FLYING IN THE FACE OF REASON: THE FACT OR FANTASY OF COMMERCIAL WING-IN-GROUND-EFFECT VEHICLES

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SUMMARY

Getting ‘wing-in-ground-effect’ (WIG) craft price and operating costs right is the key to commercial success, especially if considered against those offered by competing transport vehicles which may be available to the operator or passenger: conventional/fast ferries and aircraft. This paper describes an economic model constructed to explore WIG craft capital and running costs by comparison against existing aircraft and ferry vehicles under a variety of market scenarios. It concludes that craft capital cost is the dominant element and that the greatest challenge facing WIG designers is to constrain capital cost to a level that will make the craft attractive. This level is dependent on several factors but is generally significantly less than an equivalent aircraft. Against this, the fuel economy/efficiency offered by WIG is of second order significance.

DEVELOPMENT OF THE PAPER

This paper was originally presented at the June 1998 *‘Wise up to ekranoplan GEMs’* International Workshop of the Institute of Marine Engineers, Australia. The paper was intended to be a discussion document. Its objectives were to; a) demonstrate that it is possible to be scientific about target costs for new commercial WIG vehicles, and, b) to assess the design and marketing messages which arise from this, through interpolation of the ‘business cases’ for existing commercial aircraft and ferries. In its original form the paper achieved its objectives; however, since the original paper was published:

- errors in the presentation of data have been corrected
- the detailed 33 seat model has been re-worked to account for increase of power with speed
- provisional results explanation and other text elements have been re-worked and expanded for better comprehension

ABOUT THE AUTHOR

Graham Taylor has a background in engineering and commercial management. He gained a Postgraduate Diploma in Management Studies from the University of Westminster, London in 1993, followed by an MBA from Thames Valley University, London in 1995. He has held a variety of business analyst positions as well as the post of Director Technical of The Royal Institution of Naval Architects. He has maintained a close interest in the development of high speed marine vehicles for 20 years through practical experimentation with radio controlled models (see Appendix F) and is a frequent contributor to the model engineering press on the subject of advanced marine craft. WIG papers published include: ‘Wise up to a WIG’, ‘WIG - The concept and the Market’, and ‘Market Focused Design Strategy’.

1. INTRODUCTION

WIG offers a new transport solution somewhere between boat and aircraft. Proposals for 'commercial' WIG encompass the exotic trans-ocean passenger and freight proposals of Reeves[1], Hooker[2]and Stinton[3], through to the more modest proposals by Fischer[4] and Jörg[5]. The case for WIG has often been biased towards large long distance craft, but in the commercial world are such proposals reasonable or are they fantasy?

For any product to be commercially successful its price must not exceed that which the market will pay. Similarly, its cost must not exceed its price. This argument applies to WIG. To be commercially viable, WIG's costs of manufacture and operation must meet market expectations - but what are the expectations? On the one hand it could be argued that new craft should fit amongst the variety of existing transport solutions that are available (Akagi[6,7] see Appendix D); on the other, that true exploitation of WIG would be on routes not having competing transport systems, making other vehicles irrelevant[8]. The truth lies somewhere in between. Knowledge of cost limitations from the outset provides a clear design message. Costs comparison against aircraft and fast ferry operations would seem to be a good starting point.

This paper describes a crude model that attempts to answer the question of what the price of WIG should be and, therefore, present a clear target to designers. In so doing it moves WIG design from "what can we build?" then "how can we sell it?", to "what can we sell?" then "how can we build it?".

Past Methodology and Approaches to Economics

A variety of approaches have been used to justify the place of WIG in context of other transport solutions. They include: 'reverse transport efficiency', 'transport productivity', the 'Karman-Gabrielle diagram'[9]. Rozhdestvensky and Kubo[10] applied Akagi's scientific

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[1]Balonair BL2000 in Day A. H. & Doctors L. J.(1995) A Study of the efficiency of the Wing In Ground Effect Concept. Institute of Marine Engineers. Sydney, Australia. Proc. conference Twenty-first Century Flying Ships, University of New South Wales Nov. 7-8 1995 pp 1-22

[2]Hooker S. F. "Wingships: A Prospect for High Speed Ocean Transport" Jane's Surface Skimmers 1982.

[3]Stinton D. (1997) Heavy, Long-Haul Operations Using the Air-Sea Interface. RINA. Proc int. conference on Wing-In-Ground-Effect Craft (WIGs) 5-4 Dec. 1997 London.

[4]Fischer H. (1996) Some thoughts on the Use of lift-off-aids as one condition for the Economical Operation of Wingships. Proceedings of Ekranoplans & Very Fast Craft Workshop 1996. University of New South Wales pp 60-77

[5]Jörg G. W (1997) Tandem Airfoil Flareboats (TAF) RINA. Proc int. conference on Wing-In-Ground-Effect Craft (WIGs) 5-4 dec. 1997 London.

[6]Akagi S. (1991) Synthetic Aspects of Transport Economy and Transport Vehicle Performance with Reference to High Speed Marine Vehicles. Proceedings Fast 91, Trondheim, Norway, Vol. 1, pp 277 - 292

[7]Akagi S. (1993) A study of Transport Economy and Market Research for High Speed Marine Passenger Vehicles. Proceedings Fast 93, Yokohama, Japan, Vol. 2, pp 1129 - 1142

[8]Taylor G. K. (1997) Market Focused Design Strategy - Viable Transport System or Flight of Fancy. Proceedings of International Conference on Wing-In Ground Effect Craft, Royal Institution of Naval Architects, London

[9]Rozhdestvensky, K. V. (1995). Ekranoplans - Flying Ships of the Next Century . Proc. Institute of Marine Engineers, Sydney, Australia. Twenty-first Century Flying Ships, University of New South Wales Nov. 7-8 1995 pp 47-70

methods to WIG for Pusan-Fukuo and Niigata-Vladivostok routes. They noted in their model that the craft capital cost was a prevailing element of direct operating costs and so should be minimised. But to what degree, and what does this tell us about factors needed for commercial success?

2. MODEL DESCRIPTION

An economic model has been designed to explore WIG capital and operating costs by comparison to other vehicles, under a number of market scenarios.

The methodology in plain English:
We can make the quite reasonable assumption that the price a passenger is prepared to pay for travel on a WIG lies between that which they would pay for transport by aircraft and that for transport by boat. If we now assume that the fare price is the cost per passenger plus a percentage profit, and that the percentage profit is the same for aircraft and boat operation, we can remove profit from the equation and compare the vehicles in terms of cost per passenger. Therefore, to be competitive the costs per passenger for a WIG must lie between that of aircraft and boat. The figures for aircraft and boat effectively form the limits of a 'bandwidth' of potentially competitive costs per passenger for WIG vehicles. If we step back further, and derive the craft capital cost that would give such figures we arrive at a 'bandwidth' for the potential capital costs of WIG craft, again defined at the upper limit by aircraft and the lower limit by boat.

WIG capital cost is assessed by examining economic 'business case' models for a variety of transport vehicles over a hypothetical island-to-island route, working from capital and running costs of vehicles to arrive at the total direct operating cost (TDOC). This is divided by the number of passengers carried to give the 'total direct operating cost per passenger' (TDOCPP - see Figure 1). The total direct operating cost per passenger figure derived from the competing transport vehicles is used as a guide to set target TDOCPP for WIG craft[11]. The model is then worked back to derive a target capital cost figure for WIG craft. As the TDOCPP forms the base line for fare pricing, comparison of craft by TDOCPP is essentially the same as comparison by fare price.

[10]Rozhdestvensky, K. V. and Kubo S. (1996) A parametric analysis of Flying Wing Configuration In extreme Ground Effect. Proceedings of Ekranoplans & Very Fast Craft Workshop 1996. University of New South Wales pp 78-96

[11] This paper makes the reasonable assumption that because the aircraft and ferry vehicles used in the model already exist they are commercially viable and therefore can serve as a benchmark.

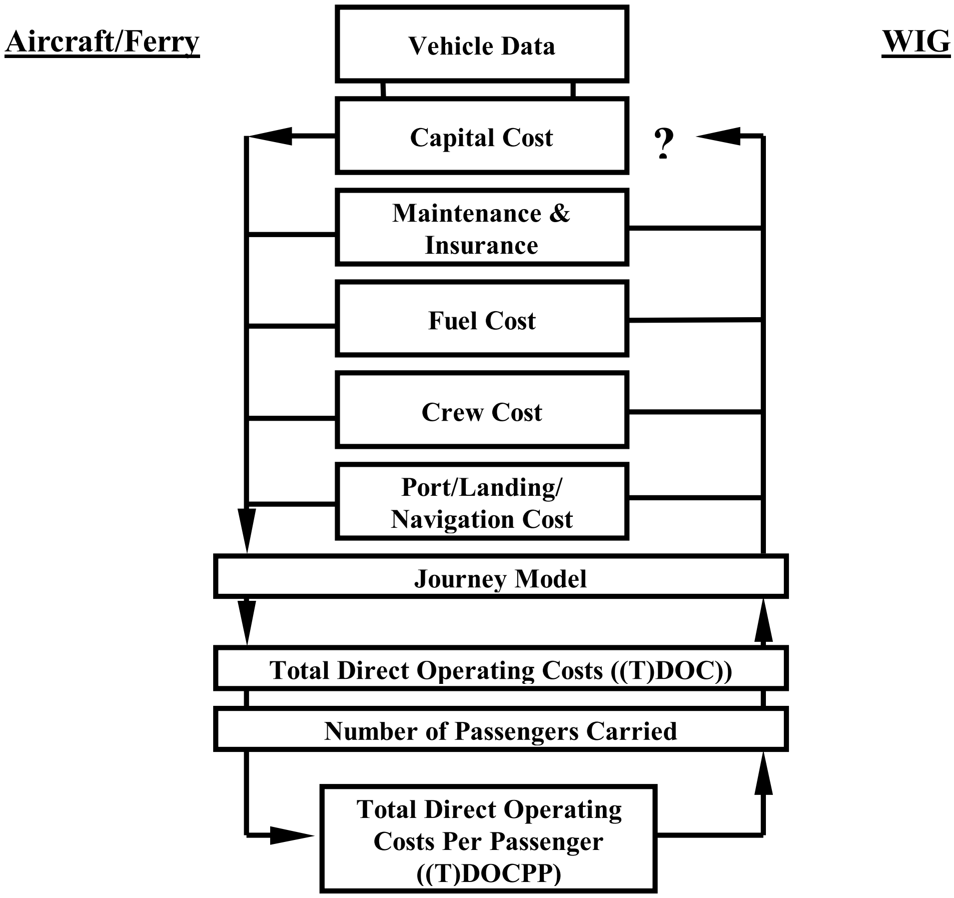

Figure 1: Analysis Framework

This approach is valid from two viewpoints:
1) the passenger, who may be presented with a variety of transport options for a given route and makes their choice based on their perception of the premium payable for dimensions of the service such as speed, comfort and convenience.
2) the potential operator who sees a route and may invest in one of a variety of transport solutions to service it.

The model is applied under the market scenarios in the following matrix:

	Formative Industry:	Established Industry:
Open Competition:	X	X
Constrained Competition:	X	X
Niche Competition:	X	X

Scenario Definition

- *Open competition:* Where the competing aircraft and ferries are free to operate at common/typical hours per day for their class.

- *Constrained competition:* There may be situations where the competing transportation is constrained to similar operating hours as WIG (e.g. insufficient demand outside daylight hours, day trips only etc.). Examples of this are the Quicksilver fast ferries, capable of a 24 hour commuter role but which, in fact, only carry high-value passengers one return trip per day to the Barrier Reef, and the Maldivian inter-island sea-plane service which only flies during daylight hours.

- *Niche competition:* Where there is no existing competition to constrain WIG capital costs. In this model WIG capital cost assumed to be 66% that of equivalent aircraft.

- *Formative Industry:* Where risks associated with pioneering WIG craft operations are reflected in short asset life and high interest rates on finance.

- *Established Industry:* Where, over time and experience, risk aspects have been reduced; (economic) asset life is lengthened and interest rates reduced.

Under Open Competition and Constrained Competition scenarios the WIG's are costed at both the average aircraft and average ferry TDOCPP; the target capital cost for WIG will fall somewhere in between.

For Niche Competition, a notional 33 seater WIG is modelled against a 33 seater regional aircraft for a 200 km journey. This is further explored over a variety of journey distances and WIG speeds.

Scenario data is set out in Appendix A - Scenarios. The economic model is set out in Appendix E.

Rider

This model is a 'first-pass' rough-and-ready assessment. It is aimed at giving an order of magnitude measure of commercial viability in order that some primary conclusions may be drawn regarding craft design and commercial potential. Because commercial data tends to be 'proprietary' or unpublished and, because of the generalised nature of this model, it has been necessary to second-guess some data and therefore make large assumptions.

3. NOTES ON MODEL CONSTRUCTION AND ASSUMPTIONS

Comparable craft[12]

The model uses costing for:

- Saab 340 regional aircraft (33 passenger seats) capital cost $ 10,800,000
- Saab 2000 regional aircraft (50 passenger seats) capital cost $ 15,500,000
- 74m wave piercer ferry (450 passenger seats, mixed traffic) capital cost $ 25,000,000[13]
- 38m Austal catamaran ferry (430 passenger seats) capital cost $ 3,520,000
- Wig 1 – 33 passenger seats, notional specification with power at 1/3rd that of Saab 340, with cruising speed of 150 km/h
- Wig 2 – 50 passenger seats, based on Raketa-2 specification with cruising speed of 150 km/h
- Wig 3 - 150 passenger seats, based on A.90. Ekranoplan specification with cruising speed of 400 km/h

Wig operational constraints - route length

Very long distance WIG transportation is questionable if one considers the degree of freedom passengers may have to move about the craft when under way. With speeds some 3+ times greater than high speed ferries and a greater likelihood of obstacle in the flight-path than for aircraft, there exists potential for high-g deceleration through emergency stop, wave contact or collision. While conventional fast ferries may stop in three boat-lengths, such a manoeuvre would be injurious to an unrestrained WIG passenger. Perhaps the closest analogy to emergency stop severity is a front foil loss on a hydrofoil. People have been killed or seriously injured in such incidents[14]. The IMO HSC code is of little help here (referring to 'G-coll' as derived from head-on collision with 2m vertical rock, which a WIG may miss completely), but if we take a 'safety case' approach it may be necessary to restrain passengers at all times. This:

1) limits journey duration to what passengers will endure, perhaps not much more than one hour.
2) could cut passenger on-board spend - which can contribute up to 25% operator revenue depending on duty-free situation[15].

For the above reasons a route length of 200 km is used as a base in the model.

Capital cost financing

There are a variety of ways in which craft can be financed. They include:

- Financing from company's own internal resources
- Loan (possibly secured on craft) resulting in ownership at the end of the term
- Leasing/lease-back for a term of several years, at the end of which the craft is returned to the leasing company (popular in airline operation)

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[12] It is argued that the price a customer is prepared to pay for transport is independent of the size of the craft. Thus the diverse craft used are all comparable at TDOCPP level as they perform the same function, and in this respect size is not important

[13] For the purpose of this model the vehicle revenue is ignored and the total costs are divided by the number of passengers

[14] Safety in Hong Kong Waters. Fast Ferry International December 1992. Two Jetfoil accidents reported in Asia. Fast Ferry International July-August 1993.

[15] Metcalf A. E. (1997) 'Realising the vision' - Assessing the North American Market for Fast Ferries. Proc. 13th Fast Ferry In. Conference 25-27 Feb 1997 Singapore

How a company accounts for the capital cost is further complicated by tax write-offs or capital allowances that may be available, the treatment of loan interest and the depreciation that may be prudent to allow. For the purpose of this paper a very simplistic (albeit slightly unrealistic) common approach has been taken - the objective being a comparison between craft rather than to precisely calculate financing costs of individual craft. Craft capital cost is assumed to be financed by a bank loan resulting in equal periodic payments, so avoiding depreciation complexities. The economic lives of the craft are co-incident with the term of the loan and differences in interest rates applied reflect perceptions of commercial risk.

Ancillary equipment and 'port fit' costs can be considerable. For the purpose of the model these can be treated as capital. There may be a requirement to invest in a quantity of spare parts so as to maintain service levels (for Saab 340 15% craft cost). Loading ramps, quay construction to fit the craft to the port etc., can be treated as capital and written down/off over the same period. Port fit for a large fast ferry can be $1m[16]. The model allows for port fit and ancillaries as a percentage of craft cost.

Craft amortisation and capital cost recovery
While financiers have built up a body of knowledge about aircraft depreciation, the difficulty comes when dealing with craft for which there is little track record, such as fast ferries and WIG's. With pioneering/developmental craft, not only is there a question concerning the longevity of the craft for economic purposes, but the residual value of the craft may be affected by obsolescence as the type evolves. Financiers may also take into account the time horizon of the operating company and its likelihood of being around in the future to pay off the debt (credit rating), or finding another buyer for the craft. Interest rate is assumed to be affected by assessment of risk, so a further percentage is added to WIG craft (see Appendix A - Scenarios).

Maintenance & insurance
Hull insurance is taken as 1% of capital cost for all craft, and 1.5% for WIG, reflecting uncertainty of risk. Maintenance is charged at 4% of capital cost per year except were specified (see Appendix E).

Fuel costs
Fuel costed at $200 per tonne for all vehicles.

Craft utilisation modelling
Craft utilisation and number of passengers carried per annum depends on the 'usual hours of operation' according to the type of craft. This will be weather and visibility dependent although 350 days per year operation is assumed for all vehicles. For WIG there are several uncertainties: will WIG operate at night? Will it fly through a fog bank? And what would be the effect on other traffic in the proximity if it did?[17] It is assumed that operating hours are restricted to good daylight visibility, and so will be shorter than for aircraft or ferries. An average of 8 hours per day is used for the WIG craft in the model.

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[16]The port fit cost for Stenna HSS rumoured to be $10m
[17]In poor visibility a military 'stealth' WIG may be flown in by radar, instruments and image intensifier. In a commercial environment however, to the occupant of a small unseen craft in the path of a commercial WIG the prospect of being over-flown must be terrifying.

For the Open Competition scenario the hours of operation reflect the common/typical hours for the vehicle type. For Constrained Competition the operating hours for aircraft and fast ferry match those of WIG. For Niche Competition the Constrained operating hours are applied (see Appendix A). A two-season model is applied which adjusts for high and low season +/- 1.5 hours. A passenger load factor of 60% is applied to all craft. Journeys rounded to return trips.

Effective 'average' cruising speed and journey time

The validity of craft cruising speed is distorted by the time it takes to accelerate and decelerate. In the model it is dealt with for surface craft by allowing a distance in which to achieve cruising speed (also recognising that a craft needs to clear port before reaching full speed). An allowance of 2 km for conventional fast ferry and 1 km for WIG is made, with a similar distance for deceleration[18]. In practice, acceleration/deceleration has a minimal effect on overall journey times for WIG's and fast ferries. For aircraft, simple application of craft nominal cruising speed to a route gives inaccurate results because an aircraft spends a proportion of its flight on climb and descent, and nominal taxi time (takeoff and landing). This is particularly true for short routes and distorts journey times substantially. Typically altitude of between 9,000 and 21,000 feet may be reached; this tends to be a function of journey length and aircraft capability. To overcome this distortion, typical journey examples (distance, flying time, altitude etc. provided by Saab) were analysed using regression analysis to provide a model in which journey times and fuel burn can be described as a function of the distance and nominal aircraft cruising speed. It was found that the effective speed for an aircraft used on short journeys can fall to about half the nominal aircraft cruising speed, and that a substantially slower WIG can offer similar route times simply because it does not absorb time in climb and descent modes.

Crew costs

Crew costs are dependent on manning levels. In order to provide guaranteed service levels two or three sets of crew may need to be retained, dependent on number of hours of operation per year. One of the areas of savings fast craft offer over conventional ships is a reduction in manning levels, the minimum crew complement being a function of passenger evacuation procedures. Figures are estimated for ferry and WIG craft.

Port/landing/navigation costs

These are dependent on region, location and the amount of land/facilities used and can be a very significant element of the total costs (typically 20% for aircraft in Europe). As this paper considers WIG in a region unlikely to be served by sophisticated systems this is not costed in the model but the TDOCPP, particularly for aircraft, may be understated.

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[18] Allowing 1 km to accelerate to 200 km/h pulls 0.15 g, which is akin to flooring the accelerator of a lazy saloon car

4. PROVISIONAL RESULTS

At the time of writing the full functionality of the model had yet to be explored. However, the early results enable certain conclusions to be drawn.

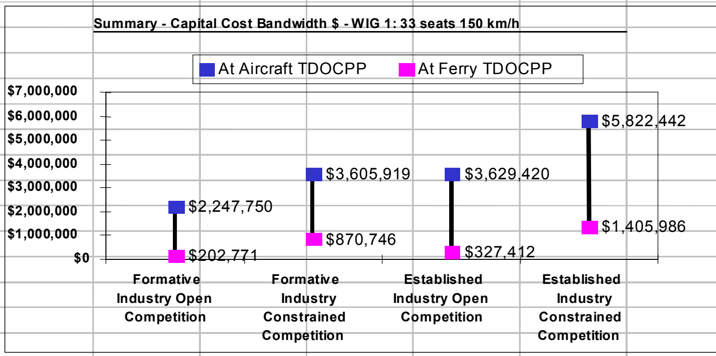
The results of an assessment for a 200 km journey distance under the matrix of market conditions are summarised in Table 1, charted and described further below.

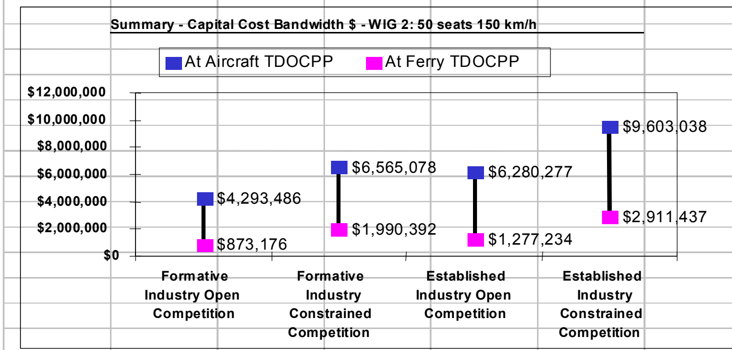
Table 1: Summary: Capital Cost Results - For 200 km journey

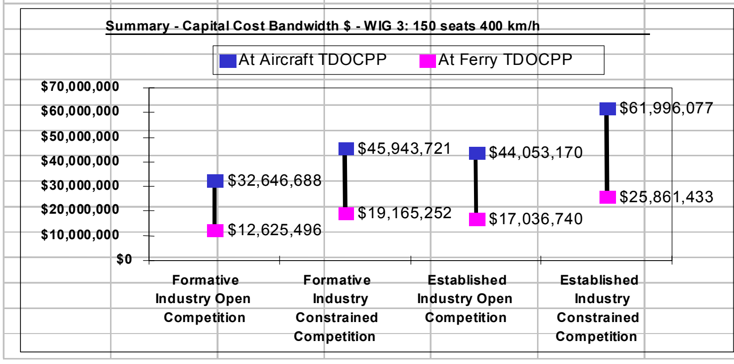
	Formative Industry				Established Industry			
	At Aircraft TDOCPP		At Ferry TDOCPP		At Aircraft TDOCPP		At Ferry TDOCPP	
	TDOCPP	Cap Cost	TDOCPP	Cap Cost	TDOCPP	Cap Cost	TDOCPP	Cap Cost
Open Competition								
WIG 1	$33.01	$2,247,750	$15.53	$202,771	$33.01	$3,629,420	$15.53	$327,412
WIG 2	$33.01	$4,293,486	$15.53	$873,176	$33.01	$6,280,277	$15.53	$1,277,234
WIG 3	$33.01	$32,646,688	$15.53	$12,625,496	$33.01	$44,053,170	$15.53	$17,036,740
Constrained Competition								
WIG 1	$44.62	$3,605,919	$21.24	$870,746	$44.62	$5,822,442	$21.24	$1,405,986
WIG 2	$44.62	$6,565,078	$21.24	$1,990,392	$44.62	$9,603,038	$21.24	$2,911,437
WIG 3	$44.62	$45,943,721	$21.24	$19,165,252	$44.62	$61,996,077	$21.24	$25,861,433
Niche Competition		Formative Market				Established Market		
		TDOCPP	Cap Cost			TDOCPP	Cap Cost	
WIG1: % cap cost to equivalent aircraft	66.7%	$75.35	$7,200,000			$51.92	$7,200,000	

Open & Constrained Competition. Formative & Established industry
In this series of scenarios the capital cost of WIG was calculated to give a TDOCPP which matched that of aircraft and ferry operations.

Open Competition:
By charting Table 1 it can be seen that there is a wide bandwidth between the target cost of WIG's when a) priced against aircraft and b) priced against ferry TDOCPP. This gives some degree of freedom to the WIG designer and marketeer. Craft costs are lowest under Formative Industry conditions because of the burden of interest rates and quick write-down that the TDOCPP carries. Indeed it is doubtful if the 33 seat WIG could be constructed for the open-competition ferry-equivalent target price of $202,771 when one considers that the 5 seater WIG Flarecraft L325 sells for $250,000. Under Established conditions the craft capital cost can rise because the burden of interest rates and quick write-down is relaxed. It seems ironic that in the early years competitive pressure keeps the capital cost down yet once industry has gained experience to build craft cheaper the financial elements allow it to rise.







Cost elements are illustrated more fully in the tables and charts of Appendix B. The 'A' series charts show each element of direct operating costs. The 'B' series charts show these elements divided through by the number of passengers carried, and therefore the composition of the TDOCPP. Note that the upper and lower target WIG TDOCPP's were taken as; (upper) an average of the aircraft TDOCPP and, (lower) and average of the ferry TDOCPP. From the B series charts it can be seen that the TDOCPP for the 74m ferry craft is about twice that of the Austal 38m[19], so if WIG was priced against the Austal the WIG capital cost would need to come down further.

Within the Formative Industry scenario the competitive range for WIG capital cost is between 2% - 33%[20] that of the equivalent aircraft; a very demanding design target! It can also be seen that the fuel element for regional aircraft is small: only 7 - 10% of the

[19] reflecting vehicle revenue
[20] From Table 1, Formative industry, Open/constrained competition, WIG 1 compared to capital cost of SAAB 340

total direct operating costs, while capital cost recovery accounts for half of the total cost. This explodes the myth that fuel/power efficiency is key to WIG's competitive advantage over aircraft, since savings on the fuel element will have little effect on the overall costs.

The 150 seater WIG is able to support a high capital cost by virtue of its high speed (400 km) and capacity which allows its costs to be spread across more passengers. A target cost, under Formative conditions of between $13m - $19m may be an achievable goal.

Constrained competition:
With competing vehicle operating hours constrained to those of WIG the cost of WIG can rise. It is most noticeable at the bottom end, allowing the 33 seater to rise by 4.3 times in the formative industry scenario[21]. Design of real WIG vehicles to the costs under Constrained competition conditions appear much more achievable than under Open competition scenarios. A sound market entry strategy would aim to locate and service such markets as a priority.

Niche Competition:
The above analysis used a 'free market' approach, working backwards to derive a target capital cost of WIG craft in a competitive situation[22]. The 'Niche competition' approach assumes that competition from other forms of transport is not an issue, and so does not drive the capital cost of the craft. For the model the 33 seater WIG capital cost is pre-set to a figure thought to be realistically achievable[23], at 66.7% that of the equivalent aircraft, and the TDOCPP is calculated according to formative and established market conditions. The vehicle costs and TDOCPP for 200 km journey, 150 km/h operating speed are set out in Table 1. It can be seen that the TDOCPP figures for the craft are considerably higher than under the Open competition and Constrained competition, reflecting the higher craft capital cost and indicating that the fare price would have to be two-to-three times more than that of aircraft.

The tables below explore this further, by setting out the cost elements for the WIG and its aircraft equivalent. Under Formative Industry conditions it can be seen that the WIG is handicapped by higher capital recovery and lower passenger numbers on the route. This situation improves under Established Industry conditions.

[21] at Ferry TDOCPP
[22] (and could be thought of as a 'market led' approach)
[23](and could be thought of as a 'cost plus' approach)

Niche Competiton: Formative Industry - 200 km - Direct Operating Costs (DOC)	SAAB 340 33 seats $10,800,000 cap.cost. 48,510 passengers pa.	WIG 1: 33 seats $7,200,000 cap.cost. 34,650 passengers pa.
Capital Cost (Finance) Recovery pa.	1,337,377	1,737,109
Maintenance & Insurance costs pa.	610,686	396,000
Fuel costs pa.	129,102	81,930
Crew cost recovery pa.	342,000	396,000
Total direct operating costs (TDOC) pa.	2,419,164	2,611,039
Niche Competiton: Formative Industry - 200 km - Direct Operating Costs Per Passenger (DOCPP)	SAAB 340 33 seats $10,800,000 cap.cost. 48,510 passengers pa.	WIG 1: 33 seats $7,200,000 cap.cost. 34,650 passengers pa.
Capital Cost (Finance) Recovery pp.	27.57	50.13
Maintenance & Insurance costs pp.	12.59	11.43
Fuel costs pp.	2.66	2.36
Crew cost recovery pp.	7.05	11.43
Total direct operating costs (TDOC) pp.	49.87	75.35

Niche Competiton: Established Industry - 200 km - Direct Operating Costs (DOC)	SAAB 340 33 seats $10,800,000 cap.cost. 48,510 passengers pa.	WIG 1: 33 seats $7,200,000 cap.cost. 34,650 passengers pa.
Capital Cost (Finance) Recovery pa.	1,337,377	925,064
Maintenance & Insurance costs pa.	610,686	396,000
Fuel costs pa.	129,102	81,930
Crew cost recovery pa.	342,000	396,000
Total direct operating costs (TDOC) pa.	2,419,164	1,798,994
Niche Competiton: Established Industry - 200 km - Direct Operating Costs Per Passenger (DOCPP)	SAAB 340 33 seats $10,800,000 cap.cost. 48,510 passengers pa.	WIG 1: 33 seats $7,200,000 cap.cost. 34,650 passengers pa.
Capital Cost (Finance) Recovery pp.	27.57	26.70
Maintenance & Insurance costs pp.	12.59	11.43
Fuel costs pp.	2.66	2.36
Crew cost recovery pp.	7.05	11.43
Total direct operating costs (TDOC) pp.	49.87	51.92

Exploring Speed and Distance Envelope

The 33 seater wig niche model is explored further, by varying the craft speed (150 – 550 km/h) and journey distance (50 – 500 km), to give a view of the its competitiveness relative to aircraft in different operating scenarios.

To maximise realism the model engine power and fuel consumption is increased with speed (albeit the capital cost of the craft remains fixed) within notional criteria:

33-seat WIG speed km/h	Percentage of 33-seat aircraft power
150	25%
550	90%

Results

The chart 'Appendix C' shows that under 'Formative' industry conditions the 150 km/h WIG gives a TDOCPP which is only less than the Saab 340 aircraft for journeys under 50 km[24]. In other words, it will be competitive only for short journeys. However, if craft speed is increased to 250 km/h the WIG becomes competitive on journeys up to around 180 km because its speed allows extra trips to be achieved in the operating day, and so carry more passengers to offset its capital cost. The message is clear: higher speed results enables more trips and a lower total cost per passenger.

Under 'Established' conditions the reduced capital cost recovery burden results in the 150 km/h craft giving in a TDOCPP which is competitive with aircraft on journeys up to around 190 km.

About the modelling

It must be remembered that in the model the price of new aircraft was used. Second hand aircraft are available at a large discount, and since capital cost is key this will have a dramatic impact to weaken the commercial competitiveness of WIG. Against this, the exclusion of aircraft navigation and landing charges may have painted aircraft economics in a better light than may be the case in many geographic/route locations.

The accuracy of the modelling is limited by the small sample of craft costs used. The considerable difference between the cost per passenger (DTOCPP) of the 38m and 74m ferry craft illustrates this and highlights the need for the analysis to be done in context of likely competition. With further work it would also be possible to develop the model and determine exactly what craft cost criteria would suit specific speed/distance parameters.

5. CONCLUSIONS

[24] The number of trips achievable in a day is rounded to return journeys, which accounts for the steps in the charted results

The basics of WIG transportation technology already exist. Whether this makes the translation from designers fantasy to business fact is an issue of commercial reasoning. As stated at the beginning, the paper set out to explore an approach to this reasoning.

The analysis has provided 'ball-park' guidance on the potential cost and operating limitations of WIG craft for them to make a reasonable business case. Further work is needed to refine the model, probably best done in context of specific routes. However, the early indicators are that factors combine to limit the commercial opportunity for WIG:

- reduced hours of operation
- reduced journey duration/distance than initially thought
- risk, obsolescence/development, economic lifetime
- competitive environment
- tight capital cost limit (depending on speed); perhaps 20% that of the equivalent aircraft

The main benefits from the ground-effect tend to be mutually exclusive: 1) a substantial reduction in propulsive power or fuel requirement, or 2) a substantial increase in load for the same power, compared to other vehicles. In this paper craft capital cost has been found to be more of a competitive issue that fuel economy. This suggests that WIG designers focus on (2) - increasing load for the same cost, rather than (1), and so maximise the revenue earning capacity against which the capital costs can be set. Another response is to focus on high operating speed, which again enables the capital cost to be set against more trips and more passengers.

Although by virtue of its wave clearance WIG is relatively immune to sea state, it is difficult not to view commercial WIG as a fair-weather craft, confined to operations in daylight hours and relatively short distance. This reduces the utilisation of the craft against which its capital costs can be set, and so makes WIG a less attractive option than competing transport vehicles unless that capital cost is minimised. WIG is also a victim of its own 'newness'. Until WIG craft have gained a track record of some 10 years service the financial factors surrounding the capital costs conspire against it.
For commercial WIG to become fact rather than fantasy, designers must respond with clear, simple concepts that match materials and construction techniques to delivering vessels within the very tight cost limitations.

ACKNOWLEDGEMENT

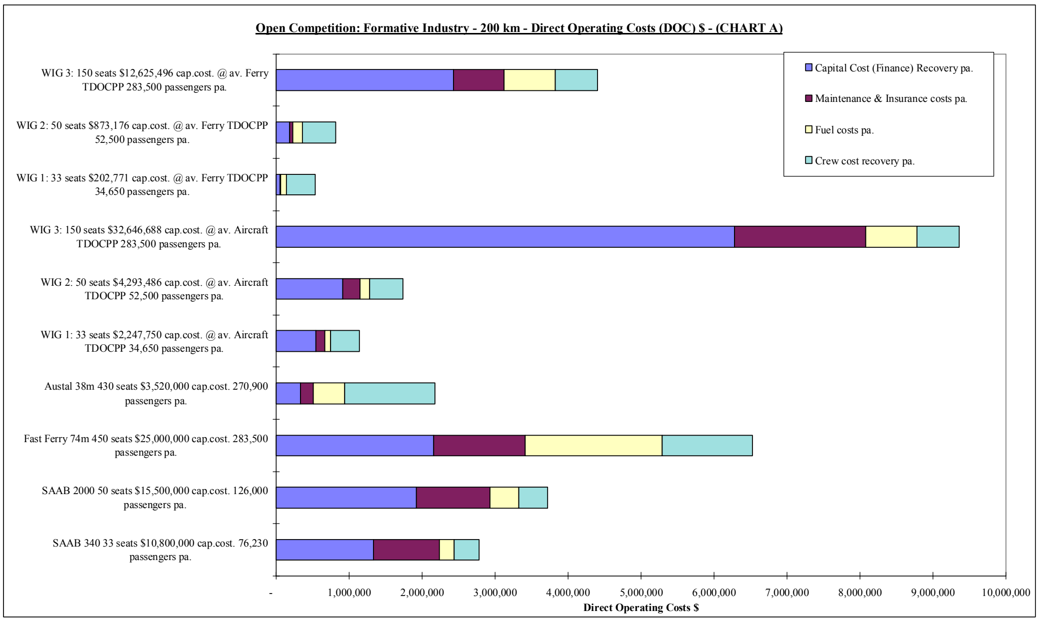
The author wishes to thank the following people for their help with this paper: Mr D Murray - Saab Aircraft International, England. Mr Andrew Blyth - Blyth Bridges Marine Consultants, England. Mr Robert Bryce - Hart Fenton & Co. Ltd, England. Special thanks is given to Professor Lawrence Doctors – The University of New South Wales for presenting the original text on behalf of the author.

APPENDIX A - SCENARIO VARIABLES

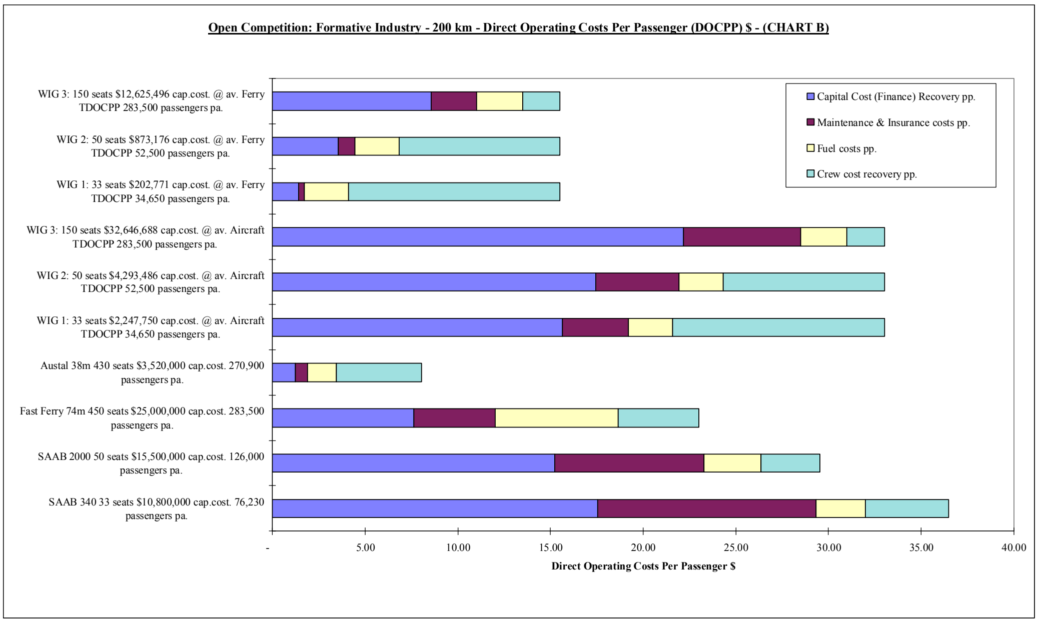
Scenarios	SAAB 340	SAAB 2000	Fast Ferry 74m	Austal 38m	WIG 1: 33 seats	WIG 2: 50 seats	WIG 3: 150 seats
Hours of Operation							
Open Competition:							
Usual hours of operation/day (base)	12	12	12	12	8	8	8
Constrained Competition:							
Usual hours of operation/day (base)	8	8	8	8	8	8	8
Formative Industry							
Amortisation years (per)	14	14	20	20	6	7	8
Rate of residual value	15%	15%	10%	10%	0%	0%	0%
Interest factor. (rate)	5%	5%	5%	5%	7%	7%	7%
Established Industry							
Amortisation years (nper)	14	14	20	20	14	14	14
Rate of residual value	15%	15%	10%	10%	10%	10%	10%
Interest factor. (rate)	5%	5%	5%	5%	6%	6%	6%

APPENDIX B - RESULTS - OPEN & CONSTRAINED COMPETITION. FORMATIVE & ESTABLISHED INDUSTRY

Open Competition: Formative Industry - 200 km - Direct Operating Costs (DOC) $ - (CHART A)	SAAB 340 33 seats $10,800,000 cap.cost. 76,230 passengers pa.	SAAB 2000 50 seats $15,500,000 cap.cost. 126,000 passengers pa.	Fast Ferry 74m 450 seats $25,000,000 cap.cost. 283,500 passengers pa.	Austal 38m 430 seats $3,520,000 cap.cost. 270,900 passengers pa.	WIG 1: 33 seats $2,247,750 cap.cost. @ av. Aircraft TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $4,293,486 cap.cost. @ av. Aircraft TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $32,646,688 cap.cost. @ av. Aircraft TDOCPP 283,500 passengers pa.	WIG 1: 33 seats $202,771 cap.cost. @ av. Ferry TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $873,176 cap.cost. @ av. Ferry TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $12,625,496 cap.cost. @ av. Ferry TDOCPP 283,500 passengers pa.
Capital Cost (Finance) Recovery pa.	1,337,377	1,919,383	2,161,914	335,467	542,304	916,171	6,287,358	48,922	186,324	2,431,518
Maintenance & Insurance costs pa.	897,935	1,014,783	1,250,000	176,000	123,626	236,142	1,795,568	11,152	48,025	694,402
Fuel costs pa.	202,874	387,468	1,878,668	428,446	81,930	124,809	699,930	81,930	124,809	699,930
Crew cost recovery pa.	342,000	402,000	1,236,000	1,236,000	396,000	456,000	576,000	396,000	456,000	576,000
Total direct operating costs (TDOC) pa.	2,780,186	3,723,635	6,526,582	2,175,914	1,143,860	1,733,121	9,358,856	538,004	815,157	4,401,850

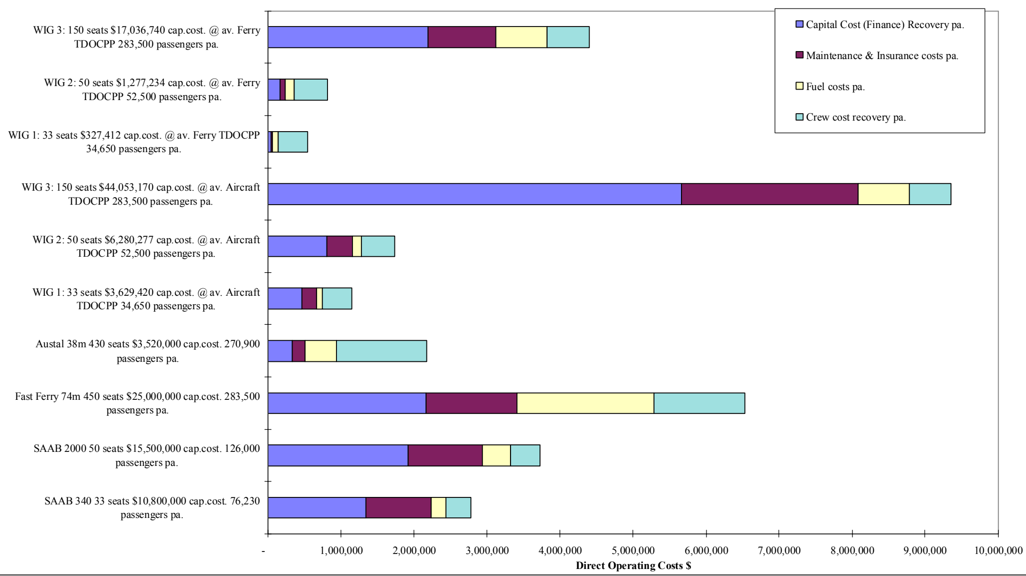


Open Competition: Formative Industry - 200 km - Direct Operating Costs Per Passenger (DOCPP) $ - (CHART B)	SAAB 340 33 seats $10,800,000 cap.cost. 76,230 passengers pa.	SAAB 2000 50 seats $15,500,000 cap.cost. 126,000 passengers pa.	Fast Ferry 74m 450 seats $25,000,000 cap.cost. 283,500 passengers pa.	Austal 38m 430 seats $3,520,000 cap.cost. 270,900 passengers pa.	WIG 1: 33 seats $2,247,750 cap.cost. @ av. Aircraft TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $4,293,486 cap.cost. @ av. Aircraft TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $32,646,688 cap.cost. @ av. Aircraft TDOCPP 283,500 passengers pa.	WIG 1: 33 seats $202,771 cap.cost. @ av. Ferry TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $873,176 cap.cost. @ av. Ferry TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $12,625,496 cap.cost. @ av. Ferry TDOCPP 283,500 passengers pa.
Capital Cost (Finance) Recovery pp.	17.54	15.23	7.63	1.24	15.65	17.45	22.18	1.41	3.55	8.58
Maintenance & Insurance costs pp.	11.78	8.05	4.41	0.65	3.57	4.50	6.33	0.32	0.91	2.45
Fuel costs pp.	2.66	3.08	6.63	1.58	2.36	2.38	2.47	2.36	2.38	2.47
Crew cost recovery pp.	4.49	3.19	4.36	4.56	11.43	8.69	2.03	11.43	8.69	2.03
Total direct operating costs (TDOC) pp.	36.47	29.55	23.02	8.03	33.01	33.01	33.01	15.53	15.53	15.53



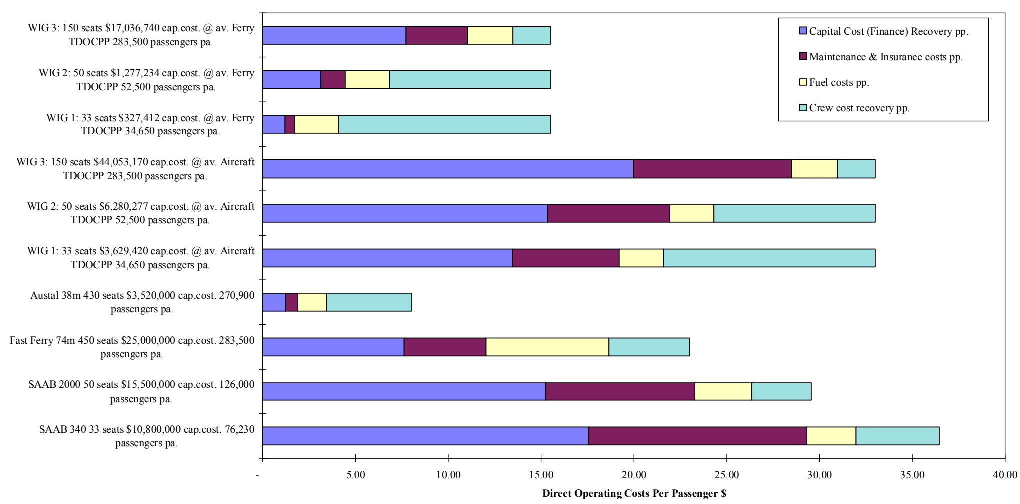
Open Competition: Established Industry - 200 km - Direct Operating Costs (DOC) $ - (CHART A)	SAAB 340 33 seats $10,800,000 cap.cost. 76,230 passengers pa.	SAAB 2000 50 seats $15,500,000 cap.cost. 126,000 passengers pa.	Fast Ferry 74m 450 seats $25,000,000 cap.cost. 283,500 passengers pa.	Austal 38m 430 seats $3,520,000 cap.cost. 270,900 passengers pa.	WIG 1: 33 seats $3,629,420 cap.cost. @ av. Aircraft TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $6,280,277 cap.cost. @ av. Aircraft TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $44,053,170 cap.cost. @ av. Aircraft TDOCPP 283,500 passengers pa.	WIG 1: 33 seats $327,412 cap.cost. @ av. Ferry TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $1,277,234 cap.cost. @ av. Ferry TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $17,036,740 cap.cost. @ av. Ferry TDOCPP 283,500 passengers pa.
Capital Cost (Finance) Recovery pa.	1,337,377	1,919,383	2,161,914	335,467	466,312	806,897	5,660,001	42,066	164,101	2,188,900
Maintenance & Insurance costs pa.	897,935	1,014,783	1,250,000	176,000	199,618	345,415	2,422,924	18,008	70,248	937,021
Fuel costs pa.	202,874	387,468	1,878,668	428,446	81,930	124,809	699,930	81,930	124,809	699,930
Crew cost recovery pa.	342,000	402,000	1,236,000	1,236,000	396,000	456,000	576,000	396,000	456,000	576,000
Total direct operating costs (TDOC) pa.	2,780,186	3,723,635	6,526,582	2,175,914	1,143,860	1,733,121	9,358,856	538,004	815,157	4,401,850

Open Competition: Established Industry - 200 km - Direct Operating Costs (DOC) $ - (CHART A)



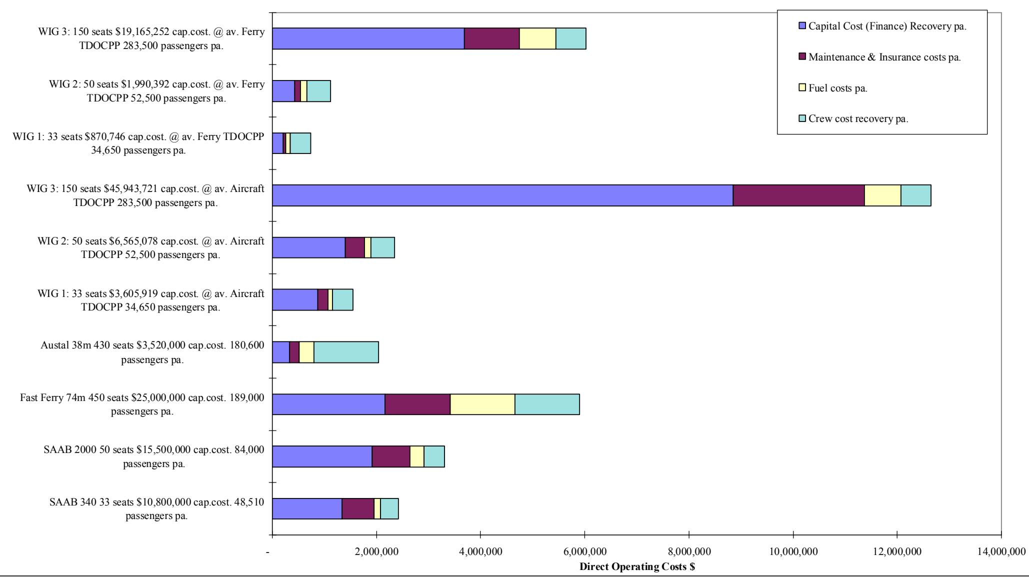
Open Competition: Established Industry - 200 km - Direct Operating Costs Per Passenger (DOCPP) $ - (CHART B)	SAAB 340 33 seats $10,800,000 cap.cost. 76,230 passengers pa.	SAAB 2000 50 seats $15,500,000 cap.cost. 126,000 passengers pa.	Fast Ferry 74m 450 seats $25,000,000 cap.cost. 283,500 passengers pa.	Austal 38m 430 seats $3,520,000 cap.cost. 270,900 passengers pa.	WIG 1: 33 seats $3,629,420 cap.cost. @ av. Aircraft TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $6,280,277 cap.cost. @ av. Aircraft TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $44,053,170 cap.cost. @ av. Aircraft TDOCPP 283,500 passengers pa.	WIG 1: 33 seats $327,412 cap.cost. @ av. Ferry TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $1,277,234 cap.cost. @ av. Ferry TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $17,036,740 cap.cost. @ av. Ferry TDOCPP 283,500 passengers pa.
Capital Cost (Finance) Recovery pp.	17.54	15.23	7.63	1.24	13.46	15.37	19.96	1.21	3.13	7.72
Maintenance & Insurance costs pp.	11.78	8.05	4.41	0.65	5.76	6.58	8.55	0.52	1.34	3.31
Fuel costs pp.	2.66	3.08	6.63	1.58	2.36	2.38	2.47	2.36	2.38	2.47
Crew cost recovery pp.	4.49	3.19	4.36	4.56	11.43	8.69	2.03	11.43	8.69	2.03
Total direct operating costs (TDOC) pp.	36.47	29.55	23.02	8.03	33.01	33.01	33.01	15.53	15.53	15.53

Open Competition: Established Industry - 200 km - Direct Operating Costs Per Passenger (DOCPP) $ - (CHART B)



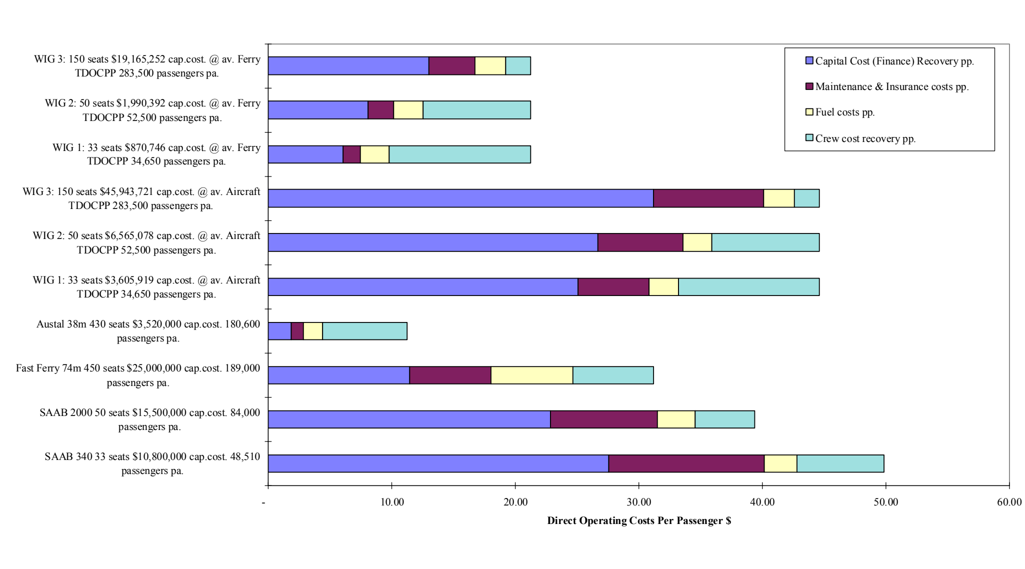
Constrained Competition: Formative Industry - 200 km - Direct Operating Costs (DOC) $ - (CHART A)	SAAB 340 33 seats $10,800,000 cap.cost. 48,510 passengers pa.	SAAB 2000 50 seats $15,500,000 cap.cost. 84,000 passengers pa.	Fast Ferry 74m 450 seats $25,000,000 cap.cost. 189,000 passengers pa.	Austal 38m 430 seats $3,520,000 cap.cost. 180,600 passengers pa.	WIG 1: 33 seats $3,605,919 cap.cost. @ av. Aircraft TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $6,565,078 cap.cost. @ av. Aircraft TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $45,943,721 cap.cost. @ av. Aircraft TDOCPP 283,500 passengers pa.	WIG 1: 33 seats $870,746 cap.cost. @ av. Ferry TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $1,990,392 cap.cost. @ av. Ferry TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $19,165,252 cap.cost. @ av. Ferry TDOCPP 283,500 passengers pa.
Capital Cost (Finance) Recovery pa.	1,337,377	1,919,383	2,161,914	335,467	869,983	1,400,897	8,848,206	210,081	424,722	3,690,996
Maintenance & Insurance costs pa.	610,686	728,189	1,250,000	176,000	198,326	361,079	2,526,905	47,891	109,472	1,054,089
Fuel costs pa.	129,102	258,312	1,252,445	285,631	81,930	124,809	699,930	81,930	124,809	699,930
Crew cost recovery pa.	342,000	402,000	1,236,000	1,236,000	396,000	456,000	576,000	396,000	456,000	576,000
Total direct operating costs (TDOC) pa.	2,419,164	3,307,884	5,900,359	2,033,098	1,546,238	2,342,785	12,651,041	735,902	1,115,003	6,021,015

Constrained Competition: Formative Industry - 200 km - Direct Operating Costs (DOC) $ - (CHART A)

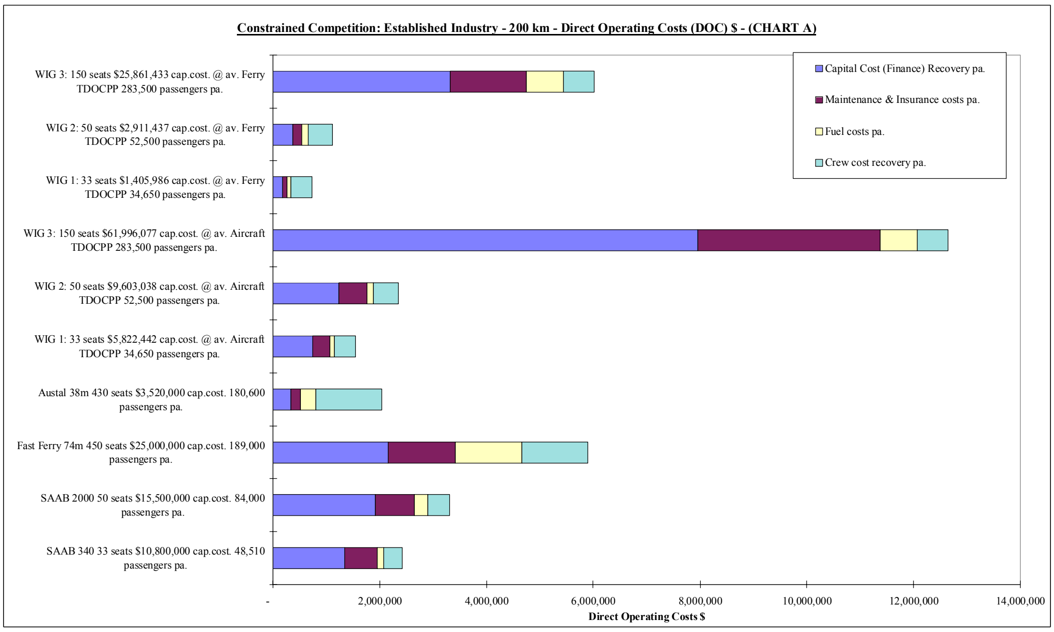


Constrained Competition: Formative Industry - 200 km - Direct Operating Costs Per Passenger (DOCPP) $ - (CHART B)	SAAB 340 33 seats $10,800,000 cap.cost. 48,510 passengers pa.	SAAB 2000 50 seats $15,500,000 cap.cost. 84,000 passengers pa.	Fast Ferry 74m 450 seats $25,000,000 cap.cost. 189,000 passengers pa.	Austal 38m 430 seats $3,520,000 cap.cost. 180,600 passengers pa.	WIG 1: 33 seats $3,605,919 cap.cost. @ av. Aircraft TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $6,565,078 cap.cost. @ av. Aircraft TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $45,943,721 cap.cost. @ av. Aircraft TDOCPP 283,500 passengers pa.	WIG 1: 33 seats $870,746 cap.cost. @ av. Ferry TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $1,990,392 cap.cost. @ av. Ferry TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $19,165,252 cap.cost. @ av. Ferry TDOCPP 283,500 passengers pa.
Capital Cost (Finance) Recovery pp.	27.57	22.85	11.44	1.86	25.11	26.68	31.21	6.06	8.09	13.02
Maintenance & Insurance costs pp.	12.59	8.67	6.61	0.97	5.72	6.88	8.91	1.38	2.09	3.72
Fuel costs pp.	2.66	3.08	6.63	1.58	2.36	2.38	2.47	2.36	2.38	2.47
Crew cost recovery pp.	7.05	4.79	6.54	6.84	11.43	8.69	2.03	11.43	8.69	2.03
Total direct operating costs (TDOC) pp.	49.87	39.38	31.22	11.26	44.62	44.62	44.62	21.24	21.24	21.24

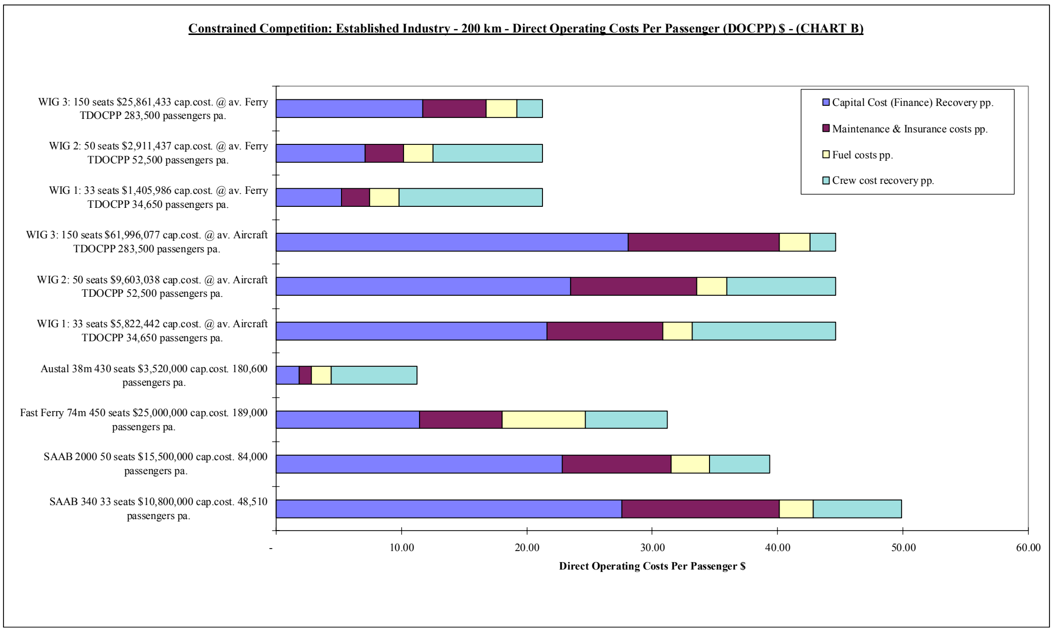
Constrained Competition: Formative Industry - 200 km - Direct Operating Costs Per Passenger (DOCPP) $ - (CHART B)



Constrained Competition: Established Industry - 200 km - Direct Operating Costs (DOC) $ - (CHART A)	SAAB 340 33 seats $10,800,000 cap.cost. 48,510 passengers pa.	SAAB 2000 50 seats $15,500,000 cap.cost. 84,000 passengers pa.	Fast Ferry 74m 450 seats $25,000,000 cap.cost. 189,000 passengers pa.	Austal 38m 430 seats $3,520,000 cap.cost. 180,600 passengers pa.	WIG 1: 33 seats $5,822,442 cap.cost. @ av. Aircraft TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $9,603,038 cap.cost. @ av. Aircraft TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $61,996,077 cap.cost. @ av. Aircraft TDOCPP 283,500 passengers pa.	WIG 1: 33 seats $1,405,986 cap.cost. @ av. Ferry TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $2,911,437 cap.cost. @ av. Ferry TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $25,861,433 cap.cost. @ av. Ferry TDOCPP 283,500 passengers pa.
Capital Cost (Finance) Recovery pa.	1,337,377	1,919,383	2,161,914	335,467	748,074	1,233,809	7,965,326	180,643	374,065	3,322,706
Maintenance & Insurance costs pa.	610,686	728,189	1,250,000	176,000	320,234	528,167	3,409,784	77,329	160,129	1,422,379
Fuel costs pa.	129,102	258,312	1,252,445	285,631	81,930	124,809	699,930	81,930	124,809	699,930
Crew cost recovery pa.	342,000	402,000	1,236,000	1,236,000	396,000	456,000	576,000	396,000	456,000	576,000
Total direct operating costs (TDOC) pa.	2,419,164	3,307,884	5,900,359	2,033,098	1,546,238	2,342,785	12,651,041	735,902	1,115,003	6,021,015



Constrained Competition: Established Industry - 200 km - Direct Operating Costs Per Passenger (DOCPP) $ - (CHART B)	SAAB 340 33 seats $10,800,000 cap.cost. 48,510 passengers pa.	SAAB 2000 50 seats $15,500,000 cap.cost. 84,000 passengers pa.	Fast Ferry 74m 450 seats $25,000,000 cap.cost. 189,000 passengers pa.	Austal 38m 430 seats $3,520,000 cap.cost. 180,600 passengers pa.	WIG 1: 33 seats $5,822,442 cap.cost. @ av. Aircraft TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $9,603,038 cap.cost. @ av. Aircraft TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $61,996,077 cap.cost. @ av. Aircraft TDOCPP 283,500 passengers pa.	WIG 1: 33 seats $1,405,986 cap.cost. @ av. Ferry TDOCPP 34,650 passengers pa.	WIG 2: 50 seats $2,911,437 cap.cost. @ av. Ferry TDOCPP 52,500 passengers pa.	WIG 3: 150 seats $25,861,433 cap.cost. @ av. Ferry TDOCPP 283,500 passengers pa.
Capital Cost (Finance) Recovery pp.	27.57	22.85	11.44	1.86	21.59	23.50	28.10	5.21	7.13	11.72
Maintenance & Insurance costs pp.	12.59	8.67	6.61	0.97	9.24	10.06	12.03	2.23	3.05	5.02
Fuel costs pp.	2.66	3.08	6.63	1.58	2.36	2.38	2.47	2.36	2.38	2.47
Crew cost recovery pp.	7.05	4.79	6.54	6.84	11.43	8.69	2.03	11.43	8.69	2.03
Total direct operating costs (TDOC) pp.	49.87	39.38	31.22	11.26	44.62	44.62	44.62	21.24	21.24	21.24

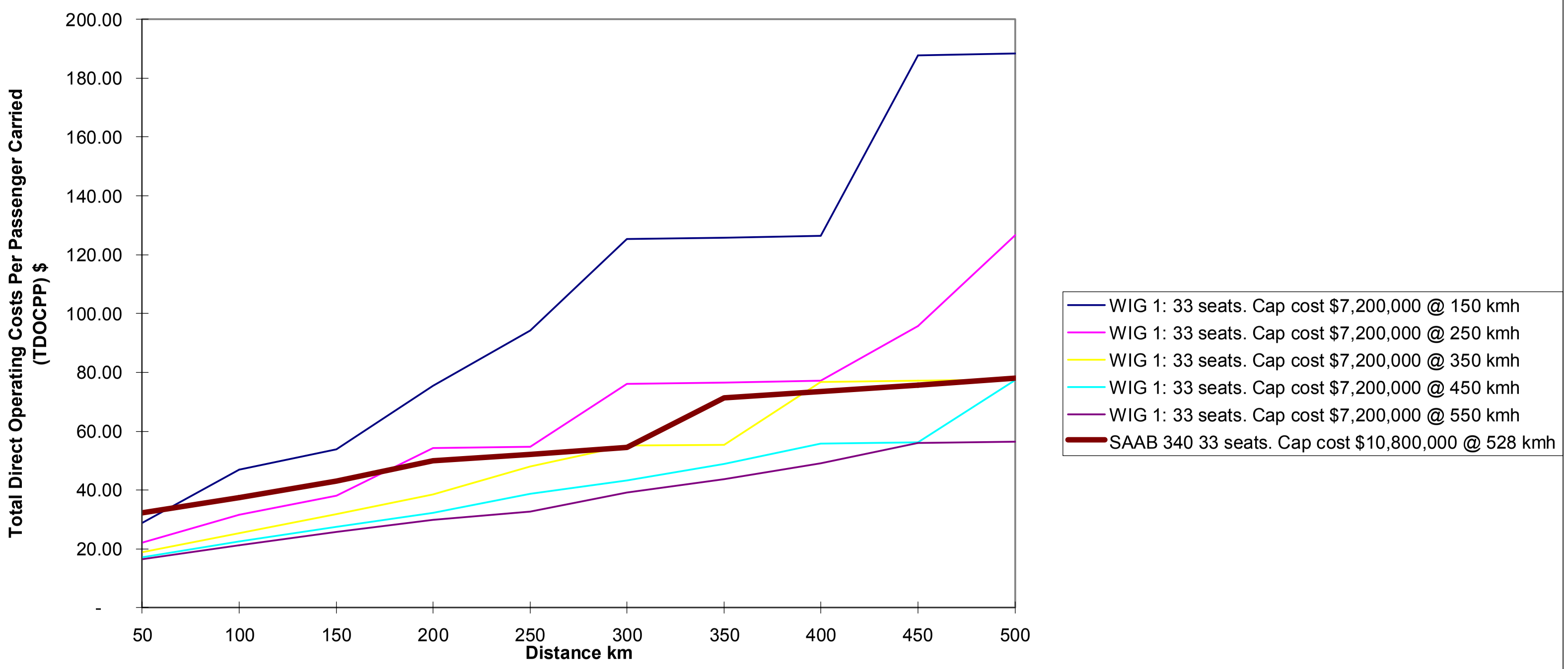


APPENDIX C - RESULTS - NICHE COMPETITION - 33 SEATER WIG MODEL COMPARED TO 33 SEATER AIRCRAFT

Comparison of Total Direct Operating Costs Per Passenger For Varying Speed and Distance- WIG and Aircraft, Formative Industry - Niche Conditions

Cap. Cost of WIG = 66.67% Cap. Cost of Aircraft			Distance km									
Speed knots	Speed km/h	Vehicle	50	100	150	200	250	300	350	400	450	500
81	150	WIG 1: 33 seats. Cap cost $7,200,000 @ 150 kmh	28.68	46.81	53.92	75.35	94.19	125.19	125.77	126.36	187.77	188.35
135	250	WIG 1: 33 seats. Cap cost $7,200,000 @ 250 kmh	21.99	31.43	38.02	54.16	54.66	76.01	76.51	77.02	95.76	126.68
189	350	WIG 1: 33 seats. Cap cost $7,200,000 @ 350 kmh	18.73	25.28	31.82	38.37	47.96	54.94	55.41	76.72	77.19	77.65
243	450	WIG 1: 33 seats. Cap cost $7,200,000 @ 450 kmh	17.05	22.37	27.42	32.21	38.73	43.23	48.75	55.71	56.15	77.45
297	550	WIG 1: 33 seats. Cap cost $7,200,000 @ 550 kmh	16.32	21.16	25.64	29.82	32.59	39.10	43.59	49.09	56.04	56.47
285	528	SAAB 340 33 seats. Cap cost $10,800,000 @ 528 kmh	32.16	37.24	43.04	49.87	52.09	54.31	71.27	73.49	75.71	77.92

Comparison of Total Direct Operating Costs Per Passenger For Varying Speed and Distance- WIG and Aircraft, Formative Industry - Niche Conditions - Cap. Cost of WIG = 66.67% Cap. Cost of Aircraft

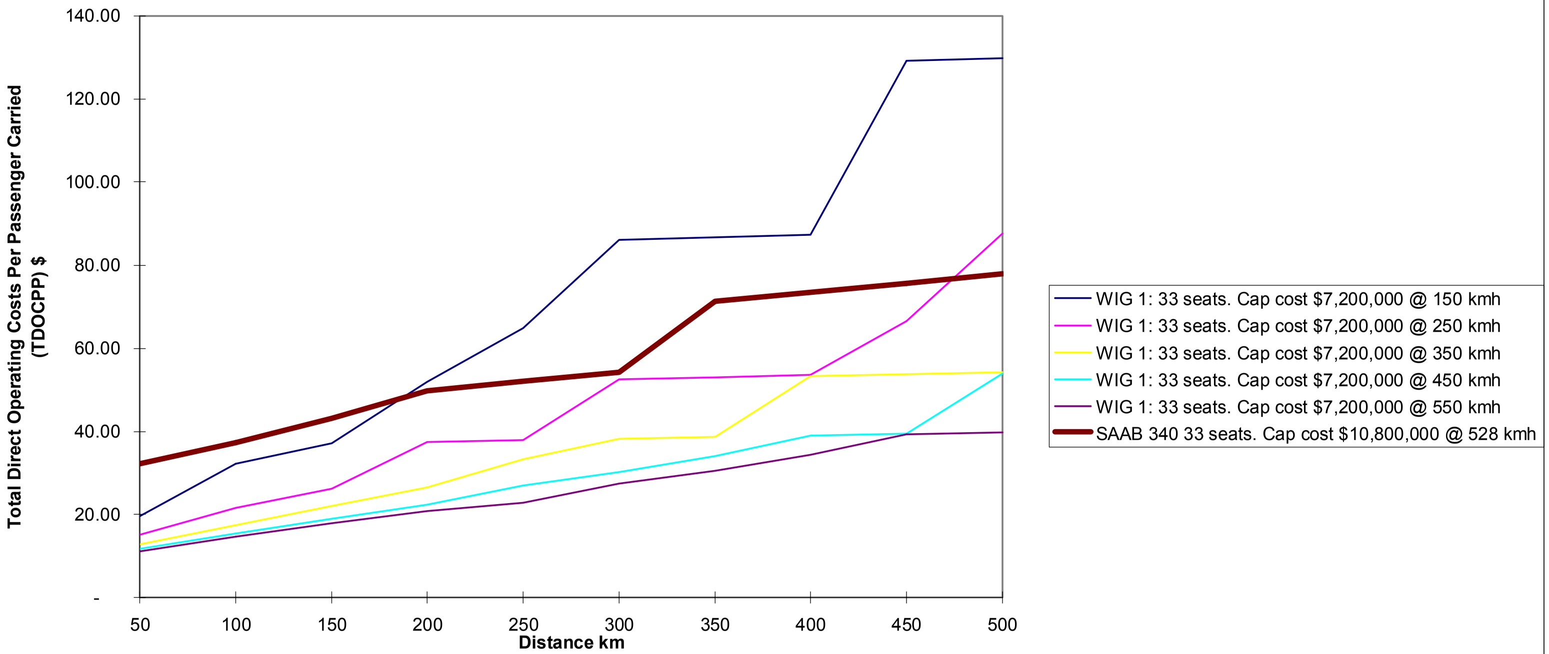


Comparison of Total Direct Operating Costs Per Passenger For Varying Speed and Distance- WIG and Aircraft, Established Industry - Niche Conditions

Cap. Cost of WIG = 66.67% Cap. Cost of Aircraft

Speed knots	Speed km/h	Vehicle	Distance km 50	100	150	200	250	300	350	400	450	500
81	150	WIG 1: 33 seats. Cap cost $7,200,000 @ 150 kmh	19.67	32.17	37.18	51.92	64.89	86.13	86.71	87.30	129.18	129.76
135	250	WIG 1: 33 seats. Cap cost $7,200,000 @ 250 kmh	15.10	21.67	26.30	37.42	37.92	52.58	53.08	53.58	66.47	87.62
189	350	WIG 1: 33 seats. Cap cost $7,200,000 @ 350 kmh	12.87	17.47	22.06	26.65	33.31	38.20	38.67	53.29	53.75	54.22
243	450	WIG 1: 33 seats. Cap cost $7,200,000 @ 450 kmh	11.72	15.48	19.05	22.44	27.02	30.21	34.10	38.97	39.41	54.01
297	550	WIG 1: 33 seats. Cap cost $7,200,000 @ 550 kmh	11.22	14.65	17.83	20.80	22.82	27.38	30.57	34.44	39.30	39.73
285	528	SAAB 340 33 seats. Cap cost $10,800,000 @ 528 kmh	32.16	37.24	43.04	49.87	52.09	54.31	71.27	73.49	75.71	77.92

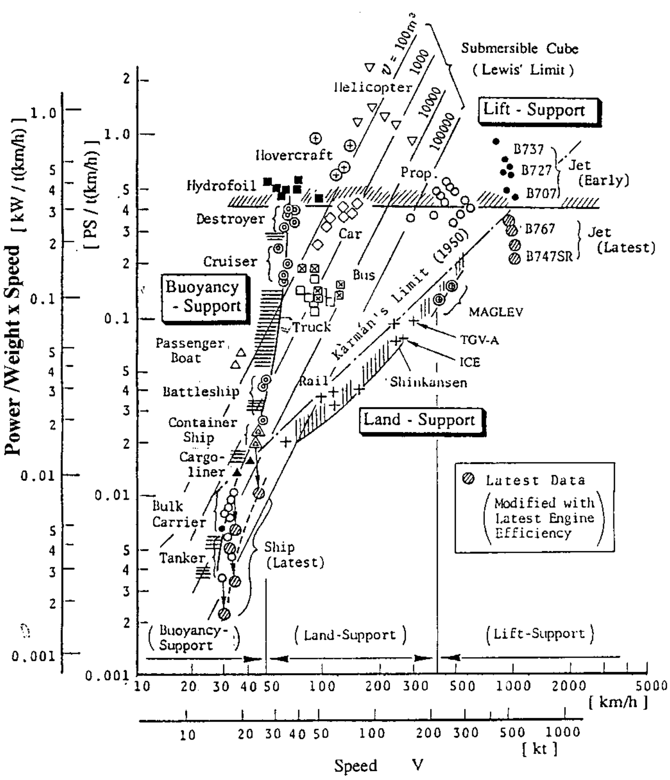
Comparison of Total Direct Operating Costs Per Passenger For Varying Speed and Distance- WIG and Aircraft, Established Industry - Niche Conditions - Cap. Cost of WIG = 66.67% Cap. Cost of Aircraft



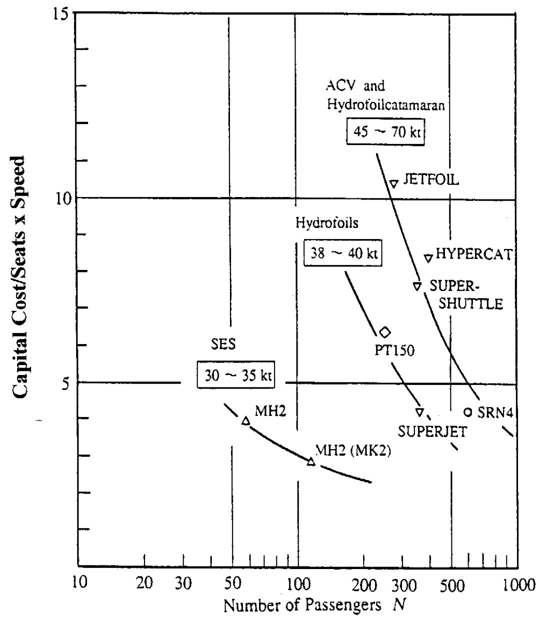
APPENDIX D – OTHER METHODOLOGIES

Examples of methods for placing high speed marine craft in context with other vehicles:

Kármán-Gabrielli diagram (Akagi 1991)



Size and Price of Marine Vehicles (Akagi 1993)



APPENDIX E – ECONOMIC MODEL EXAMPLE

All Prices in US$	Aircraft		Fast Ferry		WIG		
Craft specifics	**SAAB 340**	**SAAB 2000**	**Fast Ferry 74m**	**Austal 38m**	**WIG 1: 33 seats**	**WIG 2: 50 seats**	**WIG 3: 150 seats**
Craft length m			74	38	18	25	58
Number of seats	33	50	450	430	33	50	150
Nominal vehicle speed km/hour	528	685	65	56	150	150	400
Vehicle speed knots equivalent	285	370	35	30	81	81	216
Installed power kW	2,610	5,574	15,040	2,940	869	1,324	11,000
Engine type	Turboprop	Turboprop	Diesel	Diesel	Turboprop	Turboprop	Turboprop
Cruse allowance	82%	77%	90%	90%	80%	80%	80%
Specific fuel consumption g/kWh	210	210	210	210	250	250	250
Fuel consumption /hour (litres, kg)	449	901	2,843	556	174	265	2,200
Fuel cost/kg $	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Fuel cost/hour $	89.89	180.26	568.51	111.13	34.77	52.96	440.00
Capital Cost of Craft $	**10,800,000**	**15,500,000**	**25,000,000**	**3,520,000**	**7,200,000**	**2,911,437**	**25,861,433**
Ancillary equipment etc. (spares/port fit)	1,620,000	2,325,000	1,000,000	528,000	1,080,000	436,716	3,879,215
Total capital cost	12,420,000	17,825,000	26,000,000	4,048,000	8,280,000	3,348,152	29,740,648
Rate of residual value	15%	15%	10%	10%	10%	10%	10%
Residual value	1,620,000.00	2,325,000.00	2,500,000.00	352,000.00	720,000.00	291,143.68	2,586,143.28
Amortisation years (nper)	14	14	20	20	14	14	14
Maintenance factor if specified:	-	-	4%	4%	4%	4%	4%
Maintenance per flight hour if specified $:	350	400	-	-	-	-	-
Hull insurance factor (of cap cost)	1.00%	1.00%	1.00%	1.00%	1.50%	1.50%	1.50%
Minimum Crew Complement if specified			18	18			8
Number of attendants if specified	1	2					
Turnaround port time mins	30	30	40	40	15	15	25
Usual hours of operation/day (base)	8	8	8	8	8	8	8
Journey specifics							
Journey one-way length km	200	200	200	200	200	200	200
Journey one-way length nmiles	108	108	108	108	108	108	108
Journey model							
Journey time hrs	0.59	0.51	3.15	3.67	1.35	1.35	0.51
Effective speed km/h	341	391	64	54	149	149	396
Effective speed knots	184	211	34	29	80	80	214
Turnaround port time hrs	0.50	0.50	0.67	0.67	0.25	0.25	0.42
Inc. trip time hrs	1.09	1.01	3.81	4.34	1.60	1.60	0.92
Capital Cost recovery model							
As if loan							
Interest factor. (rate)	5%	5%	5%	5%	6%	6%	6%
Financing repayment:	1,337,377	1,919,383	2,161,914	335,467	925,064	374,065	3,322,706
Capital Cost (Finance) Recovery	1,337,377	1,919,383	2,161,914	335,467	925,064	374,065	3,322,706
Maintenance & Insurance costs							
Hull Insurance	108,000	155,000	250,000	35,200	108,000	43,672	387,921
Maintenance	502,686	573,189	1,000,000	140,800	288,000	116,457	1,034,457
Passenger insurance - not costed							
Maintenance & Insurance costs	610,686	728,189	1,250,000	176,000	396,000	160,129	1,422,379
Fuel related cost recovery							
Fuel for trip (kg)	263	461	8,946	2,040	234	357	1,111
total flying time (hrs)	1,436	1,433	2,203	2,570	2,357	2,357	1,591
Fuel consumed kg p/a	645,509	1,291,561	6,262,227	1,428,154	409,650	624,045	3,499,650
Fuel cost/kg $	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Fuel costs	129,102	258,312	1,252,445	285,631	81,930	124,809	699,930
Crew related cost recovery model							
Total inc. trip hours	2,661	2,833	2,670	3,037	2,794	2,794	2,903
Total number of crew	3	4	18	18	4	5	7
Crew cost	342,000	402,000	1,236,000	1,236,000	396,000	456,000	576,000
Crew cost recovery	342,000	402,000	1,236,000	1,236,000	396,000	456,000	576,000
Port/landing/Navigation costs							
Navigation, on-route, landing and terminal nav aid	Not costed	Not costed	Not costed	Not costed	Not costed	Not costed	Not costed
Terminal/port use total	Not costed	Not costed	Not costed	Not costed	Not costed	Not costed	Not costed
Port/landing/Navigation costs	-	-	-		-	-	-
Other Indirect Costs							
Sales, marketing, administration	Not costed	Not costed	Not costed	Not costed	Not costed	Not costed	Not costed
Offices & ground based assets	Not costed	Not costed	Not costed	Not costed	Not costed	Not costed	Not costed
Other Indirect Costs	-	-	-	-	-	-	-
Economic summary							
Total direct operating costs (TDOC)	2,419,164	3,307,884	5,900,359	2,033,098	1,798,994	1,115,003	6,021,015
Total passengers carried (fares taken)	48,510	84,000	189,000	180,600	34,650	52,500	283,500
Total Distance traveled km	490,000	560,000	140,000	140,000	350,000	350,000	630,000
Direct costs per seat $	73,308	66,158	13,112	4,728	54,515	22,300	40,140
Direct operating costs per passenger $ (TDOCPP)	**49.87**	**39.38**	**31.22**	**11.26**	**51.92**	**21.24**	**21.24**
WIG Target TDOCPP $	**44.62**	44.62	**21.24**	21.24	**21.24**	21.24	21.24

	SAAB 340	**SAAB 2000**	**Fast Ferry 74m**	**Austal 38m**	**WIG 1: 33 seats**	**WIG 2: 50 seats**	**WIG 3: 150 seats**
Capital Cost (Finance) Recovery	1,337,377	1,919,383	2,161,914	335,467	925,064	374,065	3,322,706
Maintenance & Insurance costs	610,686	728,189	1,250,000	176,000	396,000	160,129	1,422,379
Fuel costs	129,102	258,312	1,252,445	285,631	81,930	124,809	699,930
Crew cost recovery	342,000	402,000	1,236,000	1,236,000	396,000	456,000	576,000
Port/landing/Navigation costs	-	-	-	-	-	-	-
Total direct operating costs (TDOC)	2,419,164	3,307,884	5,900,359	2,033,098	1,798,994	1,115,003	6,021,015