FINANCIAL ANALYSIS OF WING IN GROUND EFFECT CRAFT USING MONTE CARLO SIMULATION

IKE SUHARYANTI

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I dedicate this thesis to my beloved family…

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ABSTRAK

Kapal *Wing in Ground* (WIG) mempunyai kelebihan dengan kelajuannya yang tinggi berbanding dengan kenderaan air lain tetapi dengan penggunaan bahan api yang lebih rendah. Kelebihan ini membuatkan WIG sebagai penyelesaian ideal untuk pengangkutan air jarak dekat. Walau bagaimanapun, kajian mendalam bagi kos dan analisis faedah daripada pelaburan di dalam kapal WIG belum pernah dibuat. Kajian ini membandingkan tiga kapal WIG, dua kapal pesawat dan satu bot feri laju. Pesawat WIG mempunyai 33, 50 dan 150 tempat duduk, pesawat terbang Austal 38m (SAAB 340 dan SAAB 200) manakala bot feri laju panjangnya 74 m. Pelbagai komponen harga dan perbelanjaan kapal berdasarkan jarak perjalanan dianggarkan termasuk kos permulaan, kos operasi dan penyelenggaraan, dalam tempoh kitaran hayat 5, 10 dan 15 tahun seterusnya dinilai dari segi ekonomi dengan analisis Diskaun Aliran Tunai (DCF). Simulasi Monte Carlo digunakan bagi menyelaku operasi pesawat-pesawat berkenaan dan analisis DCF bagi menganggarkan aliran tunai Nilai Bersih Semasa (NPV) pada kadar Diskaun tertentu yang mewakili kos peluang dan risiko. Dalam kajian ini, kadar Diskaun sebanyak 5% telah diambil dan jumlah penumpang diubah dari 75 % kepada 100 % daripada kapasiti untuk simulasi Monte Carlo dalam pengiraan NPV. Analisis Kepekaan juga telah dijalankan untuk mengenal pasti faktor-faktor yang memberi kesan kepada pelaburan. Didapati bahawa jumlah kos modal kapal adalah tertinggi untuk Austal, pesawat 38 m, sedangkan terendah untuk kapal WIG 33 tempat duduk. Di samping itu, lebihan tahunan (keuntungan) dikira daripada perbezaan antara pendapatan tahunan dan kos pelaburan. Keuntungan telah dikenal pasti sebagai faktor yang mempunyai pengaruh terbesar dalam pelaburan. Kos pelaburan kapal WIG melibatkan kira-kira dalam julat 92% sehingga 125% daripada jumlah kos modal. Masa penggunaan kapal WIG, hanya untuk 10 dan 15 tahun boleh memberi keuntungan kepada pelabur dengan operasi, penyelenggaraan dan perbelanjaan lain yang lebih rendah. Pada akhir tempoh kitaran hayat 10-15 tahun, keuntungan kapal WIG 33 kerusi dan 50 kerusi untuk jarak perjalanan kurang daripada 100 km adalah lebih tinggi daripada Austal 38m dan bot feri laju 74m, kerana kos permulaan yang lebih rendah. Tetapi kapal WIG 150 kerusi mempunyai manfaat yang lebih berbanding pesawat WIG 33 kerusi dan 50 kerusi apabila pesawat WIG digunakan untuk jarak perjalanan daripada 50 km sehingga 200 km. Menurut hasil NPV simulasi Monte Carlo, jumlah NPV menunjukkan nilai positif bagi setiap kapal WIG selama tempoh kitaran hayat 10 dan 15 tahun. Tetapi kos pelaburan yang hampir 92% di atas jumlah kos modal adalah sangat tinggi. Analisis sensitiviti juga mendapati bahawa kadar diskaun dan jumlah penumpang daripada kapal WIG mempunyai kesan yang kecil ke atas jumlah NPV. Pada masa akan datang, keputusan kajian ekonomi ini menggalakkan penggunaan kapal WIG untuk potensi pengangkutan air jarak dekat di Indonesia, terutamanya di kawasan sambungan rentas antara pulau.

ABSTRACT

Wing in Ground (WIG) crafts have the benefit of an aircraft with their high speed compared to water vehicles but with lower fuel consumption. These advantages make WIG as ideal solution for short range water transportation. However, the in depth studies of cost and benefit analysis of investing on WIG craft has never been done. This study compared three vessels of WIG craft, two vessel of aircraft and one fast ferry boat, they are WIG 33 seats, 50 seats, 150 seats, Austal 38 m aircraft (SAAB 340 and SAAB 200) and Fast Ferry Boat 74 m. Various components of the vessel prices and expenditures based on the rated travelling distance including initial costs, operation and maintenance costs, during the 5, 10 and 15-year life cycle period were economically evaluated by means of Discounted Cash Flow (DCF) analysis. DCF analysis estimates relevant Net Present Value (NPV) cash flow annually by assists of Monte Carlo Simulation at a certain Discount rate that represents opportunity costs and risks. In this study, the Discount rate was taken as 5% and the passenger load varied from 75% to 100% of capacity for the Monte Carlo Simulation in calculating the NPV. The Sensitivity Analysis was also conducted to identify factors that affect the investment. It is found that total vessel capital costs is the highest for the Austal 38 m aircraft, whereas it is the lowest for the WIG craft 33 seats. In addition, annual saving (profit) is calculated from the difference between yearly income and investment cost. Profits were identified as the factor which has the biggest influence in the investment. Investment costs of the WIG craft involve approximately in range from 92% to 125% of the total capital costs. The usage time of the WIG craft, which is for only 10 and 15 years, can provide profits to the investor with a lower operation, maintenance and other expenditure. At the end of 10-15 years life cycle period, the profits of the WIG craft 33 seats and 50 seats for the travelling distance less than 100 km are higher than Austal 38 m and fast ferry Boat 74 m, because of lower start-up costs. But the WIG craft 150 seats provides slightly greater benefits than the WIG craft 33 seats and 50 seats when the WIG craft is used for the travelling distance from 50 km to 200 km. According to the Mote Carlo Simulations NPV results, the NPV amounts show positive values for each WIG craft during 10 and 15 years life cycle periods. But the investment costs approximated about 92% above the total capital costs are very high. The sensitivity analysis also found that the discount rate and passenger load of the WIG craft have small effect on the NPV amounts. In future, the results of this economic study encourage the utilization of the WIG craft for short distance water transportation potential in Indonesia, especially in the region cross-connection between islands.

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LIST OF ABBREVIATIONS

WIG	-	Wing In Ground
DCF	-	Discounted Cash Flow
BCA	-	Benefit Cost Analysis
NPV	-	Net Present Value
PV	-	Present Value
SFC	-	Specific Fuel Consumption
IRR	-	Interest Rate of Return
ROI	-	Return On Investment
r	-	Discount rate
n	-	Period of Investment

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CHAPTER 1

INTRODUCTION

This chapter provides some background information of Wing in Ground (WIG) craft and explains the motivation, and challenges in implementing WIG craft as alternative mode of transportation. The objective, scope, and the outline of this project are also given in this chapter.

1.1 Background

At the beginning 1920s, the ground-effect phenomenon was widely known, because pilots found that their airplanes appeared to become more efficient as they neared the runway during landing. In 1934 the US National Advisory Committee for Aeronautics issued Technical Memorandum 771, *Ground Effect on the Takeoff and Landing of Airplanes*, which was a translation into English of a summary of research up to that point on the subject. The French author Maurice Le Sueur had added a suggestion based on this phenomenon: "Here the imagination of inventors is offered a vast field. The ground interference reduces the power required for level flight in large proportions, so here is a means of rapid and at the same time *economic* locomotion: Design an airplane which is always within the ground-interference zone. At first glance this apparatus is dangerous because the ground is uneven and the altitude called skimming permits no freedom of maneuver. But on large-sized aircraft, over water, the question may be attempted ..."[1] Small numbers of experimental vehicles were built in Scandinavia and Finland, just before World War II. By the 1960s, the technology started to improve, in large part due to the independent contributions of Rostislav Alexeyev in the Soviet Union and German Alexander Lippisch, working in the United States. Alexeyev worked from his background as a ship designer whereas Lippisch worked as an aeronautical engineer. The influence of Alexeyev and Lippisch is still noticeable in most GEV vehicles seen today.

One difficulty which has delayed WIG development is the classification and legislation to be applied. The International Maritime Organization recognizes three classes of ground effect craft:

1.1.1 Type A: a craft which is certified for operation only in ground effect;
1.1.2 Type B: a craft which is certified to temporarily increase its altitude to a limited height outside the influence of ground effect but not exceeding 150 m above the surface; and
1.1.3 Type C: a craft which is certified for operation outside of ground effect and exceeding 150 m above the surface. These classes currently only apply to craft carrying 12 passengers or more.

A ground effect craft may have better fuel efficiency than an equivalent aircraft due to its lower lift-induced drag. There are also safety benefits for the occupants in flying close to the water, as an engine failure will not result in severe ditching. However, this particular configuration is difficult to fly even with computer assistance. Flying at very low altitudes, just above the sea, is dangerous if the craft banks too far to one side while turning, or if a large wave occurs. Unlike an aircraft, a WIG is able to enter a harbor at slow speed into or near a town center. An important issue is the probability of collision with other conventional "slow" boats, in bad visibility conditions on dense traffic routes, due to the difference of speed.

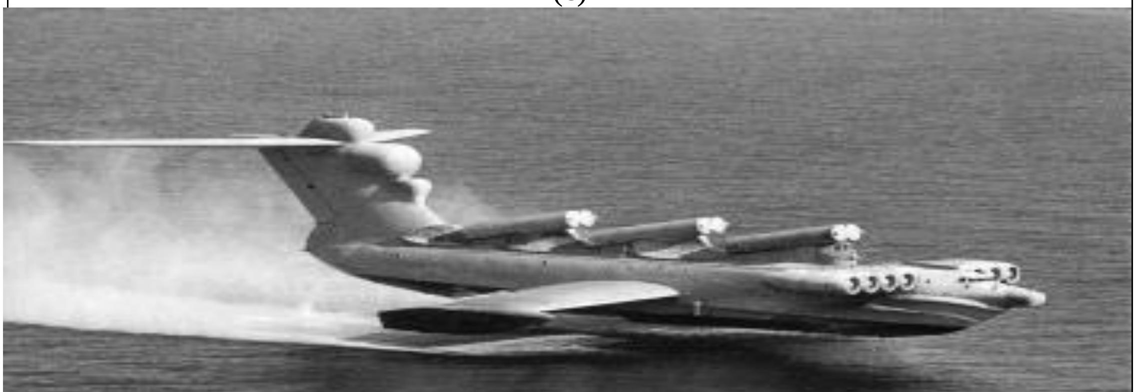
A takeoff must be into the wind, which in the case of a water launch, means into the waves. This creates drag and reduces lift. Two main solutions to this problem have been implemented. The first was used by the Russian Ekranoplan program, which placed engines in front of the wings to provide more lift (the engines could be tilted so their exhaust blast was directed under the wing leading edge). The

"Caspian Sea Monster" had eight such engines, some of which were not used once the craft was airborne. A second approach is to adopt a hybrid concept, using some form of an air cushion to raise the vehicle out of the water, making takeoff easier. This is used by Hanno Fischer in the Hoverwing (successor to the Airfisch ground effect craft), which uses some of the blowing air coming from the propellers to inflate a skirt under the craft in the style of a sidewall hovercraft. Figure 1.1 below shows some of developed WIG craft.

(a)

(b)

(c)



(d)

(e)

(f)

Figure 1-1 (a) Orlyonok A90; (b) Sea Eagle; (c) Boeing Pelican; (d) MD-160 Lun; (e) Aquaglide; (f) Do-X flying boat

1.2 Motivation

Practical applications of WIG craft have been actively researched and developed since the early 1960’s, yet in that period these craft have not reached acceptance as mainstream transport vehicles in either civilian or military applications. No single reason for this failure to develop is obvious. While there are some technical difficulties to overcome, none of these appears insurmountable and while there are some operational limitations, they are not so severe that these craft could not find useful operational niches.

WIG craft have been championed on the basis that they are more efficient than equivalent aircraft and quicker than equivalent marine vessels. The speed advantage of WIG craft over conventional marine vessels may well provide the reason for considering WIG craft for particular applications. WIG craft can be developed to travel at significantly faster speeds than the equivalent marine vessels. There may well be applications for marine vessels where the speed of the vessel is the most critical specification.

1.3 Problem Statements

Although WIG crafts have been around for many decades, but there are no economical studies that analyze the feasibility of WIG to become commercial mode of water transportation in addition to aircraft and ferries.

1.4 Scope of Projects

This project focuses on measuring the cost of developing WIG as mode of transportation and the benefit that will be obtained by applying the solution. It will be limited into;

1.4.1 It only compares WIG with aircraft and ferries.
1.4.2 Comparing WIG Craft with existing ferry.
1.4.3 Comparing WIG Craft with similar capacity of aircraft.
1.4.4 Same operating condition (travelled distance, operating daily hours)
1.4.5 Same Passenger load.

1.5 Contributions

The contributions of thesis are proposing a quantifiable method to gauge the feasibility of WIG craft used as commercial mode of transportation that may benefit to decision makers.

1.6 Thesis Organizations

This thesis is organized into six chapters. The outline is as follows;

Chapter 1-Introduction

This chapter discusses the objectives and scope of the project and gives a general introduction to WIG craft.

Chapter 2-Literature Review

This chapter reviews the relevant literature and previous works regarding benefit cost analysis and real options analysis that being used in this study.

Chapter 3-Methodology

This chapter describes in depth the methodology being used to measure the feasibility of WIG craft as alternative mode of transportation.

Chapter 4-Simulation Result

The simulation result is described in this chapter.

Chapter 5-Analysis and Discussions

This chapter analyze and discuss the result that being obtained from previous chapter.

Chapter 6-Conclusion

The final chapter concludes the thesis and provides suggestions for future improvement.

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