

This best practice is applied in the plan solicitation competence and is related to the task of formulate contracting strategy, specifically selecting proper contract type.

One of the most critical tasks in the plan solicitation competence is the identification of measurable outcomes and incentives, and the reason because its design is according to positive or negative incentives, and their variations will cause good or bad results in the performance of the contract during its execution.

According to Ellman (2017), negative monetary incentives are more productive for stimulating contractor performance. An important reason for this is that the performance is, if not wholly, then at least largely, within the ability of the contractor to plan around and control. Besides, on some PBL contracts, contractors hold their more significant subcontractors responsible for performance-based penalties. Therefore, Ellman says it is an excellent tool for controlling mainly more complex PBL contracts that require several subcontractors. Hence, according to Ellman, the positive monetary incentives are ineffective, and he points to some relevant reasons for this lack of effectiveness:

- Predicting the cost of meeting higher performance targets is particularly difficult, so properly pricing the associated monetary incentive can be challenging;

- The government is often reluctant, if not unwilling, to agree to incentive levels high enough to make hitting the higher performance target potentially profitable;

- Less than 5 percent of DoD PBL contract obligations feature positive monetary incentives as a core feature of the contract structure. (Ellman, 2017).

7. PBL Application in the Early Stages of Product Design

This best practice is applied in the Plan Solicitation competence and is related to the task Formulating Contracting Strategy.

According to Sols, Nowick, and Verma, in the *Engineering Management Journal*, (2015), the "application of a PBL strategy from the early stages of product design and development can lead, by controlling the dominating design parameters, to significant reductions in life-cycle costs" (p. 47). Therefore, it is necessary to make a considerable effort to start the application as early as possible, and it is an important factor in the plan solicitation competence.

According to Chapter II, a useful understanding of the Life Cycle management concepts is important for the analysis of the make-or-buy decision when the system is at some point past the beginning of its Life Cycle.

8. The Application of PBL in Warships Has Better Results in Small Fleets than in Large Fleets

This best practice is applied in the plan solicitation competence and is related to the task of formulating contracting strategy.

In the strategy formulation task, if we are dealing with warships, there are differences in the application of PBL in large or small fleets. Hence, it is necessary to conduct a practical analysis before the decision to use this type of contract.

According to Hunter, Riley, Sanders, and Ellman (2015), usually, the largest programs are prioritized, and it drives the investments in infrastructure and the decision-making process. Hence, smaller fleets sometimes have to adapt to a structure of a different program because of limited resources. Therefore, PBL utilization can solve this situation by contracting out and making the contractor responsible for the investments in small fleets infrastructure, which can increase efficiency and avoid unnecessary adaptations.

Therefore, when it is necessary to prioritize internal infrastructure to provide logistic support for warships, the small fleets usually have low priority, which creates the possibility of the private sector having better logistic conditions and achieving higher performance levels.

9. The Need for a Life Cycle Analysis before PBL Application to Minimize its Disadvantages

This best practice is applied in the plan solicitation competence and is related to the task of formulating contracting strategy.

As discussed in Chapter III, PBL contracts are characterized by upfront payments for the contractor, who is responsible for planning how to achieve a determined level of a system's performance. This factor may not be beneficial sometimes because the purchaser is locked into the contractor and also compromises part of the budget with this matter. Therefore, for the government to leverage the advantages of a PBL contract and avoid the disadvantages, it is important for contracting officers to analyze and predict the length and complexity of the system's Life Cycle.

> According to Jester, Ferguson & Bussier (2010), PBL application will be better suited for complex and extended life cycle products. "Simple products that should not require extensive or unique sparing and servicing in the future might be better suited to the standard approach. Likewise, short life cycle products that are not expected to outlive the manufacturing processes producing them might also be better suited to the standard approach" (p. 09).

Hence, when formulating the contract strategy, the PBL application worth, in terms of cost-benefit, if the length of the product's life cycle is enough to compensate the upfront cost of the PBL contract in a medium or extensive-term period.

10. Long-Term Contracts usually Achieve Better Results

This best practice is applied in the plan solicitation competence and is related to the task of formulating contracting strategy.

When formulating the contract strategy, a relevant factor is ensuring proper alignment of government objectives with contractor incentives. According to Lucyshyn, Rigilano, and Safai (2016), generally, a PBL type of contract is more complicated to manage and develop than other traditional types. Therefore, the conditions of the contracts and the performance metrics must be designed to create a win-win type of relationship.

About contract extension, studies show that PBL is more likely to achieve better results with long-term contracts. Typically, in those situations, the contractor is forced to make investments to reduce costs and improve the system's reliability. According to Lucyshyn and Rigilano (2019), "PBL contracts of shorter duration will not incentivize significant contractor investment since the contract must be long enough for the contractors to recoup their investments, otherwise they will not invest" (p. 25).

One great example in the DoD is the HIMARS contract case, where after 14 years, Lockheed Martin and its subcontractors had invested more than $10 million in design improvements, process changes, equipment, and facilities to improve reliability and reduce costs (Lucyshyn & Rigilano, 2019).

Comello Machado (2018) also explains the reason for making long-term PBL contracts:

> The complexity of the service to be delivered and the consequent need for investment by the contractor also creates pressure on the contract value to rise. One effective way to counter-balance the pressure for higher prices is to adopt longer contract lengths, giving enough time for the contractor to adapt properly to the tasks and to receive reasonable returns of investments. Additionally, longer contracts also appeal to the contractor as they provide a more stable flow of income. (p. 12)

11. DoD Role in the United States as an Integrator of the Armed Forces

This best practice is applied in the plan solicitation competence and is related to the task of formulating contracting strategy.

As discussed in Chapter V, when compared with the Ministry of Defense in Brazil, the U.S. DoD plays a different role related to the contracting process and the integration of all branches. In the strategy formulation task, it is necessary for contracting officers to determine whether a consolidation of customers—the branches, in this case—will create benefits in the outcomes of the contract. In various situations, the result of the centralization may be lower costs or a high level of efficiency.

One successful DoD example was the case of the PBL contract for the HIMARS, which supported both the Army and Marine Corps (Lucyshyn & Rigilano, 2019). In this case, the significant benefit was the incentive for the economy of scale, causing the cost reduction. In other cases, the utilization of the same system by more than one branch will generate an environment of exchanging expertise, and the outcome is a faster problem-solving process and an increase in the reliability of the system as a consequence.

More than that, the contractor will have opportunities to learn faster and improve the process by using in a branch the experience of the system utilization in the other one. Therefore, it is not possible to predict that every contract will be more productive with the consolidation of customers; however, as those benefits can happen, it is important to analyze the possibility of the integration before moving forward with the contracting strategy.

B. AWARD: FORM THE CONTRACT

The Contract Management Standard (NCMA, 2019a) defines the award phase:

> The Award process involves all the work performed by both the buyer and seller that produces an awarded contract. Some contracts are very simple and others are exceedingly complex, but the majority fall somewhere in between. There is one domain in the award phase: Form Contract. The job tasks and competencies of the Form Contract domain produce the contract. (p. 13)

According to the *Contract Management Standard* (NCMA, 2019a), the form contract domain has a total of four competencies: price or cost analysis, plan negotiations, select source, and manage disagreements. Each of them has related tasks, and they are the base for the organization of best practices. Figure 12 lists all job tasks that have to performed in the form contract domain, and the level of importance of each task varies depending on the type of contract.

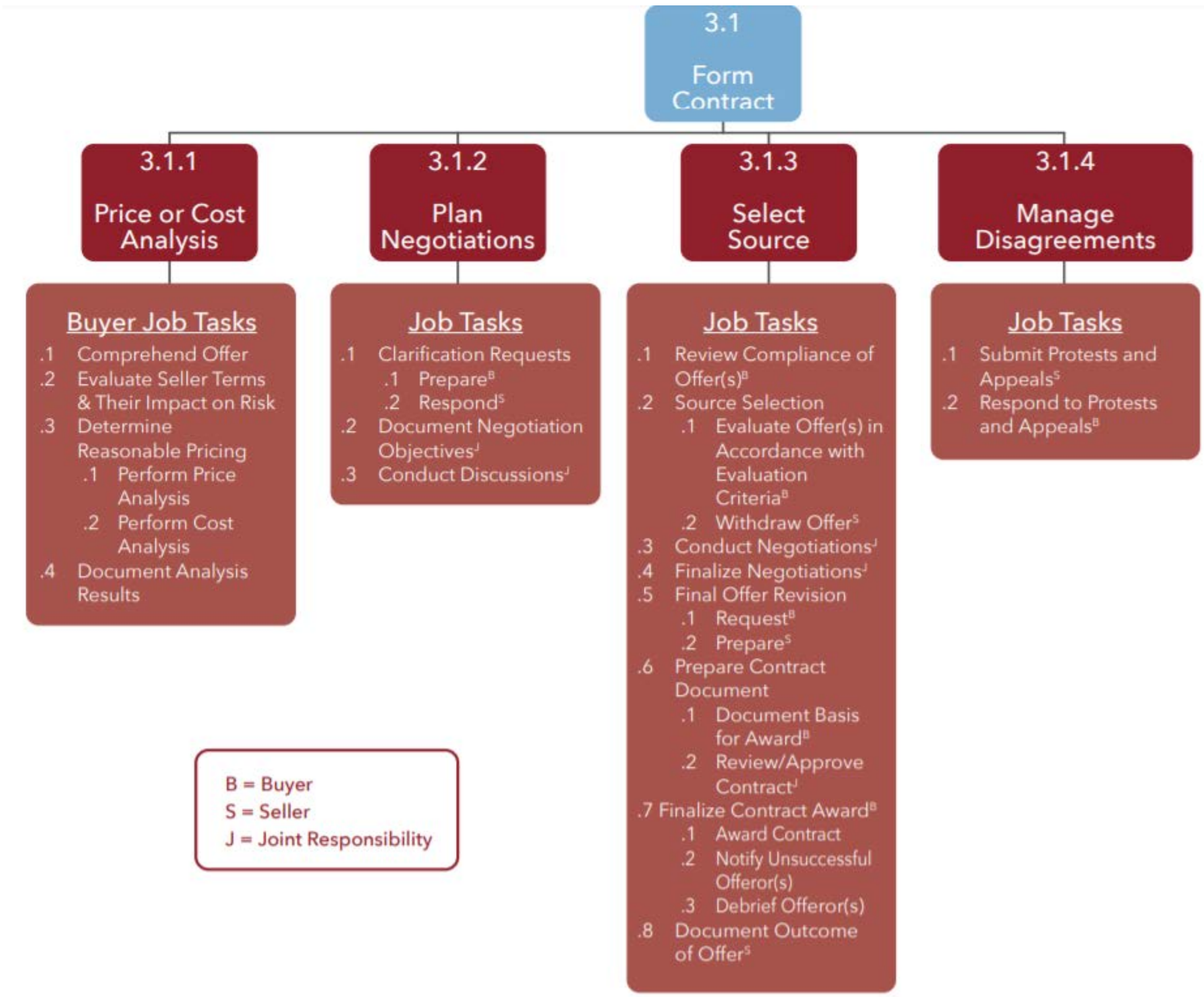

Figure 12. Competences and Tasks of the Domain Form Contract.
Source: NCMA (2019).

1. Adequate Definition of the Spare Parts' Ownership

This best practice is applied in the plan negotiations competence and is related to the task of making clarification of the requests.

When forming the contract, a relevant factor is related to the spare parts' ownership. The advantages and disadvantages of the ownership by the public or private sector have to be well analyzed, and based on that, the business requirements are specified. It is not a simple analysis, but according to Lucyshyn and Rigilano (2019), usually the cost of ownership is lower under a PBL contracting strategy where the supplier owns spare parts.

The DoD had a wrong application of this best practice in the last phase of the HIMARS PBL contract, where the government absorbed inventory management. Lucyshyn and Rigilano (2019) explained that this contract specified “stock objectives” and other inventory and operational constraints that the contractor had to respect. These conditions removed flexibility from the contractor and increased the risk for the government.

The major benefit of PBL is in providing the contractor the flexibility to determine the best options for inventory levels, maintenance activities, and other characteristics of the service being provided to accomplish the performance requirements specified in the contract (Lucyshyn et al., 2016). Therefore, every attempt to deviate from the paradigm and transfer some activities to the government can diminish this flexibility and harm the benefits of the contract, which can be represented in lower performance levels or higher costs.

2. The Contract Document Must Respect the Individual Characteristics of Each Program to Form the PBL Specifications Related to the Degree of Commercial Support

This best practice is applied in the select source competence and is related to the task of preparing contract document.

In the select source competence, it is necessary for contracting officers to consider some important details while the contract document preparation occurs. In traditional types of contracts, other contracts of similar items can serve as a standard depending on the situation. However, in PBL contracts, this practice is more complicated because it is necessary to understand the unique aspects of each contract.

According to the *PBL Guidebook* (2016), when using the PBL contracting approach, general rules should be avoided because rarely do distinct programs have similar performance measures. The *PBL Guidebook* says that there is no “one-size-fits-all” analysis. Each program has unique characteristics and desired outcomes to be achieved.

The differentiation between PBL characteristics is mostly represented by the degree of commercial support that is needed to replace the organic support. Doerr and Eaton (2004) used the following support spectrum to illustrate the scale of the utilization level of commercial support, and it is possible to note that several types of PBL contracts exist and the contracting officers choose the level of logistic support needed according to the specific circumstances.

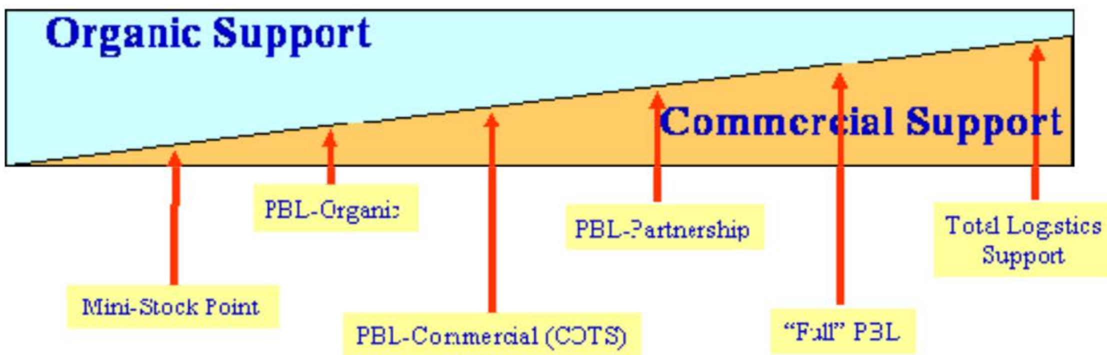

Figure 13. PBL Support Spectrum. Source: Doerr and Eaton (2004).

Therefore, the need for commercial support is a driver for the contract conditions. A useful contract document developed in the award phase results in the right conditions for efficient performance during the post-award phase.

C. POST-AWARD: PERFORM CONTRACT

The Contract Management Standard (NCMA, 2019a) defines the post-award phase:

> The contract administration functions will vary greatly depending on the complexity of the contract. Both the buyer and seller are actively involved in contract administration to ensure satisfactory performance and to bring the contract to a successful conclusion. (p. 16)

This phase has two domains, perform contract and close contract, each with several competencies and tasks to be performed.

The perform contract domain has a total of four competencies: administer contract, ensure quality, manage subcontracts, and manage changes. Following the same organization of the previous phases and domains, the best practices are divided according to the characteristics of each task. Figure 14 lists all job tasks that have to be performed in the perform contract domain, and the level of importance of each task varies depending on the type of contract.

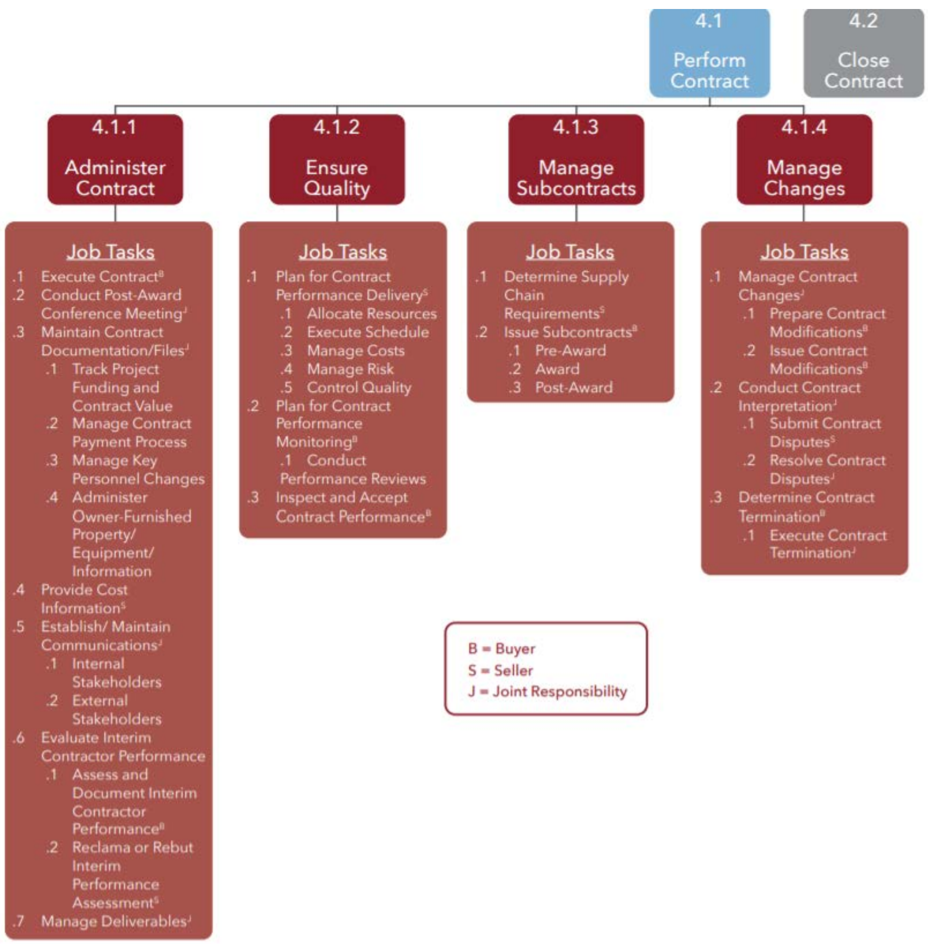

Figure 14. Competences and Tasks of the Domain Perform Contract. Source: NCMA (2019).

It is interesting to notice the absence of best practices related to the domain close contract, and the reason is because, in general, the tasks performed in this domain do not have significant differentiation between traditional and PBL contracts.

1. Performance Measurement Frequent and Transparent

This best practice is applied in the administer contract competence and is related to the task of evaluating contractor performance.

Chapter III explains that both parties must be able to monitor the measures and understand them completely, which creates an environment of consummate behavior by both parties. According to Sols, Nowick, and Verma (2015), one great example was the case of the sale of C-212 and CN-235 aircraft by the EADS CASA to several South American countries, including Chile, Ecuador, Paraguay, and Brazil, where they used PBL-type contracts with the air forces of each country.

The *Engineering Management Journal* article, "Defining the Fundamental Framework of an Effective Performance-Based Logistics (PBL) Contract" (Sols et al., 2015), explains the methods that made those measures.

> In these cases, the performance goals have been set as a certain fleet availability, which is registered on a daily basis by personnel of both client and contractor. The aircraft are daily inspected and declared to be in one of the following states:
>
> - Operational (ready to fly)
> - Under planned maintenance (not ready to fly, but its unavailability is accepted due to already programmed preventive maintenance actions)
> - Aircraft on ground (aircraft not available due to failure of systems or equipment that need to be repaired; the contractor is responsible)
> - Under maintenance (aircraft not available due to failures induced by the system user; client responsible). (p. 44)

Besides, both parties must know when the sanctions and rewards apply, the payment methods, and rules. Sols et al. (2015) mention the "dead zone" theory. It is a method for sanctions and rewards in contracts based on a performance zone defined by historical data, with an acceptable range of performance measures, where no reward or sanction is suitable. If the performance measures are below the lower limits, the authors claim, sanctions are applicable, and if the measures are above the upper limits, the rewards are relevant. Besides, the sanctions and rewards must be proportional to the under- or over-performance according to each case.

According to Sols et al. (2015), the limits must be reevaluated over time, and adjustments, if necessary, should be made by both parties after agreement. As Sols et al. claim: “The steepness of the penalty and reward slopes and the maximum penalty and reward that can be applied can also be renegotiated over time based on experience and system performance.” (p. 44). Figure 15 details how the “dead zone” functions in a PBL contract.

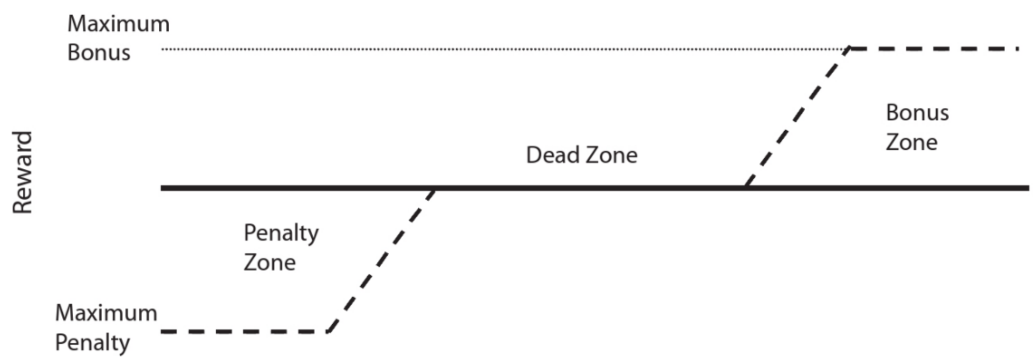

Figure 15. The Concept of Dead, Bonus, and Penalty Zones.
Source: Sols et al. (2015).

2. Use Just Relevant Metrics, and Avoid Process Metrics

This best practice is applied in the ensure quality competence and is related to the task of planning for contract performance monitoring.

According to the *PBL Guidebook* (DoD, 2016), an important PBL tenet is the “utilization of measurable and manageable metrics that accurately assess the product support provider’s performance against delivery of targeted Warfighter outcomes” (p. 110). Hence, the purchaser has to frequently and effectively monitor the metrics, to be able to require more of the contractor or sometimes to make changes to put the contract on the track for win-win outcomes.

Doerr and Eaton (2004) emphasize the importance of measuring outcomes instead of processes, and they also mention important factors that should be monitored, such as weapon system cost, readiness, and agility. According to the authors, “Process measures should only be applied when key operating decisions depend on the status of the process itself” (p. 17).

The government pays the private sector value for a PBL contract seeking to transfer the responsibility of some processes and expecting to have the desired outcome. Therefore, measuring the process performed by the contractor would be a waste of time, and more than that could reduce the focus on the outcomes, which is the reason for a PBL contract.

3. The Need for a Reliability Growth Program to Compensate for the Decline Over Time of the System Reliability Characteristics

This best practice is applied in the manage changes competence and is related to the task of managing contract changes.

All the PBL contracts require effective monitoring during their executions, which means both parties can make changes and corrections to maintain a high performance level. It is necessary even when the contract is well designed.

According to Sols et al. (2015), a PBL contract should be designed to consider all the natural changes in the system’s life cycle, due to its utilization, and a plan must exist to reduce the negative impact in the performance metrics. The natural changes in the system may cause reductions in some performance levels, such as availability and reliability. Therefore, both parties must understand it. Otherwise, either could blame the other for the difficulty in achieving the performance targets.

Therefore, both parties must have capable and reactive teams that are responsible for making the necessary adaptations caused by the evolution of the system. The changes in result make good outcomes achievable even in advanced points of the contract execution.

This chapter listed several PBL best practices of different phases of the contract Life Cycle. The application of these best practices can result in cost reduction and an increase in performance level during the contract. Chapter VII details recommendations for the application of the best practices in the Brazilian Armed Forces.

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VII. APPLICABILITY OF THE PBL BEST PRACTICES IN THE BRAZILIAN CONTRACTING CONTEXT

Chapter VI identifies best practices related to PBL application in the last twenty years. As the outcome of this thesis is to apply those best practices in the Brazilian Armed Forces (BAF), it is important for the application of this research to analyze how it is possible to optimize these best practices in the Brazilian Ministry of Defense contracting processes.

The basis of this analysis is in Chapters IV and V, which explain characteristics of the contracting strategies of the Brazilian defense industry and the Brazilian Armed Forces. The recommendations point out whether each best practice is applicable, and which factors should be considered for their utilization.

Those recommendations also consider Chapter II, which details Life Cycle management concepts and their characteristics in the Brazilian context. Finally, the organization of the best practices follows the same pattern utilized in the last chapter, which was organized by the contract Life Cycle, according to the *Contract Management Standard* (NCMA, 2019a).

The following tables organize best practices by phase and domain, for each listing job tasks, best practices, and our recommendations.

Table 1. PBL Best Practices and Recommendations of the Pre-award Phase

Phase: Pre-Award Domain: Develop Solicitation		
Job Task	**Best practice**	**Applicability / Recommendation**
Shaping Internal Customer Requirements	PBL strategies involving part of a system should have integrated weapons system analysis	The few cases of PBL use in BAF are applicable for the whole system, so it is an opportunity to expand the utilization of this tool for components of a system. Considering that the Brazilian branches' strategy of buying technology transference with the acquisition of the first item and after that to develop national technology to build other units of the system, the utilization of PBL for components of a system will create more opportunities to develop the Brazilian defense industry.
Conducting Market Research	Effective analysis of the private and public sectors' conditions before the decision to use PBL	The Brazilian defense industry is smaller than the American, with a fewer number of capable contractors. Therefore, there is a strong dependence on foreign private companies, which makes a practical analysis of the private and public sector more difficult. Even with this complexity, a comparison must be made by BAF before the decisions of using a PBL contract.
Conducting Market Research	Application for simple items and individual components if the private sector is more capable of providing the support	The culture of PBL application in the BAF is more related to increases in the performance of complex systems, and it is not being considered the cost reduction for less than complex items or individual components of a system. It is necessary to implement this new approach for PBL utilization. One method can be seeking items with good availability, logistic support, and low price in the Brazilian defense industry, and using the process as an experiment to stimulate other initiatives.
Performing Risk Analysis	Effective Cost Analysis before make-or-buy decision	A limited Brazilian defense industry can be a negative factor for making a useful cost analysis before the make-or-buy decision. Using information from foreign companies with similar products or services can solve that. Other limitations may be the lack of historical data to make comparisons with the cost analysis. Once more, foreign data of similar items can be used as a standard.

Phase: Pre-Award Domain: Develop Solicitation		
Job Task	**Best practice**	**Applicability / Recommendation**
Performing Risk Analysis	Useful measurement of the operational risk before the decision of PBL utilization	Even though the Brazilian branches lack a routine for participating in war, several situations of high operational risk must be considered for the application of this best practice. Some examples of those situations are the peacekeepers' missions in countries like Haiti and Lebanon, the missions in the Amazonia rivers operated by specific ships, and operation in the country borders with several South American countries. For those cases, it is important to keep excellent in-house capabilities and not just depend on PBL contracts.
Formulating Contracting Strategy	Negative monetary incentives are effective, even down to the subcontractor level. Positive monetary incentives usually are not useful	This best practice is useful for complex situations where the contractor needs to control several subcontractors. As the Brazilian defense industry is smaller than it is in the United States, the variety of capable companies in the private sector is limited, and there is a small chance of having a PBL with many subcontractors involved. However, the trend in PBL contracts in Brazilian branches is to hire foreign companies or partnerships of national and foreign companies, and it is necessary to have an efficient performance, hence using this best practice will be useful in the future.
Formulating Contracting Strategy	PBL application in the early stages of product design	The current culture in the Brazilian branches is to use PBL contracts only at the beginning of the Life Cycle. However, its utilization is also beneficial in the middle of the system's Life Cycle. Therefore, it is necessary to enhance the knowledge about Life Cycle management in the BAF, to improve future make-or-buy decisions.
Formulating Contracting Strategy	The application of PBL in warships has better results in small fleets than in large fleets	In BAF, the budget constraints are more significant than those of the U.S. branches. Hence the capital to invest in maintenance is limited. With a low budget, there is a need to choose the type of ships or aircraft to invest in, and the PBL method is an excellent option for the systems for which in-house capability is well structured. One relevant point is that it can be challenging to apply this best practice to the not so developed Brazilian defense industry.

Phase: Pre-Award Domain: Develop Solicitation		
Job Task	**Best practice**	**Applicability / Recommendation**
Formulating Contracting Strategy	The need for a life cycle analysis before PBL application to minimize its disadvantages	The systems used by the Brazilian branches have a high average of up-tempo, meaning that most of them are at an advanced stage in their life cycle. Therefore, the analysis recommended by this best practice becomes even more critical. It is necessary to avoid using PBL contracts in situations where the contract will not benefit the government in the system's remaining Life Cycle.
Formulating Contracting Strategy	Long-term contracts usually achieve better results	This best practice suggests a significant change in the BAF approach to PBL utilization. The reason is the misunderstanding that PBL is useful for only a maximum of five years, and after that, the in-house maintenance infrastructure is ready to take responsibility for the system maintenance. This approach does not consider the possibility of low costs and higher performance that can be achieved by the private sector in the long run. It does not consider as well that for PBL contracts' worth, the contractor must have time to have benefits by the capital invested.
Formulating Contracting Strategy	DoD role in the United States as an integrator of the Armed Forces	The Ministry of Defense in Brazil does not make the role of the integrator for contracting processes, and some issues arise regarding this lack of cooperation. First of all, as the branches do not use similar products, it is more complicated to share expertise related to problem-solving. Besides, with several small purchases instead of one bigger and centralized acquisition, the final price of a product or service is higher and harms the defense budget. Finally, at the end of the line, the excess of individualization of the branches can be a negative factor for the development of the Brazilian defense industry. Therefore, the recommendation is the creation of studies to analyze the possibility of increasing the integration of the Brazilian Armed Forces related to contracting processes.

Table 2. PBL Best Practices and Recommendations of the Award Phase

Phase: Award Domain: Form Contract		
Job Task	**Best practice**	**Applicability / Recommendation**
Making Clarification of Requests	Adequate definition of the spare parts' ownership	The lack of PBL expertise by the Brazilian branches may create a false sense of not trusting the contractor enough. It may create a probability of Brazilian contracting officers taking measures to reduce dependency. One of those measures can be having the spare parts' ownership, which can create problems, the main one is the cost increase. By doing that, it will create a lack of flexibility for the contractor in choosing a strategy to achieve the performance outcomes, which is one of the important factors of a PBL contract.
Preparing Contract Document	The contract document must respect the individual characteristics of each program to form the PBL specifications related to the degree of commercial support	The current moment of PBL implementation by the BAF is the perfect momentum to follow this best practice. The reason is that, in the implementation of a new process, it is common to take shortcuts to reduce the time for the new process to turn into a routine. In the case of the PBL application, it will be important not to use previous models for building new contracts for different items. A right performance level will only be achieved during the contract execution if the contract document is built respecting the individual characteristics of a system.

Table 3. PBL Best Practices and Recommendations of the Post-Award Phase

Phase: Post-Award Domain: Perform Contract		
Job Task	**Best practice**	**Applicability / Recommendation**
Evaluating Contractor Performance	Performance measurement frequent and transparent	The BAF has little experience in PBL contracts, and the lack of expertise in some activity requires an environment that stimulates learning. Hence, frequent measurements and transparency will increase the trust of both sides of the contract and will be positive for future transactions as well. The Brazilian branches have a strategy of buying technology transference with the first unit of a system and using it to develop other systems in the national territory. Hence, it is important to have efficient control and monitoring of the contract, and to create a healthy and beneficial relationship with the contractor in order to achieve the outcomes of this strategy.
Planning for Contract Performance Monitoring	Use just relevant metrics, and avoid process metrics	The lack of experience in this method may cause in the BAF the sensation of over-control of the contractor, and beginning to create additional metrics to have the whole idea of what the provider is doing. This practice can harm the contract in several ways, such as using a workforce with unnecessary tasks instead of useful activities and creating a perfunctory behavior also by the contractor. It can result in both parties deviating from the agreement, and the consequence is the loss of benefits for both parties.
Managing Contract Changes	The need for a reliability growth program to compensate for the decline over time of the system reliability characteristics.	When implementing a new method, such as the PBL implementation in the BAF, good outcomes will accelerate the change, and negative results may cause insecurity and diminish the pace of the implementation of a new process. Therefore, BAF must actively follow this best practice to mitigate the risk of having adverse outcomes caused by the lack of correct utilization of the PBL method. Because most of the systems of BAF are in an advanced stage of their life cycle, the reliability growth program becomes an important need to make PBL contracts worthwhile.

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