A partial listing of the various projects provided by Weir-Jones follows:

PIPELINE MONITORING AND TESTING PROJECTS

Foothills Pipelines

Fairbanks Permafrost Test Facility -multiple tasks over a 20 year period	1979 - 2000
Northern Alberta Burst Test Facility Rainbow Lake, Alberta - 11 full scale pipeline burst tests carried out over a 30 month period	1980 - 1982
American Gas Association Los Angeles - Burst Test - fracture arrester evaluation	1987

Nova Corporation

Field investigations on pipeline components, static and dynamic data acquisition during testing	December1984
Hussar	December1984
High Level	December1984
Fort McMurray	December1984
IPI Simonette High Level	December1984
Spruce Grove burst test	December1984
Princess Bottle	January 1985
Bossano	January 1985
Noname Creek	April 1985
A-M	April 1985
Algar Lake	April 1985
Spring Creek	April 1985
Spring Creek	July 1985
Simonette River	September 1985
Island Lake Lateral	October 1985
Spruce Grove	June 1986
Strain gauge monitors	June 1986
Liege Lateral	October 1986
Dusty Lake	April 1987
Pipeline measurements	January 1990
Zama Lake	November 1995
Nova Gas Algor Lake Lateral	December 1995
Athabasca River Crossing	April 1997
Simonette River Crossing	February 2000

Westcoast Energy

Pipeline static and dynamic analyses - Fort St. John	October 1993
Strain gauging on gas line - Fort Nelson	January 1994
Load measurements on Poll Welder	February 1994
Strain gauging on gas line -Fort Nelson	September 1994
Pipeline strain gauge data processing -Fort Nelson	November 1994

Westcoast Energy Cont'd

Pipeline strain gauging - Fort Nelson	October 1997
Pipeline stress/strain data processing - Delta	June 1999

Others

Greater Vancouver Regional District - stress analyses related to 48" water main failures	1999
General Accident Insurance -services related to pipeline failures	1995 - 2000

Greater Vancouver Regional District - 1999 - 2004
-long term static and dynamic analyses on water mains

BC Hydro - April 1999
- strain gauge installations on water and sewer mains

AEC Pipelines - September 1999
- oil pipeline strain gauge installation at Horse River crossing

Agra E & E - December 1999
- strain gauge installation at Frost Heave Test Facility, Fairbanks AK

Anadarko Canada Corporation - April - August 2001
- strain gauging and residual stress measurements on pipeline

AEC Pipelines - July 2001
- pipeline strain gauging & analysis on gas and oil lines at Syncrude Site

Syncrude Canada - May - December 2001
- structural integrity assessment on slurry transport lines

Suncor - December 2001
- static and dynamic analyses on bitumen lines

Suncor - December 2001 - February 2002
- static and dynamic analyses on slurry lines and pumps

Simmons Pipelines - January - April 2002
- integrity assessment of lines at river crossing

Colt Engineering (on behalf of Corridor Group) - January - February 2002
- instrumentation and monitoring of twin diluent and
product lines at Clearwater River Crossing

AEC Pipelines/Pembina - December 2001 - April 2002
- integrity assessment of Athabasca River Crossing

Terasen Pipelines - February 2002- ongoing
- ongoing monitoring of pipelines on unstable slopes

Shell Canada - July 2003
- stress analyses of pig launching systems

Siemens Canada - October 2004 - December 2004
- dynamic analyses of pump system

INDUSTRIAL AND MARINE PROJECTS

Client	Location	Description of Work
AEC Pipelines		various strain gauge installations & residual stress measurements on operating pipelines
American Gas Association	Los Angeles	pipeline burst testing and fracture arrestor evaluations
AMP Corporation	Toronto	strain gauging, data collection, & analysis associated with ultra high speed testing of explosively powered devices
Agra Environmental	Fairbanks	strain gauge installation & long term data acquisition on pipeline test sections
Axton Manufacturing	Coquitlam	experimental stress analysis on pressure vessels
Robert Allan	Vancouver	numerous projects, strain gauging & propeller shaft torque measurements on various vessels
BC Transit	Vancouver	strain gauging & experimental stress analysis on linear induction motors, rail bolts & bridge monitoring
BC Ferries Corporation	Victoria	numerous projects including hull strain monitoring, engine & drive train monitoring, stability & vibration measurements
BC Research Corporation	Vancouver	experimental stress analyses, supply of specialized DAS equipment
BC Hydro & Power Authority	Vancouver	long term strain gauge installation & measurements of strain change in structural components over a period of almost 30 years, numerous strain gauging & DAS projects
BC Department of Highways	Victoria	numerous projects including strain gauge measurements on steel tunnel linings, bridge components, *etc.*
BC Gas	Burnaby	strain gauge installation & DAS on gas pipelines
Bechtel Corporation	San Francisco	strain gauging & DAS associated with dam monitoring
Boeing Aircraft Corporation	Seattle	experimental stress analysis on aircraft components
Baker Materials	Vancouver	strain gauging & experimental stress analyses
Ballard Power	Burnaby	vibration & stress testing on fuel cells
Beaudrill	Beaufort Sea	strain gauging & stress analysis on drill ships
Bombardier Corporation	Montreal	strain gauge monitoring on vehicles & airframes
Bristol Aerospace	Winnipeg	strain gauging & DAS monitoring on missile components
CAE Industries	Vancouver	strain gauging on forest industry equipment
Canmar	Beaufort Sea	numerous strain gauging and DAS projects on ice breakers & supply vessels
Canship Ugland	St. John's	strain gauging of engine drive shafts
Client	**Location**	**Description of Work**
Canadian Coast Guard	Ottawa	strain gauging & stress analysis on various ships
CMC	Vancouver	strain gauging & load analysis on passenger access gantries
Canadian National Railways	Edmonton	stress & strain analysis, data reduction
Canadian Steamship Lines	Montreal	strain gauging & stress analyses on various ships

Cancar/Bombardier	Thunder Bay	strain gauging & stress analysis on subway cars for Boston, New York, Santa Clara, Toronto, *etc.* subway systems
Can Dive Services	N. Vancouver	various strain gauging projects on submersible hulls
Canadian Standard Association	Vancouver	strain gauging, stress analysis & vibration testing on various components
Cominco Metals	Trail	stress analysis, strain gauging & technical review of work on refinery rectifier system
Canadian Stevedoring	Vancouver	stress analysis on passenger loading facilities in marine terminals
Du Pont Corporation	Delaware	long term strain gauging on toxic chemical disposal wells
Ellett Copper & Brass	Coquitlam	strain gauging associated with proof tests on titanium pressure vessels
Friede Goldman	Marystown	strain gauging of engine drive shafts
Forest Industry Research Corp.	Vancouver	strain gauging & monitoring equipment for use in forest industry
Finning Industries	Vancouver	strain gauging on drive trains & propellor shafts for vibration monitoring
Fed. Dept. of Fisheries & Oceans	Ottawa	strain gauging on hydrological monitoring equipment
Flex Tip Trailers	Darwin	strain gauging & stress analysis of off-road truck chassis
Fluor Alaska	Fairbanks	strain gauging of gas pipeline test sections for long term assessment of response to frost heave
Foothills Pipeline	Calgary	strain gauging associated with burst testing of large diameter pipelines, also high speed data acquisition
Gulf Canada Resources	Beaufort Sea	strain gauging & hull strain monitoring of ice breakers and offshore drilling platforms
General Accident Insurance	Toronto	strain gauging & residual stress measurements on large diameter gas pipelines
Genstar Cement	Richmond	strain gauging & fatigue assessment on structural components
GVRD	Vancouver	strain gauging & data analyses on water & sewage lines
HG Engineering/Jenike Johansen	Toronto	strain gauging & load measurements in power station fuel silos
Hardsuits International	N. Vancouver	various projects associated with strain gauging & stress analysis of submersible hulls
Hibernia Management	St. John's	instrumentation and monitoring systems for the Hibernia Platform
Hytac Corporation	Vancouver	strain gauging & load analysis on marine equipment
ISE	N. Vancouver	strain gauging & stress analysis on submersibles
Iron Ore Company	Labrador City	various projects associated with materials handling equipment
Marathon Offshore	Sakhalin	strain gauging of marine structure on drilling platform
Marine Industries Ltd.	Sorel	strain gauging & stress analysis of propeller shafts
McMillan Bloedel	Port Alberni	strain gauging & stress analysis on papermaking equipment

Client	Location	Description of Work
Monsanto Corporation	St. Louis	strain gauging & stress analysis on toxic effluent deep well disposal systems
Metro Canada	Kingston	strain gauging & stress analysis on advanced light rail passenger car
Newfoundland Hydro	St. John's	strain gauging & stress analysis associated with ice load monitoring on transmission lines
Nodeco	St. John's	strain gauging & stress analysis associated with offshore structures
Nova Pipelines	Calgary	numerous projects associated with strain gauging & stress analysis of oil & gas pipelines
NRC of Canada	Ottawa	equipment supply & stress analysis for various projects, supply of proprietary strain gauge cabling for use in underwater applications
NRC Building Research Facility	Ottawa	supply of strain gauge ice force panels for measurement of ice loads at various locations
Neptune Terminals	N. Vancouver	supply of strain gauging equipment for use on ship loaders
Offshore Research	Vancouver	strain gauging & stress analysis for marine testing
Owen Design Associates	Vancouver	strain gauging & stress analysis on ice breaker propeller shafts
QNS&L	Sept-Îles	strain gauging & stress analysis of rail cars & loading facilities
Royal Caribbean International	Miami	strain gauging and analysis of steering gear systems
Royal Australian Navy	Adalaide	strain gauging and stress analysis of manned submersibles
Seatronics	Burnaby	strain gauging associated with dynamic measurements on tug & barge systems
Siemens Masa	Toronto	strain gauging & stress analysis associated with torque measurements
Skytrain System	Vancouver	strain gauging & stress analysis associated with automated light rail transport system
Syncrude	Alberta	strain gauging stress analysis of pipelines
Teleflex Canada	Richmond	strain gauging & instrumentation associated with high speed vessel steering systems
Tilbury Cement	Richmond	numerous projects involving strain gauging on cement plant components including high temperature & residual stress measurements
Tyco Electronics Canada	Markham	strain gauging, testing & analysis of power distribution components
UTDC	Kingston	strain gauging & stress analysis associated with behaviour of rail system components
US Navy	Washington	strain gauging and stress analysis of manned submersibles
Vancouver Shipyards	Vancouver	strain gauging & vibration analysis of new ships
Westcoast Energy	Vancouver	strain gauging on various pipelines in Western Canada
Wartsila Marine	Vancouver	strain gauging associated with propulsion system monitoring on various ice breakers & other vessels including testing in the Beaufort Sea & vessel testing in the North Atlantic
Westshore Terminals	Delta	strain gauging & stress analysis associated with marine terminal facilities
Weyerhaeuser	Prince Albert	strain gauging & stress analysis associated with pulp & paper manufacturing equipment

MINING INDUSTRY INSTALLATIONS

Client	Location	Description of Work
Atlantic Newcem	Maryland	strain gauging & stress analysis on milling equipment
Allis Chalmers	Highland Valley	strain gauging & stress analysis on large in-pit crusher
BHP	Utah	strain gauging and stress analysis on mining & conveying equipment
Boliden Allis	Chile	strain gauging on milling equipment
Carlin Gold	Nevada	strain gauging & stress analysis on SAG mill
Cementos Yura	Peru	residual stress measurements & stress analysis on cement finish mill
Codelco	Chile	strain gauging and stress analysis on grinding mills
Cypress Bagdad Mining	Arizona	strain gauging & load determination on grinding mill components
Dennison Mines	Elliott Lake	strain gauging & stress analysis on overland conveyors, strain gauging & analysis of gear drives
Dennison/Quintette	Tumbler Ridge	strain gauging & stress analysis of Demag excavators
Fluor Daniel Wright	Vancouver	overland conveyor structural monitoring, strain gauging & stress analysis associated with large grinding mills
Highland Valley Copper	Logan Lake	strain gauging associated with overland conveyor monitoring, strain gauging & stress analysis on large SAG mills
Hepburn Ltd.	Toronto	strain gauging & load measurements on mining components
International Minerals Corp.	Esterhazy	various projects including strain gauging & stress analysis of underground bulkheads subjected to 1600 psi static head
International Nickel Company	Sudbury	strain gauging & stress analysis of underground mining machinery
Iron Ore Company of Canada	Labrador City	strain gauging & stress analysis of iron ore pellet silos, kilns and grinding mills
Kemess Mines	BC	dynamic analysis of grinding mills
Krupp Canada	Calgary	remediation monitoring of materials handling equipment
Mossgas	South Africa	dynamic analysis and remediation of a catalyst reprocessing mill
MPSI	Philadelphia	strain gauging & torque measurements on mining equipment in Chile
Osborne Coalequip	South Africa	strain gauging & stress analysis of various pieces of mining equipment
Quintette Coal	Tumbler Ridge	strain gauging & stress analysis on overland conveyor systems
Rio Algom Mining	Nova Scotia	strain gauging & stress analysis of crusher remediation program

SNIM	Mauratania	strain gauging and dynamic analysis of grinding mills
Syncrude	Alberta	various projects including strain gauging & stress analysis of in-pit crusher drive shafts using real-time telemetry systems
Utah Mines	Port Hardy	strain gauging & stress analysis of overland conveyor components
Wajax Industries	Coquitlam	strain gauging & stress analysis of various pieces of Demag mining equipment

MARINE INSTRUMENTATION AND TESTING SERVICES

The Weir-Jones Group is a Vancouver based group of specialist companies who provide, among other services, operational testing and scientific instrumentation for ships and offshore structures. Projects have been carried out on container vessels, bulk carriers, cruise ships and ferries, as well as on tugs and barges, ice breaking supply ships, various types of manned and unmanned submersibles, and offshore platforms. The company maintains a wide range of instrumentation for shipboard measurement programs which can be deployed anywhere in the world. Data is acquired digitally using both high-speed and low speed data acquisition systems making it immediately available for data processing and analysis. The Group offers the following specific services for marine clients:

- Measurements of propulsion system performance. Shaft torque and power can be monitored using wireless telemetry equipment; vibration analyses can also be performed on drive trains in real-time.
- Measurement of ship's performance in open water or ice, including open water speed trials, turning performance and manoeuverability, and command response.
- Monitoring of steering gear performance in either real-time or historical mode.
- Structural integrity monitoring systems for offshore platforms to meet or exceed classification society requirements.
- Measurement of vessel motions using accelerometers, gyros and differential GPS.
- Real-time hull monitoring systems to classification society standards, DNV, ABS, Lloyds.
- Structural design and analysis using a range of analytical techniques, including 3-D Finite Element Analysis, to US Navy and classification society standards.
- Forensic investigations for legal or insurance purposes.
- Proprietary systems for real-time automatic draught monitoring of vessels, **ADIS™**, real-time wave height monitoring, ***WHAM™*** and hull condition monitoring, ***HMON™***.

For the last twenty-five years Weir-Jones has carried out work for many marine clients. These include Canmar, Gulf Canada, B.C. Ferries, Canadian Coast Guard, Canadian Steamship Lines, Melville Shipping, Can Dive Services (on behalf of Royal Australian Navy, United States Navy) Hibernia Management and Development Corporation, Canadian Transport Company, as well as numerous naval architects and marine equipment suppliers.

I TRANSPORTATION SECTOR

Typical clients and projects in the passenger, Ro-Ro, and container/bulk sector include:

BC FERRY CORPORATION

In addition to providing engineering services on many vessels in the BCFC fleet the Weir-Jones Group has installed Automated Draught Indicator Systems (**ADIS™**) on the following vessels:

The Royal Victorian	***Queen of Esquimalt***	***Queen of Prince Rupert***	***Queen of Cowichan***
Queen of Victoria	***Queen of Oak Bay***	***Queen of Nanaimo***	***Queen of Alberni***
Queen of Coquitlam	***Pacificat Explorer***	***Queen of Saanich***	***Pacificat Discovery***

Currently structural and performance monitoring systems, real-time wave height monitoring units, and **ADIS™** are being supplied for the High Speed Catamarans built for BC Ferries to DNV classification standards.

FOSS MARITIME

Bollard pull and engine/drive train performance evaluations on various tugs undergoing propulsion system modifications.

PRINCESS CRUISES

Vibration analyses on various rotating systems on cruise vessels.

MELVILLE SHIPPING

Various testing programmes on an ice strengthened bulk carrier in the Eastern Arctic and late season North Atlantic crossings.

CANADA STEAMSHIP LINES

Evaluation and testing of materials handling systems on bulk carriers transporting mineral products.

CANADA TRANSPORT COMPANY

Testing and analyses of cargo handling gear on specialized bulk carrier.

ALLIED SHIPBUILDING LTD.

Testing and analysis of propulsion systems.

FRIEDE GOLDMAN NEWFOUNDLAND LTD.

Bollard pull and shaft torque measurements on tugs.

PORTS CANADA

Testing, evaluation and system design for passenger access facilities.

KVAERNER MASA MARINE

Marine systems testing and analysis.

ROYAL CARIBBEAN CRUISE LINES

Testing and analysis of steering systems.

ULSTEIN MARITIME LTD. (ROLLS ROYCE GROUP)

Performance testing on propulsion systems.

II GOVERNMENT AND DEFENCE SECTOR

Clients in the government and defence sectors include:

CANADIAN COAST GUARD

PAPA Trials - Post Acceptance Performance Assessment:

A comprehensive series of performance trials have been conducted on the Coast Guard ships ***C.C.G.S. Henry Larsen*** (Type 1200), ***Anne Harvey*** and ***George Pearkes*** (1100 types) to measure the performance of the vessels and their systems relative to design criteria. These trials were carried out in conjunction with a number of other companies, including Wartsila Marine Inc., the predecessor of Kvaerner Masa Marine Inc., with WJEC having responsibility for the entire instrumentation programme. Typically a PAPA trial monitored ship performance and dynamic ice interaction, propulsion parameters and statistical recordings of hull and deck strains, shaft line torque and forward thrust, and rudder stock and steering gear loads.

CCGS George R. Pearkes ***CCGS Ann Harvey***
CCGS Henry Larsen ***CCGS J.E. Bernier***

Sea Trials - Shaft and Rudder Torque Measurements:

CCGS George R. Pearkes ***CCGS Edward Cornwallis*** - bollard pull
CCGS Martha L. Black ***CCGS William Alexander*** - bollard pull

Rudder Stock & Steering Gear Load Measurements:

CCGS Pierre Radisson ***CCGS Des Groseilliers***
CCGS Henry Larsen - propulsion monitoring system

Stability Measurements:

CCGS Gordon Reid - dynamic stability monitoring
CCGS George R. Pearkes - buoy handling measurements

CAN-DIVE SERVICES

Detailed 3D FEA of the submarine rescue system ***Remora*** on behalf of the Royal Australian Navy. Work carried out to facilitate DNV certification. Design and implementation of equipment related to certification.

Strain gauging and structural analysis of manned submersibles to ABS certification standards.

INTERNATIONAL HARD SUITS

Design and 3D FEA of a new rigid diving suit to USN specifications. Strain gauging and analysis of various rigid diving suit components for commercial and military applications.

AUSTRALIAN SUBMARINE CORPORATION

Design and testing of recovery system components on a submarine rescue system.

III RESOURCE SECTOR

In the course of the last twenty years a significant portion of the Group's marine work has included the offshore energy sector. Representative clients and projects include:

GULF CANADA RESOURCES

Permanent Ice Management Instrumentation:

Operational hull strain monitoring systems were designed, manufactured and installed on the ***M.V. Terry Fox*** and ***M.V. Kalvik***, two Ice Class 4 icebreaking/support vessels. The systems provided real time safety data about the strain levels induced in the hulls during icebreaking operations.

MV Terry Fox - Icebreaker ***MV Kalvik*** - Icebreaker

Sea Trials:

Instrumentation was installed on several of GCRI Ice Class 4 Icebreaking support vessels to facilitate trials similar to those defined in the Coast Guard PAPA series. More extensive tests were completed on the ***M.V. Kalvik*** and ***M.V. Ikaluk*** and included icebreaking performance, rudder stock and steering loads.

MV Terry Fox - Icebreaker ***MV Ikaluk*** - Icebreaker
MV Kalvik - Icebreaker ***MV Miscaroo*** - Icebreaker

Monitoring Programs:

On offshore drilling structures for safety and structural integrity assessment.
Molikpaq - caisson retained drilling island ***Kulluk*** - conical drill ship

ESSO RESOURCES CANADA

Structural Monitoring:
Offshore drilling platforms for safety and structural integrity assessment.

ESSO CRI - caisson retained island - static and dynamic response of the structure under ice and wave loading.

HIBERNIA MANAGEMENT AND DEVELOPMENT CORPORATION

Overall system design and implementation responsibility for the geomechanical and structural integrity monitoring systems for the Hibernia Gravity Based Structure 350 kms. east of Newfoundland.

CANSHIP UGLAND LTD.

Bollard pull and propulsion system torque measurements on two large tugs designed for shuttle tanker handling in ice infested waters.

MARATHON OFFSHORE

Instrumentation equipment for offshore drilling platform in ice infested waters.

IV PROPRIETARY PRODUCTS AND SYSTEMS

In addition to providing design and analytical services, the Weir-Jones Group has developed a range of proprietary products and systems designed to enhance the safety and cost-effective operation of various types of vessels. These include:

AUTOMATIC DRAUGHT INDICATOR SYSTEM - ADIS™

With the support and co-operation of the British Columbia Ferry Corporation, the Group developed an Automatic Draught Indicator System, ADIS™, for commercial vessels. The system has the following significant features:

- No hull penetrations are required, and an installation can be completed in as little as 8 hours on existing vessels.
- ADIS™ is significantly less costly than systems requiring hull penetration and is essentially maintenance free. Mean time between failures exceeds 50,000 hrs.
- ADIS™ can provide very accurate draught measurements during cargo loading.
- ADIS™ provides real-time loading information about hogging, sagging and inclination.
- The ADIS™ real-time digital bridge display shows the draught of the vessel, port and starboard, forward, amidships and aft with an accuracy of better than ±2 cm.

B.C. Ferries operates one of the world's largest ferry fleets and require an accurate, reliable and cost effective solution to their draught monitoring system needs. The ADIS™ system was designed to meet their specific requirements and it has proven to be extremely reliable during a ten vessel three year Beta test programme. This system is now available to marine operators as a commercial product with distribution and support available internationally.

HULL CONDITION MONITORING SYSTEMS AND VOYAGE DATA MONITORING, *HMON*™

The Weir-Jones Group designs, builds and installs hull condition and motion monitoring systems for a variety of vessels and offshore structures. A wide range of data display and storage options are available for these systems to meet the requirements of various classification societies eg. DNV Rules for classification of High Speed and Light Craft, Lloyds, ABS, Guide for hull Condition Monitoring Systems, *etc*. Specifically hull condition monitoring systems can be supplied which comply with the classification society requirements of the following areas:

- Hull Girder Stress
- Local Load Monitoring
- Ship motion
- Slam Warning
- Green Seas Warning
- Fatigue Monitoring

In addition Voyage Data Monitoring, VDM, equipment can be provided which can acquire and store the data generated by the Hull Condition Monitoring Systems as well as other operational parameters including radar, and bridge/engine room voice communications, video feeds, *etc.*

REAL-TIME WAVE HEIGHT MONITORING, *WHAM*™

The Weir-Jones Group has developed a system which provides the Masters of high speed vessels with information about the significant wave height that their vessels are encountering. The information can be made available as a digital display on the bridge or it can be supplied to a Voyage Data Monitor.

Further information about the services provided by the Weir-Jones Group can be obtained by contacting:

Iain Weir-Jones, Ph.D., P.Eng., President