Industrial Development Subsidiary Agreement

Executive Summary

A Study Of Helicopter-Related Potential In Overhaul, Servicing And Manufacturing In B. C.

Research Report

Province of British Columbia
Ministry of Industry and Small Business Development

Government of Canada / Gouvernement du Canada
Regional Economic Expansion / Expansion Économique Régionale

Executive Summary

A Study Of Helicopter-Related Potential In Overhaul, Servicing And Manufacturing In B. C.

Prepared for:
Canada-British Columbia
Industrial Development Subsidiary Agreement
Industrial Development Committee

Prepared by:
Wayne McNeal
Columbia Pacific Resources Group Ltd.
1700 - 1050 West Pender Street
Vancouver, British Columbia

83.420
June 1984

Canadian Cataloguing in Publication Data

McNeal, Wayne

Executive summary : a study of helicopter-related potential in overhaul, servicing and manufacturing in British Columbia

"Columbia Pacific Resources Group Ltd."
On cover: Industrial Development Subsidiary Agreement research report.
ISBN 0-7726-0109-7

1. Helicopters - Maintenance and repair. 2. Helicopters - Equipment and supplies. 3. Helicopter industry - British Columbia. I. Industrial Development Subsidiary Agreement (Canada). Industrial Development Committee. II. British Columbia. Ministry of Industry and Small Business Development. III. Canada. Dept. of Regional Industrial Expansion. IV. Columbia Pacific Resources Group. V. Title: A study of helicopter-related potential in overhaul, servicing and manufacturing in British Columbia.

HD9711.2.C33B75 1984 338.4'76291346 C84-092183-7

ACKNOWLEDGEMENT

This study was funded by a grant from the Research Program of the Canada-British Columbia Industrial Development Subsidiary Agreement. This Agreement, which provides a variety of programs for industrial development, is cost shared equally by the governments of Canada and British Columbia through the Department of Regional Economic Expansion and the Ministry of Industry and Small Business Development respectively. Programs under the Agreement are administered by the Ministry of Industry and Small Business Development and managed by a joint Federal/ Provincial Committee.

The responsibility for the content of this report is the consultant's alone, and the conclusions reached herein do not necessarily reflect the opinions of those who assisted during the course of this investigation or the Federal and Provincial governments which funded the study.

TABLE OF CONTENTS

1.0 INTRODUCTION

British Columbia has a limited aerospace manufacturing industry but has substantial aircraft overhaul and repair facilities. There may be potential for British Columbia firms to participate in helicopter-related repair and overhaul servicing since the province constitutes one of the most active helicopter operations areas in Canada and is strategically located to the other active helicopter centres in the Western United States.

Two market regions were identified in the study. These two regions, a Primary Market Area and a Secondary Market are based on their geographic distance from British Columbia. The Primary Market Area is within 500 miles while the Secondary Market Area is within approximately 1,000 miles distance. The following provinces and states are in these two regions:

Primary Market Area	Secondary Market Area
British Columbia	Saskatchewan
Alberta	Manitoba
Yukon Territories	Northwest Territories
Washington	Wyoming
Oregon	Nevada
Idaho	Colorado
Alaska	New Mexico
	Arizona
	Montana
	California

2.0 WORLD HELICOPTER MARKET

In 1980, there were some 35,856 active helicopters in the Western World. The number of civil helicopters of this total were 15,344 (43 percent) and military units the remaining 20,512. The historical growth rate since 1970 has been 3.6 percent per annum . During the 1980's the world helicopter fleet is expected to grow by 4.3 percent per annum to reach 57,352 helicopters by 1990.

The following presents the estimated geographical distribution of helicopters in 1980.

Geographic Location	Civil	Military	Total
Mid East/Africa	500	2,740	3,240
Latin America	1,100	745	1,845
Asia/Pacific	1,700	2,260	3,960
Europe	2,000	5,025	7,025
North America	9,500	9,730	19,230
Unknown	500	-	500
	15,300	20,500	35,800

In the 1970's the world's helicopter manufacturers produced some 23,173 helicopters which had a current market value of production over $15 billion. The civil helicopter portion was close to 10,000 units but valued at only $3.2 billion of the total. During the period 1980-1990, it is estimated that some 32,428 helicopters will be manufactured at a

production value of $64 billion. The civil portion is forecast to be some 24,186 units with a production value of $23.8 billion in current dollars.

The following presents the expected geographic distribution of helicopters to be manufactured in the 1980's.

Geographic Location	Civil		Military	
	Units	$M	Units	$M
Mid East/Africa	1,099	1,007	1,116	4,651
Latin America	1,722	1,703	726	1,959
Asia/Pacific	2,286	2,124	1,169	3,905
Europe	2,721	3,547	3,134	11,962
North America	13,429	12,141	2,057	17,439
	21,257	20,522	8,202	39,916

The civil helicopter world market is dominated by the light single-engine class such as the Bell 206 and Hughes 500. In the 1970's some 5,790 of this class were manufactured and it is expected that in the 1980's another 14,311 will be produced.

Piston-powered helicopter class, of all weights, such as the Hughes 300 and Robinson R22 are also a large class of helicopter. In the 1970's some 2,403 units were manufactured and 3,773 are forecast to be produced in the 1980's.

The light twin helicopter class was introduced to the market in the 1970's and some 482 have been manufactured. In the 1980's this class is expected to show strong growth and some 3,735 units are forecast to be manufactured.

Medium twin-engine helicopters, of which the Bell 214 and the Sikorsky S76 are examples, in the 1970's were produced in growing numbers with some 814 units of this class produced. In the 1980's some 2,386 units are expected to be produced indicating strong demand for this helicopter class.

The medium single-engine class has been largely replaced by the twin-engine helicopter. In the 1970's some 262 were manufactured. There are none of this class now being manufactured.

Heavy multi-engine helicopters, due to the specialized rate and high cost, have been a low production class of helicopter. Only 12 of this class were produced in the 1970's and, in the 1980's, some 35 are expected to be manufactured.

In the military helicopter market, the single light helicopter class also dominates. In the 1970's, some 4,986 units of this class were produced. In the 1980's, the twin-engine class is expected to replace the single light class to a large extent but some 1,361 units are forecast to be manufactured.

The medium single-engine class is also large in the military market. In the 1970's, some 3,810 units were produced for the military. Twin-engine helicopters are also expected to take over this class in the 1980's and only 106 units are expected to be manufactured for the military.

The medium twin-helicopter class significantly increased its share of the military market in the 1970's. Some 1,744 were produced. In the 1980's, this class is expected to experience significant growth with some 4,052 units expected to be manufactured.

The armed military class helicopter accounted for 939 units manufactured in the 1970's and some 1,258 units of this class are expected to be produced in the 1908's.

The heavy multi-engine helicopter class in the 1970's was significant with some 1,105 units being manufactured. In the 1980's, only 144 are expected to be produced.

There are some 16 manufacturers of helicopters of their own design in the Western World which currently produce some 43 different helicopter models. In addition there are another 14 manufacturers which manufacture helicopters under license, major helicopter components or which have the capability to resume helicopter production. In the Eastern Block countries, helicopters are being produced in the U.S.S.R., Poland and Rumania. China also produces helicopters. MiL, Kamov in the U.S.S.R. and WSK, Swidnik in Poland are the largest of these manufacturers.

The largest helicopter manufacturer in both the number of units manufactured and revenues earned from manufacturing is Bell Helicopter Textron. In 1980, this one firm manufactured over 36 percent of all the Western World's military and civilian helicopters. In 1980, it produced some 864 helicopters with a manufacturing value of $556 million. Aerospatiale Helicopter Corporation ranked second in 1980 in terms of the number of helicopters produced (405) and third in terms of value ($320 million) after Sikorsky Aircraft. Hughes Helicopters ranked third in 1980 in terms of units of helicopters produced (370) but the production value was only $76 million. Sikorsky Aircraft ranked fourth in the number of units manufactured in 1980 (179) but second in terms of the value of production ($428 million). Agusta Aviation Corporation ranked fifth in terms of the number of helicopter units manufactured (162) valued at $227

million. Other significant helicopter manufacturers include Westland Helicopters, Messerschmitt-Bolkow-Blohm (MBB) and Boeing Vertol.

3.0 REGIONAL MARKET DEMAND

The regional market which British Columbia based helicopter-related overhaul, repair and servicing companies could effectively serve is Western Canada and the U.S. Pacific Northwest. The geographic scope can be expanded to include Central Canada and the U.S. Southwest for overhaul and repair work of a more specialized nature or for maintenance of lesser known or unique helicopters. In some cases, the market could be all of North America and beyond for certain maintenance activities. Western Canadian helicopter maintenance firms already have established a reputation in South America and Southeast Asia for their specialized overhaul and repair work.

In 1982, there were some 8,884 registered civil helicopters operated by 2,680 operators in North America. Some 7,378 were U.S. registered, 1,464 were Canadian registered and 32 were registered in Mexico. In the United States, California has the largest number of helicopters, some 904. Louisiana ranks second with 840, followed by Texas with 648 and Florida with 457. In Canada, British Columbia has the largest number of helicopters, some 457. Ontario ranks second in terms of the number of helicopters with 294, followed by Alberta with 286 and Quebec with 233.

In the Primary Market Area (Western Canada and the U.S. Pacific Northwest) it is estimated that there are 1,763 helicopters of which British Columbia accounts for 25 percent of the total. In the Primary Market Area, Bell Helicopter products have the largest market share followed by Hughes Helicopter products. The most popular helicopter types are the following.

Most Popular Types in Primary Market Area	Number	Percentage
Bell 206	625	35.5
Hughes 500	207	11.7
Bell 47	119	6.7
Aerospatiale ASTAR	80	4.5
Hiller UH-12	71	4.0
Hiller UH-12 Soloy	61	3.5
Bell 206L	60	3.5
Bell 205	55	3.1
Bell 212	54	3.1
Aerospatiale Alouette	52	2.9
Other	379	21.5
	1,763	100.0

Within British Columbia there were 408 helicopters with a valid Certificate of Airworthiness (accredited to be airworthy). Of this total 254 (62 percent) were registered in the Vancouver area of the province. Northern British Columbia had 56 helicopters (13.7 percent), Vancouver Island had 48 helicopters (11.8 percent) and the interior region of the province had some 34 helicopters (8.3 percent). The Bell 206 is the most popular helicopter type with some 175 in the province, followed by the Bell 47 (54) and the Hughes 500 (38).

The Secondary Market Area which includes Central Canada and the U.S. Southwest includes an additional 1,742 helicopters and is therefore about the same size as the Primary Market Area. The State of California, however, accounts for over half of the helicopters in the Secondary Market Area. Bell Helicopter products also dominate the Secondary Market Area. Hughes Helicopter products are significant in this market as are

Aerospatiale and Hiller products. In terms of the most popular helicopter types in the Secondary Market Area, the ranking is as follows:

Most Popular Types in Secondary Market Area	Number	Percentage
Bell 206	383	22.0
Bell 47	300	17.2
Hughes 500	194	11.1
Hiller UH-12	147	8.5
Hughes 300	110	6.4
Bell 206L	77	4.4
Aerospatiale Lama	60	3.4
Aerospatiale Alouette	54	3.1
Enstrom	51	2.9
Other	366	21.0
	1,742	100.0

When the Primary and Secondary Market Areas are combined, there are over 3,500 helicopters which are potential customers of British Columbia-based helicopter overhaul and repair companies. The number of helicopters in the two market areas represents about one-third of the total North American civil helicopter fleet. It is forecast that the number of helicopters in both the Primary and Secondary Market Areas will increase to 4,435 helicopters by 1990 with the Primary Market Area increasing slightly more than the Secondary Market Area during the next few years. (eg. 52.1 percent in 1990 in comparison to 50.3 percent in 1982).

The Bell 206 helicopter in 1982 dominates both market areas with a total of 1,008 units or 29 percent of the total helicopter fleet. By 1990, this figure is expected to increase

to 1,445 units and account for 32.6 percent of the two market areas. British Columbia has the largest number of Bell 206's followed by California, Alberta and Alaska.

The Bell 47 piston helicopter, which was in production from 1946 to 1974, represents the second largest helicopter type in the two market areas. In 1982 there were 469 units, including the Soloy conversion models, which is 13.4 percent of the total number of helicopters. Due to attrition the number of Bell 47's is expected to decrease in numbers to 310 units by 1990. California has the largest concentration of Bell 47's.

The Hughes 500 represents a sizeable market opportunity with some 401 units (11.5 percent of the total) located within the two market areas. The number of Hughes 500's is forecast to increase to 590 by 1990 (13.3 percent of the 1990 total market). California has the largest number of Hughes 500's followed by Alaska and Alberta.

The Aerospatiale ASTAR with 133 units in 1982 (3.8 percent of the total) is expected to increase to 220 units by 1990 and increase its market share to 5.0 percent of the total. The Hughes 300, Hiller UH-12, and Bell 206L also represents possible opportunities now and in the future due to their numbers in the two market areas.

The geographic location of military helicopters is not known, but it is possible that some 200 to 2,500 could be based in the two market areas.

4.0 FUTURE HELICOPTER TECHNOLOGY

New technology use in helicopter design and manufacturing is rapidly changing the helicopter industry. These changes are already affecting methods of overhaul, servicing and parts manufacture. Newer technology requires that helicopter maintenance capabilities now include skills in composite materials, metal alloys, electronic test equipment as well as new maintenance procedures and use of modern maintenance equipment and tools. The following outlines the expected technology which may be incorporated into helicopters manufactured over the next decade.

- **Digital Systems Integration**
  The next generation of helicopters will offer digital systems integration between the various avionic equipment by using multiplexing techniques. Advanced avionics components and systems are now being tested by the military. Improvements in navigation are being achieved with the use of lightweight doppler navigation systems, global positioning systems, radar systems and digitally stored maps and records. Improved communication is being enhanced by multi-band radios and digital voice processing. Very high speed integrated circuits will also increase the capability and reliability of electronic components as well as to reduce the size, weight and cost.

- **Advanced Cockpit Technology**
  Studies are underway to determine the medium which will be used for cockpit displays including cathode ray tubes, plasma and flat panel units. Efforts are also

made to reduce the pilot visual and decision-making workload by automatically displaying only what the pilot needs to know when he needs to know it. On-board computers will provide information on lift margin, fuel management and cruise capability. Voice interactive systems are being developed with the pilot "talking to the helicopter" to display information, turn off and on systems or to warn off pending problems. Infared systems now provide military pilots with the capability of maneuver at night at low levels.

- **Improved Handling Qualities**

  Advances in microprocessors, optical transmission and advanced control concepts offer opportunities for improved handling qualities and better aeromechanical performance in helicopters. The potential for digital microprocessors to provide task automation will result in substantial reduction in pilot work load. The new control technologies offer the potential to improve ride qualities, in particular, vibration and gust suppression. Articulated rotor heads are already providing some ride quality improvements. Use of higher harmonic control is a possible technology to vibration suppression which may result in a smoother flight along with weight savings if normal vibration control devices can be eliminated.

- **Fly-by-Wire**

  Fly-by-wire or fly-by-light technology offers the opportunity of eliminating the weight and complexity of mechanical control systems. The electronic or optical replacement of mechanical control is largely independent

of helicopter size, therefore weight savings can be considerable for complex helicopters which now require redundancy in mechanical controls.

- **Composites**

  Extensive use of composite materials is apparent in all recent helicopter designs. By 1990 all the rotor blades on U.S. Army helicopters will be made of composite materials. Aerospatiale helicopters use composite main rotor hubs. Composite technology is also planned for primary airframe structures. In addition to the advantages of field repairability, low manufacturing cost and inherent serviceability, the use of composite materials affords greater design flexibility and weight savings of up to 20 percent. Crashworthiness and ballistically tolerant structure concepts are another advantage of composite materials.

- **Empennage Size**

  Empennage size reduction is another design trend. The need for more tail surface area for stability now presents a problem. It affects main rotor downwash in transition and picks up periodic loadings from blade vortices in forward flight which adds to vibration. The empennage also has its own resonant tendencies which adds drag. The use of active control and other control technologies will provide for a reduced tail size which, in turn, will allow the helicopter to go faster with the same amount of power.

- **Engine Development**

  As fuel consumption becomes increasingly important, new fuel efficient engines are being developed. Lower engine weights and regeneration are also expected to

reduce fuel use. Major engine improvements are being made in inlet protection, electronic fuel controls, improved bearings and seals, and advanced drive system controls. Use of ceramics for bearings and other selected engine components will improve helicopter engines as well. Transmissions, weight reductions, better efficiency, lower noise and increased time between overhauls are also being developed in conjunction with improved engines.

Engines and transmission are also using better materials. High hardness steel for improved gear life and high temperature capacity are now in use. Increased use of ceramic coatings for temperature barrier protection and control of engine clearance would improve overall engine efficiency.

- **Rotor System Design**

  Rotor system design now employs tip-shaping, advanced airfoils and higher rates of twist. A completely bearingless main rotor has been tested and a bearingless hub-absorber is also in use. Aeroelastic conformability which would permit the rotor to respond to control inputs or gusts in such a manner as to always seek the optimum loading distribution is another concept being developed.

5.0 HELICOPTER MAINTENANCE RELIABILITY

Information on the reliability of civil helicopters is limited. Helicopter and engine manufacturers do not release this type of information. In recent years, helicopter operators have organized the collection and dissemination of information on maintenance but the data base has not been significantly developed to indicate common maintenance problems. The military, on the other hand, do have a substantial repository on helicopter maintenance and reliability. The military also works closely with the helicopter manufacturers using defence research contracts to improve the reliability, availability and maintenance (RAM) of military helicopters based on the information collected.

The maintenance costs associated with operating helicopters is significantly more expensive than comparable fixed-wing aircraft. The hourly maintenance costs, including maintenance burden, for the Sikorsky S-76 is about $270 per block hour as compared to about $126 per block hour for the Beechcraft King Air. A cost figure of two to three times comparable fixed-wing maintenance costs is normal for most helicopters.

Of the direct maintenance costs, component part repair/overhaul constitutes 35.5 percent of the total direct maintenance costs. Fueling, washing and ground handling of the helicopter are the next highest maintenance cost at 23.5 percent. Fixing helicopter problems in the field is the next highest cost category at 15.3 percent. Unscheduled maintenance costs form a significant portion of maintenance (i.e., averages about 20 percent of total maintenance) costs and operators rank the following as the most common repair parts costs:

Rank	Relative Repair Parts Costs
1	Compressor failures
2	Transmission bearing spalls
3	Turbine failures
4	Transmission housing cracks
5	Tension-torsion assembly failures
6	Blade cracks and corrosion
7	Fuel governors
8	Gearscuffing and spalling
9	Hub bearing failures
10	Main rotor mast retainer nuts

The most common cause of unscheduled maintenance is vibration (31.0 percent of total), followed by vehicle design (29.4) and operational environment conditions (23.4 percent). Engine failure causes are 11.8 percent of the total unscheduled maintenance causes.

The most cost-significant maintenance actions are replacement of repairables and preventative maintenance inspections due to high material costs and the frequency of preventative maintenance. Unnecessary maintenance such as erroneous removals and repairs as well as unnecessary inspections are also costly. Controllable factors which contribute to helicopter maintenance costs are the following:

- **Vibration**

  Vibration impact on maintenance cost is usually a causal factor for the resultant failure of a helicopter component. Incorporation of vibration absorbers can reduce maintenance expenditures particularly in the airframe, drive and flight control sub-systems.

- **Scheduled Time Between Overhauls (TBO's)**
  A large contributor to helicopter operating costs is the policy of scheduled removal and overhaul of components. The concept requires that the component be removed from service at a pre-determined time. The TBO intervals were reduced on components until some intuitively acceptable balance was struck between the frequency of unscheduled removals encountered and the TBO duration. Many specifications are now calling for an on-condition (OC) removal criterion for components which formerly had TBO intervals. When compared with a TBO, an on-condition criterion is less expensive in terms of maintenance costs.

- **Foreign Object Damage (FOD)**
  Foreign object damage is a contributor to maintenance costs. Military data indicates that 12 percent of engine replacements are caused by FOD and that 43 percent of these FOD failures are caused by improper maintenance procedures such as leaving hardware (tools, lock pins, etc.) and rags, clothing, in the helicopter while maintenance was being performed.

- **Inspection**
  Many inspection requirements are based on a premise that undesired events could be precluded if a time-phased inspection procedure were in place. The cost of these routine inspections is about 10 percent of the total direct maintenance cost. Inproved development of diagnostic and prognostic techniques are assisting to determine reliable failure warning levels and thereby reducing inspection time.

- **Technical Publications and Training**

  Civil operators do not have the training facilities of the military and therefore rely on individuals to possess basic skills and licenses prior to hire. They also rely on helicopter manufacturers to include special training. The training quality of a manufacturer, however, is usually related to the volume of the company's sales. Technical publications are again the responsibility of the manufacturer and poor quality technical manuals can lead to higher maintenance costs.

6.0 HELICOPTER MAINTENANCE FACILITIES

The Primary and Secondary Market Areas have a number of helicopter repair and overhaul maintenance facilities. In the Primary Market Area there are about 50 firms which offer helicopter maintenance services and another 75 firms which provide support in terms of component servicing, parts distribution and other related services. The Secondary Market Area also has a number of helicopter maintenance firms and firms which provide associated services, particularly in California.

British Columbia has several companies which are engaged in helicopter maintenance. There are 16 companies which can perform a variety of repair and overhaul services on helicopters. There are another 47 companies identified in British Columbia which provide associated services such as instrument repair, parts distribution and other services related to helicopter maintenance. Another 5 firms has some capability to design and manufacture certain helicopter components.

The following outlines the capabilities of the larger helicopter maintenance facilities in British Columbia.

- **Okanagan Helicopters Ltd. - Richmond, B.C.**
  This is the largest helicopter maintenance facility in the province. It has a facility located at Vancouver International Airport for general helicopter servicing and other facility located in an industrial park in Richmond which is used for component repair and overhaul. Okanagan Helicopters does offer helicopter maintenance to other helicopter operators. It is capable of offering nearly a complete repair and overhaul service

for a number of helicopter models. Okanagan Helicopters is an approved Bell Helicopter service centre and has engineering expertise for the Bell 206, 205, 212 and 214 models. It also has expertise for the Sikorsky S 61, S 76, Aerospatiale AS 350, AS 332 and Hughes 500. Okanagan Helicopters is certified to conduct component repair and overhaul support for the Allison 250 series turbine engine and the General Electric CT-58 turbine engine. It also has an approved avionics repairing and servicing facility.

- **Helicopter Welders of Canada Ltd., Richmond, B.C.**
  This firm has established an international reputation for quality helicopter airframe repairs. The firm's capabilities include helicopter airframe repair and overhauls, conversions and modifications for nearly every popular helicopter model. In addition, it manufactures repair jigs, handles honeycomb and bonded metal repairs and does precision machining.

- **Meridian Heliflight Inc. - Prince George, B.C.**
  This firm is an approved Bell Helicopter service centre and has expertise in general maintenance, component overhaul and helicopter modification services for certain Bell Helicopter products. It is also an Aerospatiale service centre. Meridian Heliflight is also an Aviall agent to conduct engine component tear-downs and rebuilds for the Allison 250 engine. It does not, however, perform the overhaul and repair on the engine at its Prince George facility. It also has a similar arrangement for the Lycoming LTS 101 engine which is used in the Aerospatiale ASTAR.

- **EM Heli-Logistics Ltd. - Langley, B.C.**
  This company specializes in Hughes 500 overhaul and repair. As a Hughes Helicopter service centre it can undertake airframe rebuilds, overhaul component parts and distribute parts. The firm also has expertise in the overhaul of older Sikorsky S-55 and S-58 models.

- **Deltaire Industries Ltd. - Richmond, B.C.**
  This was one of the largest repair and overhaul companies specializing in helicopters in Western Canada but experienced financial difficulties and closed. Delta Rotorcraft Ltd. has recently purchased the assets from the receiver and maintenance operations will resume in the near future.

- **Western Heli-Craft Ltd. - Delta, B.C.**
  This company is a Bell Helicopter service centre and has Bell 206 expertise. It also specializes in the rebuilding of Bell 206, Aerospatiale ASTAR and Hughes 500 helicopters.

- **Highland Helicopters Ltd. - Richmond, B.C.**
  Highland Helicopters is an authorized Bell Helicopter service centre for the Bell 206. It can overhaul all components except for the Allison 250 engine on the Bell 206.

- **Frontier Helicopters Ltd. - Abbotsford, B.C.**
  This company is authorized by Bell Helicopter to conduct component overhauls, general maintenance and spare parts sales for the Bell 206 and Bell 47.

- **Quasar Helicopters Ltd. - Abbotsford, B.C.**
  Quasar Helicopters is both a Hughes Helicopter and Bell Helicopter service centre. It is authorized to perform component overhaul, avionics repair, modifications and general maintenance on the Hughes 500 and the Bell 206, 205, 212, 412 and 214 models.

- **North Delta Copters Ltd. - Delta, B.C.**
  This company provides maintenance and overhaul for the Hiller UH-12 and FH 1100 helicopters including airframe rebuilding.

- **Vancouver Island Helicopters - Sidney, B.C.**
  Vancouver Island Helicopters is an authorized Bell Helicopter service centre for component overhaul, avionics, modifications, general maintenance and spare parts sales for the Bell 47 and Bell 206.

In addition to helicopter maintenance and overhaul firms, there are companies in British Columbia which have experience in helicopter sheet metal working, upholstery and interiors, helicopter welding, painting, parts and supplies, avionics and instruments, engine overhauls and manufacturing and engineering.

7.0 HELICOPTER MAINTENANCE REQUIREMENTS

The maintenance requirements of the major helicopter models were documented in the study and an estimate of the maintenance revenue potential was developed. The information sources included data from the helicopter manufacturers, engine and accessory manufacturers as well as information from helicopter repair and overhaul companies. The maintenance requirements are based on the manufacturers' schedule of time between overhauls (TBO's), retirement (limited) life hours, and on-condition experience. They do not include unscheduled maintenance which could add 20 - 25 percent to the total maintenance requirement in terms of maintenance costs. The costs used in the estimates represent approximate values and are to be used as a relative cost guide to compare one helicopter model with another.

For each of the selected helicopter models the estimated manhour costs and unit price for the overhaul or limited life component was determined. These costs were assessed in relation to the annual maintenance costs for the specific component and then multiplied by the number of helicopters of the model type in Primary and Secondary Market Areas. A 1982 estimate and a 1990 forecast were developed. The 1990 maintenance value is expressed in constant 1983 dollars. The following summarizes the helicopter maintenance requirements by major helicopter model.

- **Bell 47**

  It is estimated that in 1982 some $8.7 million was allocated to the maintenance of this helicopter model. In 1990 the maintenance revenue is projected to decrease to $5.7 million due to the reduced number of Bell 47's expected to be still in operation. The higher value

overhaul components are engine overhauls, main transmissions, main rotor heads and tail gearboxes. The higher value limited life components are main rotor blades, main rotor hub yokes and tail rotor blades.

- **Bell 205/205**

  In 1982, it is estimated that the Bell 204/205's in the two market areas required about $11.1 million in maintenance to meet their maintenance requirements. Due to the reduced number of Bell 204/205's which are expected to be in operation by 1990, the maintenance value at that time is projected to decrease to $9.4 million, about 15 percent less than 1982. The higher value overhaul components are main transmission, engine overhauls, main rotor heads, and main rotor masts. High value limited life components are main rotor blades, main rotor head yokes, torsion tension straps and main mast bearing assemblies.

- **Bell 206**

  Due to the large number of Bell 206's in both market areas this helicopter model represents the largest maintenance revenue potential. In 1982, it is estimated that some $34.4 million was expended to meet the maintenance requirements of the Bell 206. It is projected that by 1990 some $50.1 million will be required as additional Bell 206's are added to the fleet. The higher value overhaul components are the main rotor hub assemblies, transmission, tail rotor gearbox assemblies and swashplate assemblies. In terms of limited life components, the main rotor blades have the highest value followed by the main rotor retention straps and tail rotor blades.

- **Bell 206-L**

  In 1982, it is estimated that $6.8 million was allocated to the maintenance requirements of this helicopter model. By 1990, it is projected that $10.0 million will be required for its maintenance. The higher value overhaul components are the engine overhauls, main rotor hub assemblies and transmissions. Main rotor blades, main rotor retention straps, tail rotor blades, main masts and main rotor grips are the higher value limited life components.

- **Bell 212**

  The maintenance value to meet the maintenance requirements of this helicopter model are estimated to be $6.8 million in 1982. This figure is expected to increase to $9.2 million by 1990. The higher value component overhaul items are engine overhauls, transmission assemblies, swashplates and supports, scissors and sleeves, and main rotor hub assemblies. Higher value limited life components include main rotor blades, main rotor straps, yokes, tail rotor blades, and main rotor mast bearings.

- **Bell 412**

  The Bell 412, which is a four-bladed version of the Bell 212, is estimated to have required $1.8 million in maintenance to meet its maintenance requirements. This figure is projected to increase to $2.7 million by 1990. The higher value overhaul components are engine overhauls, transmissions and main rotor hub assemblies. The higher value limited life components are the yoke assemblies, and the spindles.

- **Bell 214**

  In 1982, it s estimated that the helicopter model required some $2.7 million to meet its maintenance needs. Due to the forecast increase in the use of this type of helicopter in the two market areas, it is projected that by 1990 some $7.6 million will be needed for maintenance requirements. The higher value overhaul components are the engine overhauls and transmissions. The higher value limited life components are rotor blades and hydraulic actuators.

- **Hughes 500**

  Due to the number of Hughes 500's in the two market areas the maintenance value is some $12.2 million in 1982. It is projected that the maintenance value will increase to $17.9 million by 1990 due to the increasing popularity of this light turbine helicopter. The higher value overhaul components are engine overhauls, main rotor hub assemblies and main transmissions. Higher value limited life components are main rotor blades and the horizontal and vertical stabilizers.

- **Aerospatiale 350 ASTAR**

  In 1982, it is estimated that some $8.8 million was expended on the ASTARS in the two market areas to meet its maintenance requirements. This figure s projected to increase to $14.8 million as additional ASTARS are added to the fleet. The higher value component overhaul items are engine overhauls, reduction gearboxes, epi-cyclic gears and the tail rotor gearboxes. In terms of limited life items, main rotor blades, starters, generators, main rotor shafts, Starflex body (main rotor hub) and tail rotor blades have the higher value.

- **Aerospatiale 355 Twin Star**

  The Twin Star is estimated to have required some $3.1 million to provide maintenance needs to the fleet in 1982. By 1990, this is projected to increase to $5.4 million. The higher value overhaul components are the engine overhauls, main gearboxes and starter/generators. Higher value limited life components are the main rotor blades, gimbal ring assemblies, rotor shafts, Starflex bodies and the spherical thrust bearings.

The total maintenance expenditures for the principal helicopter models is estimated to be more than $96.4 million in 1982 and is projected to increase to over $132.8 million by 1990. This represents an average annual growth of 4.0 percent in maintenance expenditures. These maintenance expenditures do not include the maintenance requirements of Sikorsky, Hiller, Enstrom and Agusta and other helicopters which are located in the two market areas nor new helicopter models to be introduced. The maintenance estimates also do not include the costs for unscheduled maintenance nor general routine servicing, airframe rebuilding, avionics servicing instrument and flight instrument repair, interior upholstery or painting. An additional $70 - 85 million could be allocated to helicopter-related annual expenditures in the two market areas.

Tables 1 and 2 which follow summarize the major expenditures by helicopter model for the years 1982 and 1990.

TABLE 1

MAJOR OVERHAUL AND LIMITED LIFE REPLACEMENT COMPONENTS BY HELICOPTER TYPE IN 1982

	B 47	204/205	206	206L	212	412	214	Hughes 500	AStar	Twin Star	Total
COMPONENT OVERHAUL											
Main Transmission	$2,247,576	$ 3,141,505	$ 1,862,280	$ 469,370	$ 916,320	$ 248,640	-	$ 724,608	$1,477,213	$1,414,146	$12,501,658
Main Rotor Head	629,388	391,920	4,074,840	687,904	423,625	-	-	1,383,652	-	-	7,591,329
Swashplate Assembly	355,576	269,400	1,111,320	-	585,295	-	-	-	-	-	2,321,591
Tail Rotor Gearbox	443,044	-	1,317,456	291,940	-	-	-	-	306,565	-	2,359,005
Main Rotor Mast	-	384,560	370,440	-	205,400	-	-	-	-	-	960,400
Freewheeling Assembly	-	-	346,632	-	-	-	-	-	-	-	346,632
Tail Rotor Hub	204,061	-	596,736	-	-	-	-	-	-	-	800,797
Scissors & Sleeve Ass.	-	213,120	-	-	448,350	-	-	-	-	-	661,470
Engine Overhaul	2,682,680	4,143,400	14,281,400	2,542,650	1,360,000	340,000	802,000	4,807,600	1,808,800	704,348	33,472,878
Engine Fan Assembly	244,338	-	-	-	-	-	-	-	-	-	244,338
Hydraulic Servo Actuator	-	-	298,368	-	-	-	-	-	-	-	298,368
Hydraulic Pump & Reservoir	-	-	298,368	-	-	-	-	-	-	-	298,368
Drive Shaft Ass.	-	-	-	-	224,175	-	-	260,034	-	-	484,209
Other	391,132	821,626	-	665,466	807,491	455,963	588,048	78,505	213,913	272,661	4,294,805
	7,197,795	9,365,531	24,557,840	4,657,330	4,970,656	1,044,603	1,390,048	7,254,399	3,806,491	2,391,155	66,635,848
COMPONENT LIMIT LIFE											
Main Rotor Blades	594,567	635,910	3,246,830	840,336	863,829	-	391,760	2,194,714	2,082,267	-	10,850,213
Main Rotor Retention Strap	-	-	2,157,321	355,274	233,982	-	-	257,587	-	-	3,004,164
Main Rotor Retention Strap Fittings	-	-	365,753	-	-	-	-	-	-	-	365,753
Servo Actuator Support	-	-	711,358	-	-	-	-	-	-	-	711,358
Main Rotor Grips	-	-	681,913	-	-	-	-	-	-	-	681,913
Tail Rotor Blades	-	-	1,425,816	237,636	-	-	-	-	244,708	-	1,908,160
Starflex Body	-	-	-	-	-	-	-	-	465,764	-	465,764
Main Rotor Shaft	-	-	-	-	-	-	-	-	481,422	-	481,422
Starter/Generator	-	-	-	-	201,660	-	-	-	633,204	-	834,864
Horizontal Stabilizer	-	-	-	-	-	-	-	396,195	-	-	396,195
Vertical Stabilizer	-	-	-	-	-	-	-	443,735	-	-	443,735
Tail Rotor Yoke	-	-	224,721	-	-	-	-	-	-	-	224,721
MR Vertical Hub	-	-	-	-	-	-	-	251,215	-	-	251,215
Main Transmission Drive Shaft	-	-	-	-	-	-	-	260,034	-	-	260,034
Other	927,877	1,078,362	1,029,066	740,647	542,564	777,887	956,833	1,142,455	1,164,501	797,595	9,157,787
	1,522,444	1,714,272	9,842,778	2,173,893	1,842,035	777,887	1,348,593	4,945,935	5,071,866	797,595	30,037,298
	$8,720,239	$11,079,803	$34,400,618	$6,831,223	$6,812,691	$1,822,490	$2,738,641	$12,200,334	$8,878,357	$3,188,750	$96,673,146

TABLE 2

MAJOR OVERHAUL AND LIMITED LIFE REPLACEMENT COMPONENTS BY HELICOPTER TYPE IN 1990

	B 47	204/205	206	206L	212	412	214	Hughes 500	AStar	Twin Star	Total
COMPONENT OVERHAUL											
Main Transmission	$1,483,400	$2,303,840	$2,663,060	$ 689,974	$1,246,195	$365,500	$523,334	$1,065,174	$2,466,945	$2,404,050	$15,211,472
Main Rotor Head	415,396	333,132	5,827,021	1,011,219	576,130	-	247,505	2,033,968	-	-	10,444,371
Swashplate Assembly	234,680	228,990	1,589,188	-	796,000	-	-	-	-	-	2,848,858
Tail Rotor Gearbox	292,409	-	1,883,962	429,152	-	-	-	-	512,115	-	3,117,638
Main Rotor Mast	-	326,876	599,729	-	279,344	-	-	-	-	-	1,205,949
Freewheeling Assembly	-	-	495,683	234,137	-	-	-	242,221	-	-	972,041
Tail Rotor Hub	-		853,332	-	-	-	-	-	-	-	853,332
Scissors & Sleeve Ass.	-	-	-	-	609,756	-	-	-	-	-	609,756
Engine Overhaul	1,770,569	3,521,890	20,422,402	3,737,770	1,849,600	499,800	2,253,620	7,067,172	3,020,696	1,197,392	45,340,911
Engine Fan Assembly	-	-	-	-	-	-	-	-	-	-	-
Hydraulic Servo Actuator	-	-	-	-	-	-	-	-	-	-	-
Hydraulic Pump & Reservoir	-	-	426,666	-	-	-	-	-	-	-	426,666
Drive Shaft Ass.	-	-	426,666	-	304,878	-	-	-	-	-	731,544
Other	554,090	1,245,982	3,697,924	744,097	1,098,186	670,266	861,576	255,432	357,083	471,525	9,956,161
	4,750,544	7,960,710	38,885,633	6,846,349	6,760,089	1,535,566	3,886,035	10,663,967	6,356,839	4,072,967	91,718,699
COMPONENT LIMIT LIFE											
Main Rotor Blades	392,414	635,910	4,642,968	1,235,294	1,174,807	-	1,100,846	3,226,229	3,477,386	203,088	16,088,942
Main Rotor Retention Strap	-	-	3,084,970	522,253	318,217	-	219,268	378,652	-	-	4,523,360
Main Rotor Retention Strap Fittings	-	-	523,753	-	-	-	437,049	-	-	-	960,802
Servo Actuator Support	-	-	1,017,242	-	-	-	-	-	-	-	1,017,242
Main Rotor Grips	-	-	975,134	-	-	-	-	-	-	-	975,134
Tail Rotor Blades	-	-	2,038,917	349,324	-	-	220,927	-	408,663	-	3,017,831
Starflex Body	-	-	-	-	-	-	-	-	777,826	-	777,826
Main Rotor Shaft	-	-	-	-	-	-	-	-	803,975	-	803,975
Starter/Generator	-	-	-	-	-	-	-	-	1,057,451	-	1,057,451
Horizontal Stabilizer	-	-	-	-	-	-	-	582,407	-	-	582,407
Vertical Stabilizer	-	-	-	-	-	-	-	652,290	-	-	652,290
Tail Rotor Yoke	-	-	321,351	-	-	-	-	-	-	-	321,351
MR Vertical Hub	-	-	-	-	-	-	274,776	369,286	-	-	644,062
Main Transmission Drive Shaft	-	-	-	-	-	-	-	382,250	-	-	382,250
Other	612,398	821,170	2,445,972	1,141,670	1,012,140	1,175,552	1,532,292	1,679,407	1,944,722	1,152,788	13,518,111
	1,004,812	1,457,080	15,050,307	3,248,541	2,505,164	1,175,552	3,785,158	7,270,521	8,470,023	1,355,876	45,323,034
	$5,755,356	$9,417,790	$53,935,940	$10,094,890	$9,265,253	$2,711,118	$7,671,193	$17,934,488	$14,826,862	$5,428,843	$137,041,733

8.0 HELICOPTER-RELATED FACILITIES AND SERVICE MARKET OPPORTUNITIES

An overall assessment of the possible market opportunities for British Columbia based helicopter-related repair, overhaul and maintenance companies was conducted in the study. The analysis and evaluation of the possible market opportunities identified in the study are considered preliminary in nature. Based on the information collected and its subsequent analysis and evaluation undertaken, there are a number of possible opportunities for British Columbia firms to examine more closely to expand their market share and/or to establish new endeavours in the helicopter industry. The following outlines some of the possible market opportunities.

- **Routine Inspection, Repair and Maintenance**

  The inventory of facilities and services conducted indicates that the Primary and Secondary Market Areas are likely adequately serviced with regard to routine inspection and maintenance services. If there are opportunities they are for smaller maintenance facilities located in sub-regions of the province located close to existing helicopter populations not served adequately by established maintenance firms. There are likely opportunities for the established maintenance centres to provide these routine services if they are not now being offered particularly for those helicopters which are relatively complex or specialized. There is also an opportunity to expand the spare parts distribution network and to provide potential customers additional information on the availability of spare parts. There are few opportunities for the manufacture of parts or components used in routine inspection,

repair and maintenance but there could be for helicopter accessories such as cargo nets, cargo hoists, canvas covers, search lights and other equipment.

- **Complete Engine Overhauls**

This maintenance activity is the highest value in terms of maintenance expenditures. The repair and overhaul of the Allison 250 engine, for example, accounted for some $25 million in overhaul value in the Primary and Secondary Market Areas. This popular engine is now used in a variety of helicopter models including twin-engine applications. By 1990 over $60 million could be expended on engine overhauls to the Allison 250. This one-engine series accounts for 75 percent of the total engine overhaul costs in the two market areas. There are only a very limited number of firms which can completely overhaul and repair turbine helicopter engines. Okanagan Helicopters has some engine overhaul capabilities but is restricted to replacement of components due to a lack of certain facilities and skills. There are only four companies which are authorized to overhaul and repair the Allison 250 in North America. There are also only a few firms authorized to overhaul Pratt and Whitney, General Electric, Turbomeca, Rolls Royce and Lycoming helicopter engines in addition to the manufacturer. Until recently, Standard Aero, based in Winnipeg, Manitoba, performed most of the Allison 250 engine overhaul work in Canada due to an agreement with Detroit Diesel Allison, the manufacturer. Allison has changed its agreement and U.S. firms are now competing for a larger share of the engine overhaul market including Canada. Aviall, a Dallas, Texas based firm, which is the largest engine-overhaul company in North

America, has established a franchised agency network in North and South America and has recently established representatives in Canada, including British Columbia.

The value of the engine overhaul and repair market is large enough to present possible market opportunities for British Columbia based firms. The possible scenarios for the development of expanded engine overhaul facilities could include the following:

- Establish a business venture with Standard Aero to have overhaul work done in British Columbia similar to an Aviall agency agreement. (It is understood Standard Aero and Okanagan Helicopters may be working on such an arrangement).
- Establish a business venture with Pratt and Whitney to overhaul PT6 engines including the PT6T-3B Twin Pac used in helicopters. A working agreement to overhaul the PT-6 would have advantages to later overhaul the STEP (Small Turbine Engine Program) which Pratt and Whitney is developing for the Canadian-made Bell 400 series.
- Expand Okanagan Helicopters' overhaul and repair facility to include engine overhaul testing and repair capabilities which it does not have for the Allison 250 and General Electric CT-58 engines.
- Expand Meridian Heli-Flight's capabilities to include more advanced engine component work than the current inspection and replacement services.
- Develop, with one of the major U.S. engine overhaul and repair firms, a subsidiary or franchise company in British Columbia with the capability to undertake major component overhaul work.

- Expand the local Detroit Allison industrial turbine overhaul and repair company to include aviation turbines.

There may be also some potential to provide turbine engine conversions in conjunction with Soloy Conversions Ltd. This firm now converts piston-powered Bell 4 and Hiller UH-12 helicopters to Allison 250 turbine power. A technical agreement may provide an opportunity for some conversions. There also may be the possibility of a STC turbine conversion for the Hughes 300 and other piston helicopters.

o **Rotor Heads, Transmissions and Gearboxes**

The repair, overhaul and servicing of rotor heads, transmissions, main rotor gearboxes, tail rotor gearboxes and drive shafts are high maintenance requirement items. All these components are rotary and subject to vibration and therefore have to be balanced on replacement.

The expansion of opportunities to increase the market share of British Columbia firms which now conduct maintenance on these components will require an increase in their capabilities to include more complex helicopters and additional helicopter models in their area of expertise.

o **Engine Accessories**

Firms which have experience in engine component overhauls are those which likely have the expertise to conduct engine accessory overhauls and repairs. Fuel control and other engine accessories are normally over-

hauled at the same time as the engine. Repairs may present an opportunity as most of these are now sent to Eastern Canada or the United States.

- **Major Airframe Repair and Rebuilding**
  In British Columbia, Helicopter Welders of Canada Ltd., has an established reputation for helicopter airframe repairs. It would appear that they have developed the market for repairs and rebuilding to the extent possible given the current economic climate. There may, however, be additional opportunities in the future to perhaps coordinate rebuilding with other firms to provide overhaul, upholstery and interiors and painting as does Field Aviation in Calgary, Alberta. The spare parts requirements to rebuild a damaged helicopter can be substantial and there may be opportunities to coordinate these requirements to improve availability and costs.

- **Fabric Repair, Recovering and Upholstery**
  There is a possible need to coordinate upholstery and interior completions with the firms which undertake helicopter maintenance. The demand for upholstery work is, however, relatively limited.

- **Avionics Repair, Installation and Sales**
  British Columbia firms are relatively well positioned to take advantage of the growing market opportunities in the avionics field with respect to repair, overhaul and servicing. There will have to be investments made in equipment and training to ensure that British Columbia firms will have the expertise necessary for new sophisticated equipment being offered by the manufacturers.

Pacific Avionics and Instruments appear to be one company well positioned to serve the helicopter avionics repair and service area.

There are two manufacturers of avionics equipment in British Columbia. Northern Airborne Technology located in Prince George, specializes in electronic equipment for helicopters. It manufactures a number of products which are being used by helicopter operators. Spillsbury Communications has been manufacturing radio communications for some time for use by helicopter and fixed-wing aircraft.

o **Instrument and Accessory Overhaul and Repair**

Some repair and overhaul of flight instruments is done in British Columbia as well as work on electrical accessories, starters/generators and hydraulic accessories but the market has not been well developed. It would appear, since most operators now send instrument and accessory equipment to Eastern Canada and the United States for repair, that there should be a market opportunity for a British Columbia company.

o **Other**

There are some miscellaneous areas which may present market opportunities for British Columbia companies.

- Rotor Blades

  It would seem, with the growing trend to the use of composite blades and the fact that multi-blade designs are common, that there may be a need for a rotor blade and repair facility in British Columbia.

- Tension Torsion Straps

  These straps have a limited life of only 1,200 hours and a relatively high unit cost making this product one which could be a possible original equipment part for Bell Helicopter products to be built in British Columbia. The retention strap fittings and pins also are possible items to be manufactured.

- Other Possibilities

  These include blade tracking and balancing equipment, bearings of all types, chip detectors and boroscopes, nickel/cadmium batteries and custom cockpit displays.

9.0 CONCLUSIONS

While there is a substantial amount of helicopter-related maintenance, overhaul and repair capability in British Columbia, there is a need to coordinate the various maintenance activities. These activities are presently in various locations throughout the Vancouver Lower Mainland and other locations throughout the province. Prospective helicopter maintenance customers usually are aware of a particular firm's skills only from previous experience or reputation. It would appear that a helicopter maintenance association of British Columbia firms, which could coordinate the industry, would assist in marketing the members' various capabilities.

There is also a need for coordination in the use of helicopter facilities and equipment. In order to maintain, overhaul and repair new types of helicopters, there will be a continual need for capital investment which often cannot be economically justified for the use by one company. As the costs increase, there may be a need for a common maintenance centre where special equipment and testing facilities can be used on a "user pay" basis. It is suggested that the planned new facilities for the Pacific Vocational Institute could form the nucleus for such a specialized maintenance equipment and test centre.

cc