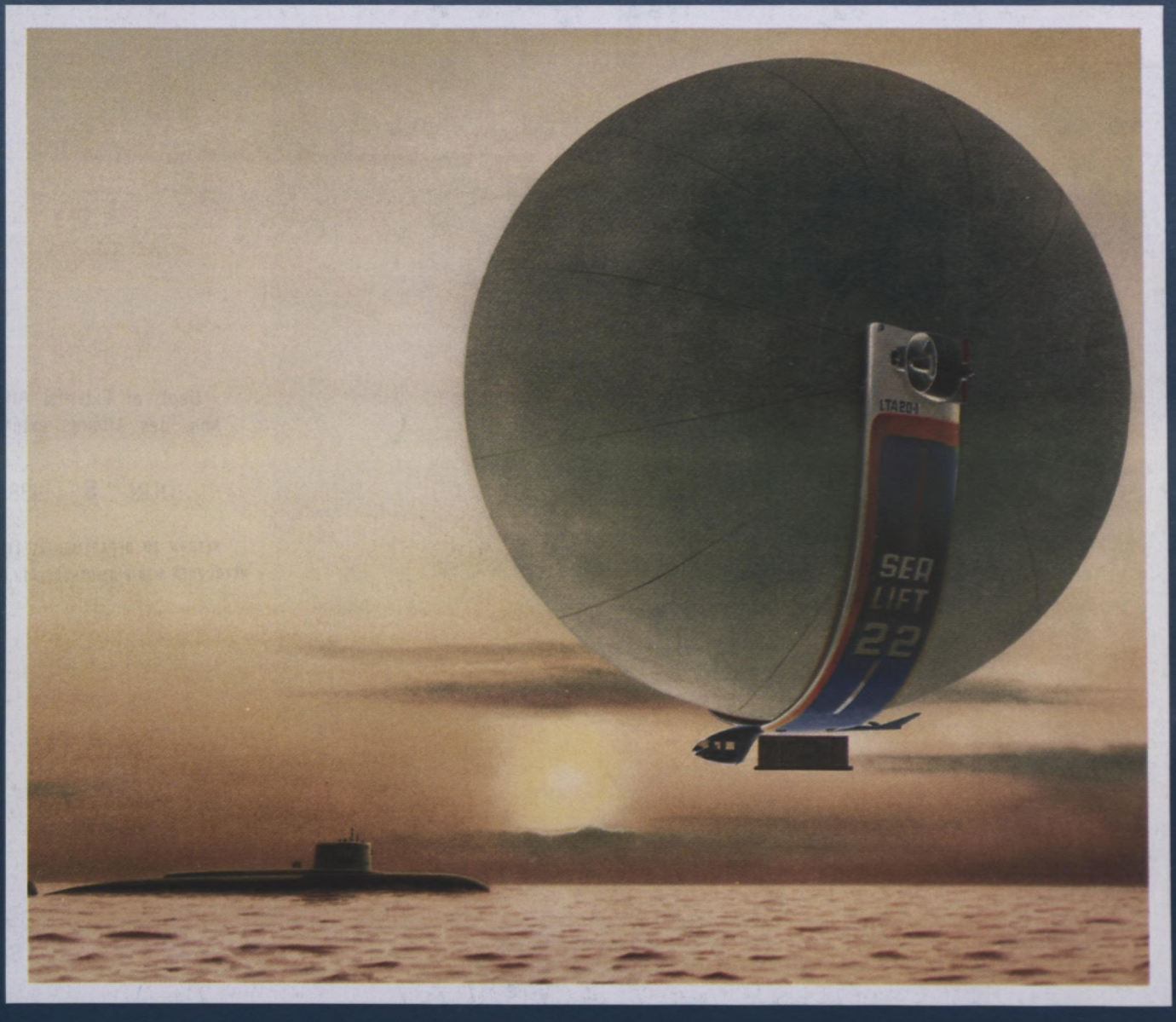
TRANSPORTATION TECHNOLOGY:

THE CANADIAN EXPERIENCE



Canada

Deep Rover, manufactured by Can-Dive, was developed for underwater scientific research, such as geological or oil exploration and under-ice operations.

This book is based on the film, *Canadian Expertise for the Transportation Industry. . . Canada in Motion*, produced by the Department of External Affairs.

The companies and products depicted in this publication are intended to be representative. Space limitations do not permit the portrayal of all new Canadian developments in the field of transportation or mention of all Canadian companies engaged in the design, development or production of Canadian transportation equipment.

(Publié également en français)

The purpose of this series is to inform readers of current trends in Canadian technology.

Cover photo:
Van Dusen's airships can carry up to four times the load of a helicopter for a tenth of the cost. *See Page 5.*

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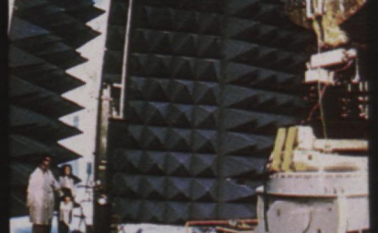
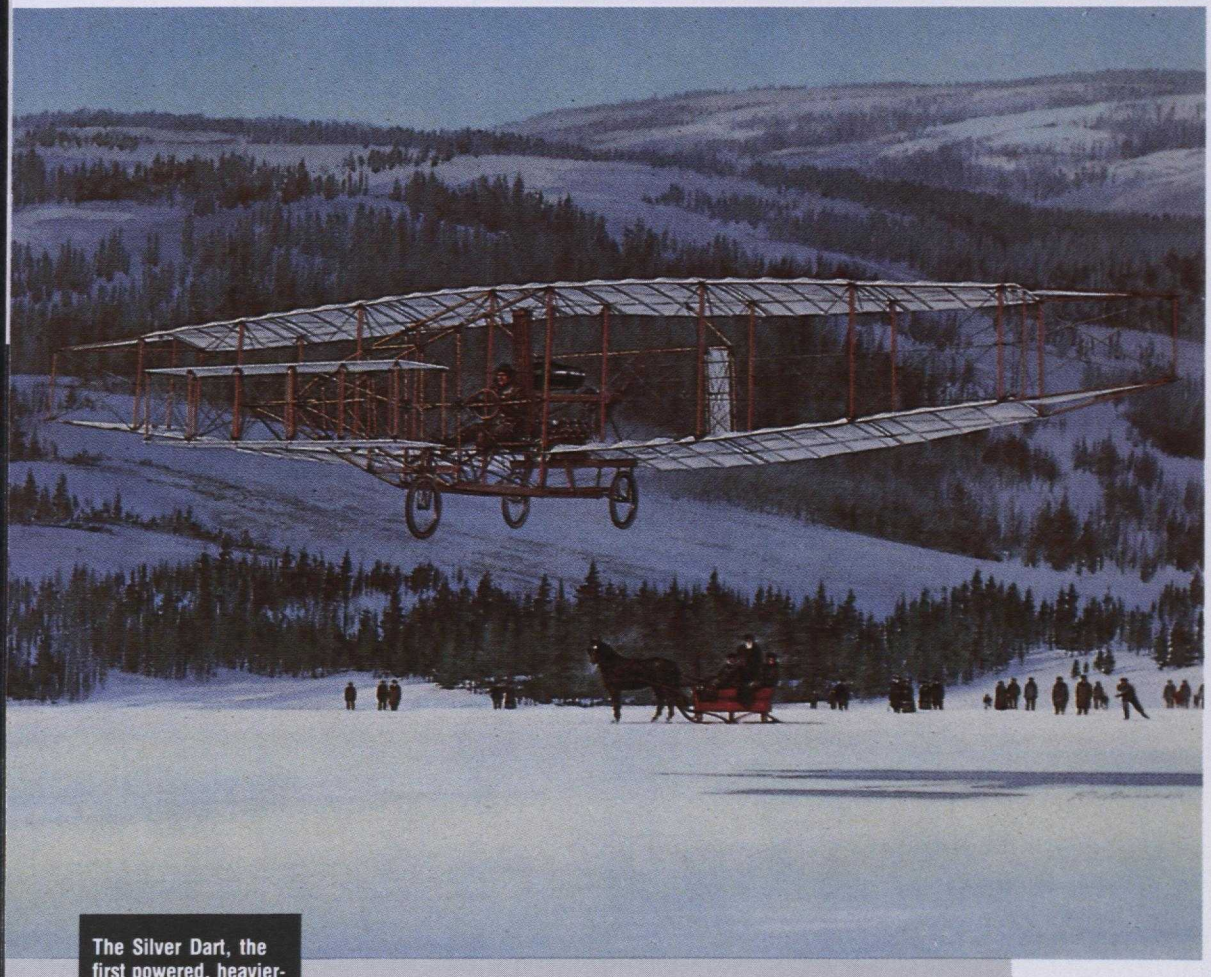


Introduction



The Silver Dart, the first powered, heavier-than-air machine to fly in Canada, piloted by J.A.O. McCurdy, made its first flight over Baddeck Bay, Nova Scotia, on February 23, 1909.

When Canada became a nation in 1867, the major obstacle in forming a united country was the vastness of the land — an enormous expanse of over 10 million km^2 from east to west and north to south. A demanding climate and geography also created some of the most challenging conditions on earth. Today, most of Canada's 26 million people are clustered in large cities in a narrow 5 500-km-long ribbon of land skirting its southern border with the United States.

Canadians have not so much tamed their land as they have been inspired by it, and they have used their environment as a means of discovery. They have, for example, cracked the granite shield wide open to let the railway through, linking the Pacific with the Atlantic. They invented vehicles to carry people and goods across snow and muskeg; ships that could ply through the thickest sheets of ice; and they developed aircraft that could fly into isolated wilderness, then land and take off again on short, crude runways, or on numerous lakes and rivers. In large, crowded urban areas they designed elevated guideways and propelled automated vehicles up and out of the way of city traffic.

Confronted with great distances, Canadians have had to develop flexible and efficient transportation routes. Scientists, engineers and technicians have designed and adapted new technologies to create these networks — networks that have made Canadians leaders in providing transportation solutions to countries throughout the world.

Aviation

Canada's size — 5 500 km from the Atlantic to the Pacific oceans, 4 600 km from Ellesmere Island in the north to its southern border with the United States — means that wide expanses often separate one population centre from another. It also means that much of the nation's natural resource wealth, which is located in its remote regions, must be transported immense distances for processing.

It was inevitable that Canada would be a leader in the design and manufacture of aviation products to move people and goods quickly over great distances. From the design of the variable pitch propeller (recognized as one of the more important inventions in the history of aeronautics) to world-class corporate jets, Canada has a history of technological innovation stretching back to the historic flight of the *Silver Dart* in 1909.

The de Havilland Dash-8 aircraft, which can accommodate 36 to 40 passengers, has a large cabin that can be adjusted to meet work or conference requirements.

STOL planes and business jets

De Havilland "*bush planes*" opened up the Canadian North, carrying cargo and supplies to remote communities.

Bush planes can take off and land on short, crude runways, on ice and snow, and on lakes and rivers in normally inaccessible areas, and they perform in every type of weather. Names like *Beaver* and *Buffalo* have become synonymous with search and rescue, emergency and supply aircraft throughout the world. The success of these aircraft created a global demand for Canadian short take-off and landing (STOL) technology.

Today, a new generation of STOL aircraft like the de Havilland *Dash-7* and *Dash-8* has been adapted to urban requirements. They are ideal both for busy airports in dense urban areas, providing efficient downtown to downtown service, or for short runways in rough terrain. The Dash-7 and 8 can take off and land in very short distances (usually less than 610 m for the Dash-7 and less than 915 m for the Dash-8). The Dash-8 seats 36 to 40 passengers while the Dash-7 accommodates 50. The newest version of the Dash-8, the Series 300, can seat 50 to 56 persons. (Initial customer deliveries for this new series are planned for late 1988.) Efficient wing design and low speed manœuvrability, plus economical fuel consumption make these planes very desirable for airlines around the world; and their specially constructed turboprop engines, also developed and manufactured in Canada, make them the quietest planes flying today.

Fast, fuel-efficient and quiet, Canadair's Challenger is a modern long-range, high-technology private corporate jet.

Canadair also builds the CL-215, specially developed for fighting forest fires.

STOL aircraft, such as the Dash-7 and Dash-8 fly for airlines in the Caribbean, throughout Europe and the Far East, as well as in North America. In fact, a Stolport is being built in London, England's crowded city centre for the Dash-7 which will provide a unique gateway to Europe. It will enable commuters to fly direct from the downtown core of London to major urban centres in Europe.

What Canadians learned in designing specialty aircraft they have applied to solving the transportation problems of the global business community. The *Challenger*, built by Canadair Limited, is one of the world's best private corporate jets. It can fly transatlantic routes as efficiently and quietly as it does short inter-city hops. The Challenger can also take off and land at noise-restricted airports inaccessible to most other private jets, with its two extremely quiet high bypass turbofan engines. Advanced-technology wings make the Challenger fast and fuel-efficient, using 20 to 40 per cent less fuel than previous generation corporate jets. It has a range of up to 3 500 nautical miles (approximately 6 486 km) and can carry 19 passengers in comfort, which is why more than 140 Challengers have been sold throughout North America and across the world.

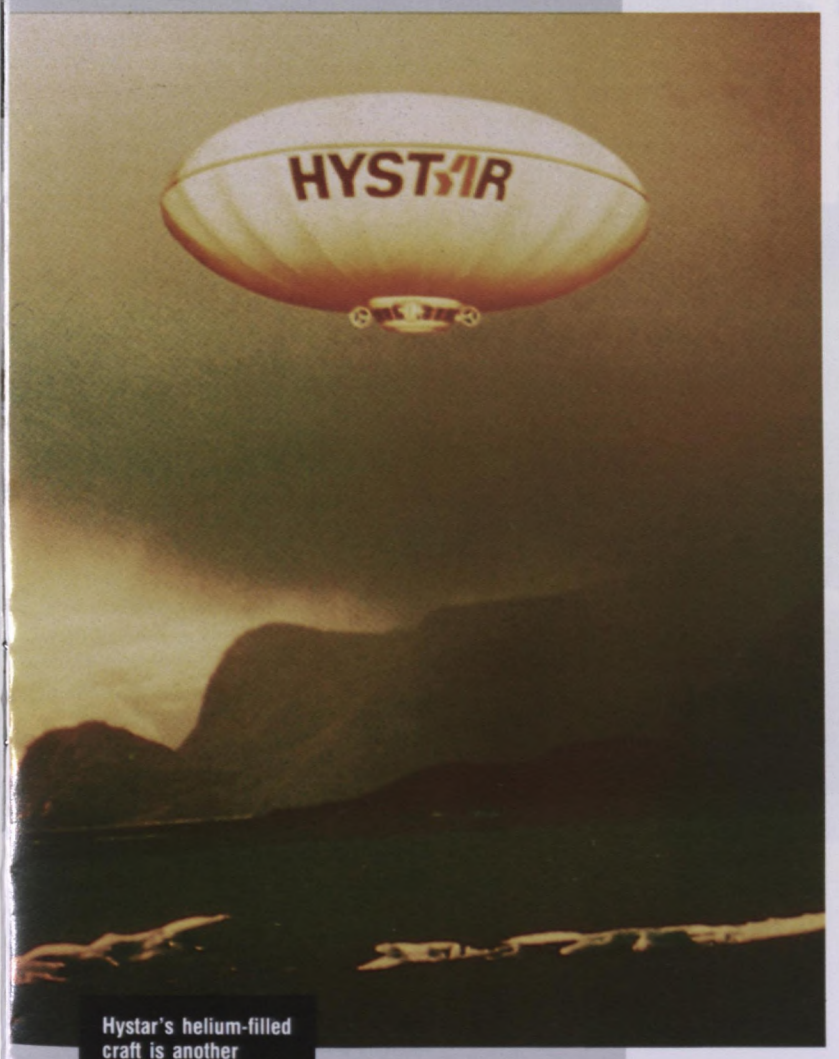
Forest firefighter

The forest is a precious resource on which Canadians depend for trade, employment and recreation. A special waterbomber, the *CL 215* is the only plane in the world specially developed to fight forest fires. It can speed along the surface of a lake, scoop up 6.6 tonnes of water in 10 seconds and drop it with pinpoint accuracy over a fire. This plane can make over 200 separate drops in a day, representing a phenomenal volume of water for effective fire saturation and control.

Make-it-yourself

Some inventors start young. Dale Kramer, Canadian inventor of the *Lazair*, an "ultralight" plane, started making wooden airplanes at age five and has been building them ever since. The Lazair was not the first ultralight built, but it did contribute to the resolution of manœuvrability and safety problems that plagued the early models. In the Lazair, the pilot is positioned under the wings, with no cockpit to block the view. The plane can operate on its two engines or, with engines turned off, it can be flown as a glider. The Lazair, available in kit form from Ultraflight Sales Limited, can be assembled by anyone possessing moderate mechanical skills, without special tools, in about 150 hours.

The Lazair "ultra-light," which has a flight endurance of four hours, is sold in kit form by Ultraflight Sales Limited. (Photo courtesy of Ultraflight Manufacturing Ltd.)



Hystar's helium-filled craft is another modern-day dirigible that would be economical for hauling large, heavy goods.

Dirigibles

Some people will remember the airship disaster on May 6, 1937, when the German dirigible *Hindenburg* ignited and crashed to the ground in a fireball at Lakehurst, New Jersey, U.S.A. That tragedy might never have happened if the use of a safer gas — helium — had been considered earlier. John Cunningham McLennan, a Canadian, suggested the use of helium for airships and found a way to produce it cheaply.

Transporting resources economically from remote and inaccessible areas has always been a priority for Canadian engineers and designers. The result is the development of a new generation of dirigible like the *Van Dusen* and *Hystar* which can haul up to 80 tonnes — four times the payload of the largest helicopter — and do it for a tenth of the cost.

The Van Dusen looks like a giant manta ray floating through the air, its upswept wings cradling an 18-storey sphere. To help it stay up, even when carrying heavy loads, the sphere slowly spins backwards around an axle that runs between its two small engines. Air passing over the spinning sphere helps lift it (much like a golf ball), while maintaining the cabin at the base of the sphere in a stable, fixed position.

The Hystar is a donut-shaped craft filled with helium. It has thrusters in its central core so that it can move up and down, and even hover like a helicopter. The passengers sit in a gondola underneath the craft.

Flight simulation

Aircraft simulators have all but replaced conventional methods for training pilots. CAE Electronics Ltd. *flight simulators* use versatile modular components to suit the needs of individual customers. These simulators provide a setting so realistic that government licensing authorities consider one hour of flight training on a simulator equivalent to an hour in a real aircraft. Canada now supplies 40 per cent of the commercial flight simulators in the world.

Ships and the sea

International Submarine Engineering manufactures the Dolphin (above) and Arc, radio-remote-controlled submersibles.

As with air transportation, Canadians responded with the same creativity and ingenuity when it came to developing technology for the sea. Bordered by the Atlantic on the east, the Pacific on the west and the Arctic Ocean to the north, and with much of the country blessed with thousands of lakes of all sizes, it is not surprising that Canadians are experts in marine technology.

Shipbuilding was one of the nation's first major industries and Canadians have developed specialized ships such as the *self-unloading freighter*. The bottom of the hold feeds bulk cargo to a moving conveyor belt, allowing quick and efficient loading and unloading. These ships have been adapted for use in the Caribbean and other parts of the world.

Canada Steamship Lines' Self-Unloader is a totally self-contained system that unloads thousands of tonnes an hour automatically, with significant savings in stevedore work and shore equipment.

The great advances that have been made in shipbuilding have been matched by those in marine technology. From the Gulf of St. Lawrence on the Atlantic coast, a system of connected inland waterways permits ocean-going freighters and other vessels to travel thousands of kilometres into the heart of Canada. These waterways, which are an outstanding feat of engineering, use a system of locks to raise and lower ships, allowing them to bypass navigational obstacles like Niagara Falls.

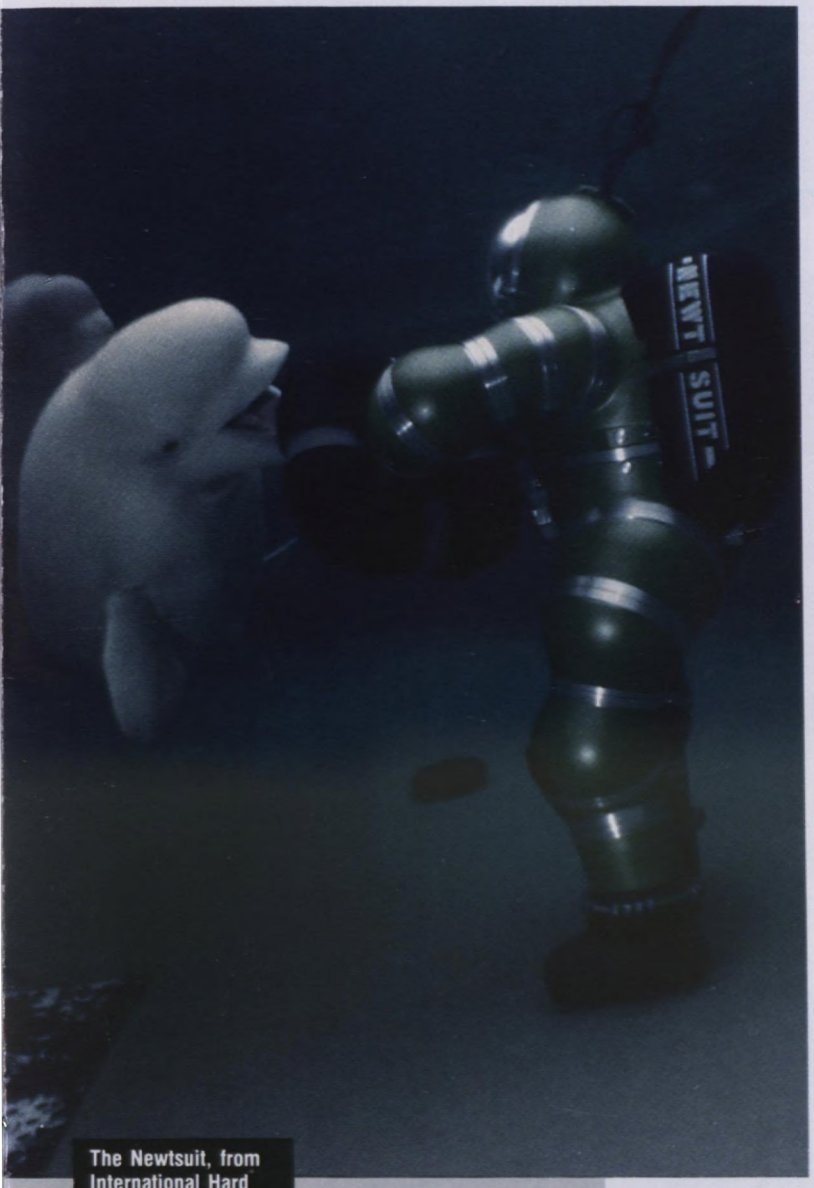
Ice breakers

In the Arctic, winter sets in early and stays late. Ice floes block shipping lanes and restrict access to northern communities for much of the year. To create year-round access to Arctic shipping lanes, Canadians have developed the world's most sophisticated ice-breaking technology.

Canadian icebreakers built with special hulls can plough through Arctic ice from spring to early winter. They can clear a path for cargo ships, tow oil rigs from one site to another and move dangerous ice floes away from anchored rigs. They can also lassoo icebergs and tow them out of harm's way.

Some of the biggest icebreakers in the world are built in Canada. The *Terry Fox*, for example, uses a gently sloped "spoon bow" that lets the ship ride gradually up onto the ice instead of ramming or crushing it. The ice bends and then breaks under the weight of the ship. Controllable-pitch propellers (another Canadian innovation) allow more efficient power control in varying ice and sea conditions.

Canada is committed to the construction of the largest conventionally powered icebreaker in the world, the *Polar 8*. It is scheduled to be operational in early 1993.



The Newtsuit, from International Hard Suits Inc., allows its wearer to dive to 300 m without suffering from the effects of compression and decompression.

Canadians are also combining technologies in new and effective ways to assist ships in ice-bound seas. New shipboard navigation systems unite airborne radar with satellite imaging. Together, they plot safe, efficient routes and pinpoint dangerous weather or ice conditions. A new Canadian satellite called *Radarsat*, for example, will be launched in the early 1990s. Using radar it will scan the Arctic at least once a day, through clouds, darkness or any atmospheric conditions. This technology will aid marine navigation throughout the world.

Under the sea

Canada's marine experience has also led to major achievements in undersea exploration. Two Canadian companies — International Submarine Transportation Systems and Can-Dive — have developed a line of submersibles that are adaptable to a variety of marine environments.

The *Deep Rover* is the world's most advanced one-person submarine. Looking like a spherical, transparent crab, it can dive to depths of 1 000 m and stay there for seven days. Like a helicopter, it can move vertically and horizontally, has 360-degree visibility, and is simple to operate. Its two manipulator arms can pick up objects as delicate as an egg, without risk of breakage. The Deep Rover has been used extensively by American marine biologists to study undersea life, and is readily adaptable to all types of underwater operation.

The *Dolphin* and the *Arc* are part of a family of radio-remote-controlled submersibles, manufactured for the world market. The Dolphin uses a sonar system to bounce sound waves off the sea floor. It can perform hydrographic surveys used for planning navigation routes and for all kinds of underwater mapping. It travels steadily about 3 m down, just beneath the motion of the waves. Its Arctic equivalent, the Arc, is designed specifically to work under the polar ice caps.

The *Newtsuit* is a Canadian breakthrough in diving gear. Made of material five times stronger than steel, it allows divers to go to depths of over 230 m and return rapidly without risk of decompression. This suit, weightless in water, has joints that can bend and freely rotate under extreme pressure.

The U.S. National Aeronautical Space Administration is currently interested in adapting the Newtsuit for use in outer space.

Canadian industry has also developed expertise in oceanographic and hydrographic equipment and survey capabilities, as well as navigation and positioning equipment and services.

Intercity rail and urban transit

The Canadian dream was to build a great transcontinental rail line linking east with west. It would mean for the first time that Canada would be a unified country, with the means to connect its people and resources efficiently. Some 30 000 men toiled for five years to lay 3 500 km of rail. An epic in railway engineering was completed. The year was 1885.

The 1980s demand new approaches, new products. Today, the Canadian rail system is one of the longest and most sophisticated in the world. Canadians continue to be at the forefront in developing and exporting rail and transit products and technologies, such as the LRC.

The LRC is Bombardier's highly successful intercity train.

The ALRT — up and out of the way of city traffic.

Bombardier's *LRC*, which stands for "light, rapid, comfortable" passenger train, is in service along Canada's busiest traffic corridors — Toronto, Montreal, Ottawa and Quebec City. These trains can take curves at full speed while maintaining maximum passenger comfort.

What has been learned in moving people and goods efficiently across thousands of kilometres has been adapted to solve the problem of moving thousands of people quickly and comfortably across short distances in the cities.

The *Advanced Light Rapid Transit (ALRT)* vehicle, developed by the Urban Transportation Development Corporation (UTDC), can move up to 20 000 people an hour per direction and is operating in Detroit, Toronto and Vancouver. The ALRT, or sky train, can be elevated on its own right-of-way, up and out of the way of city traffic without the visual and noise pollution associated with other types of elevated rail systems.

The ALRT is a special application of proven and new transit technologies. It incorporated such technical innovations as linear motors and steerable axle undercarriages. Together, they significantly reduce noise and wear. The steerable axle undercarriage improves ride quality, reduces screeching on curves, and creates substantial savings by extending the life of wheels and rails.

Each ALRT car has two linear induction motors that use magnetic force to propel the vehicle forward and to provide braking. These motors do not use gears or transmissions, and have no moving parts that require maintenance. The ALRT can be equipped with a computerized train control that eliminates the need for a driver. As well, the waiting

The Canadian Light Rail Vehicle is a highly efficient commuter.

The Canadian-designed bi-level train is said to be the world's largest and most effective commuter vehicle.

time between trains is significantly decreased, since with train speed and position controlled by computer, the space between trains can be reduced with no compromise on safety.

Trolleys, trams and streetcars have been around since the turn of the century. Today, there is a new awareness of the streetcar's value. And, a new generation of *light rail vehicles* offers a viable alternative to continued freeway expansion.

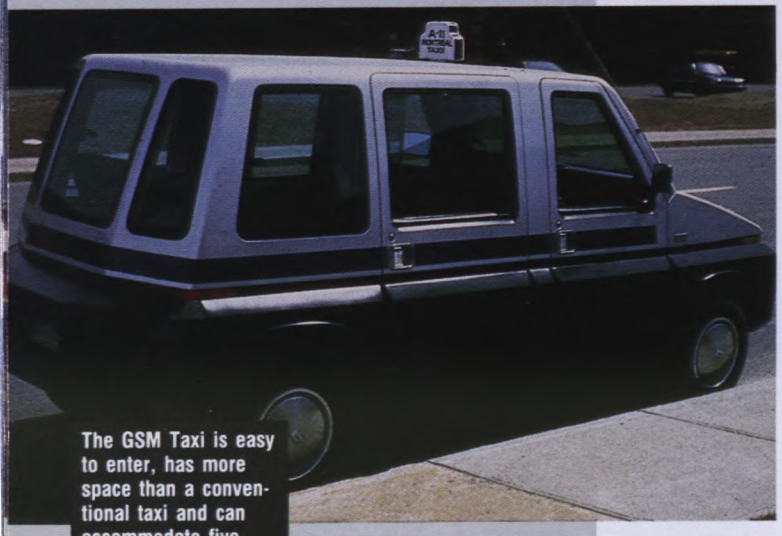
Electrically powered, light rail vehicles make more economic and environmental sense than most other city transportation systems. They offer the versatility of street or private right-of-way operation. They can run on existing or refurbished tram or railway tracks.

Canadian light rail vehicles (CLRV) incorporate the most advanced technologies available, and the most thorough testing systems. As a result, these vehicles have accumulated 16 million km of almost uninterrupted revenue-generating service since 1979.

One of the unique features of Canadian-manufactured streetcars is their modular design. Four-axle designs have been successfully adapted to a six-axle articulated streetcar which can provide up to twice the passenger capacity. The streetcars are in service in Toronto, Ontario, and Santa Clara County, California.

Efficient and economical commuter transit is a high priority for many cities today. Canadian-designed *bi-level cars* are among the world's largest and most effective commuter vehicles. They feature washrooms, air conditioning, and seating so comfortable that many business commuters use them as temporary offices. A built-in cab-control car allows these trains to be run from either end, eliminating the need to be turned around when they reach the end of the line.

Versatile Pacific Shipyard's Seabus is an integral part of Vancouver's rapid transit system. (Photo by Gar Lunney)



The GSM Taxi is easy to enter, has more space than a conventional taxi and can accommodate five mobile passengers or three mobile passengers and a wheelchair.

The Orion II bus from Ontario Bus Industries, designed for the disabled, can "kneel" at the curb for easy access.

The *GSM Taxi*, another vehicle used to transport the elderly or disabled, has been specifically designed for large-city driving. Using a heavy-duty truck chassis, it can withstand rugged driving, while still providing passengers with a comfortable, smooth and safe ride. The body of the GSM has been designed with interchangeable modular parts, which reduce maintenance and inventory costs.

Seabus

At rush hour in Vancouver, bridges from the downtown area to the North Shore are jammed with vehicles. As the great spans make the cost of additional bridges or tunnels prohibitive, Canadian marine specialists teamed up with engineers to develop a new approach. The *Seabus* is more than a simple ferry service. It is an integral part of Vancouver's rapid transit system. Terminals and schedules are fully timed and integrated with Vancouver's buses and inter-city trains.

A Seabus vehicle can reach speeds up to 13.5 knots and carry 400 passengers on each 12-minute crossing, with a turnaround of 90 seconds at each end. Two motors forward and two aft allow the Seabus the capability of turning around in its own length.

The elderly and disabled

In designing and building transportation networks, Canadians have not forgotten the disabled and elderly. Life for them is difficult enough without their having to manœuvre getting on and off conventional transit vehicles, which is why the *Orion* II was developed. This bus rides on a "bag" of air which not only gives the passengers a comfortable journey, but, by simply letting out some of the air, the bus can "kneel" to within 5 cm of the curb. It can also be equipped with a wheelchair ramp.

Snowmobiles and all-terrain vehicles

The Ski-Doo, designed and built by Bombardier, radically changed modes of transportation in northern Canada where the dog sled was the main means of travel. Snowmobiling is now a popular sport in Canada and parts of the U.S.

In 1922, a 15-year-old named Armand Bombardier from Valcourt, Quebec, came up with the idea of attaching an old airplane propeller and motor to a family sled and invented the *snowmobile*. By 1964, the perfected snowmobile had all but replaced the dog sleds of northern Canada and enabled many people in other parts of Canada and the world to enjoy winter travel.

The snowmobile led the way to a family of all-terrain vehicles, each developed to solve a specific transportation problem such as traversing the muskeg of northern Canada. Muskeg is a layer of dead plants that become moist in the summer and sink underfoot, making travel difficult. Roads often cannot be built on such terrain. Tropical countries with rain forest, swamp, and desert face similar problems.

To deal with these various environments, Canadian manufacturers such as Bombardier and Canadian Foremost have designed a family of *all-terrain vehicles* (ATVs) for world markets. Heavy tracked and wheeled ATVs can carry large loads of people and machinery — sometimes as much as 70 tonnes. They are used throughout the world for activities as varied as fighting fires in the U.S.S.R., laying powerlines in the Amazon Basin, surveying land in the Arctic, and installing pipeline in China and Peru.

Another amphibious ATV, Terra Bus, built by Canadian Foremost can also negotiate all types of terrain.

The *Terra Bus*, manufactured by Canadian Foremost Limited, is an ATV that has been used to help move people from one area to another quickly and safely. Balloon-like low-pressure tires on these vehicles allow them to manœuvre freely on all types of terrain, adapting with speed and ease from water to desert, from rocky bluffs to ice and snow. They do not damage environmentally sensitive terrain and are important for areas where low population makes the building of conventional roads uneconomical.

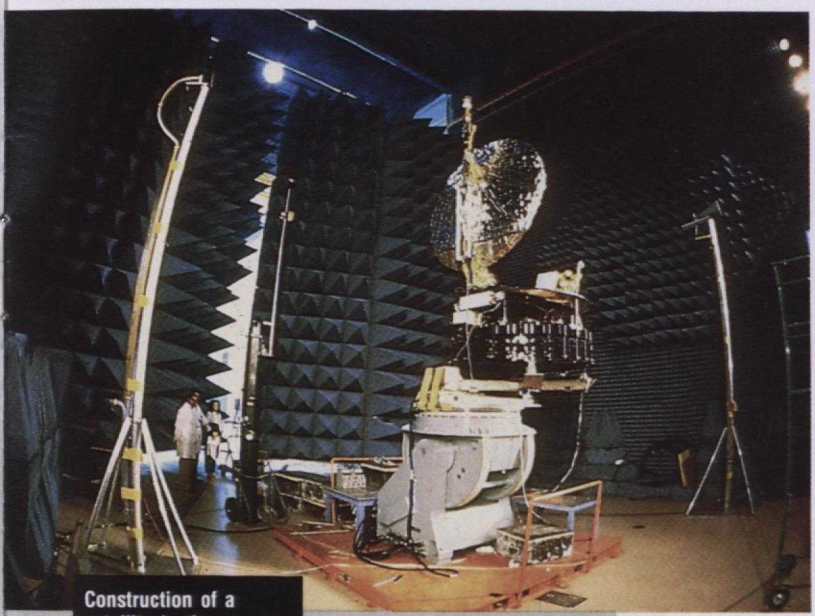
The prototype Aerobac, 11.5 m long and 6.2 m wide, will be marketed by Vitri Robots and Vehicles Inc.

Aerobac, a concept developed by the Transportation Development Centre, ingeniously combines hovercraft capabilities with superb traction on land. Over water, it rides on a cushion of air; moving onto rocky ground, its caterpillar tracks come into use.

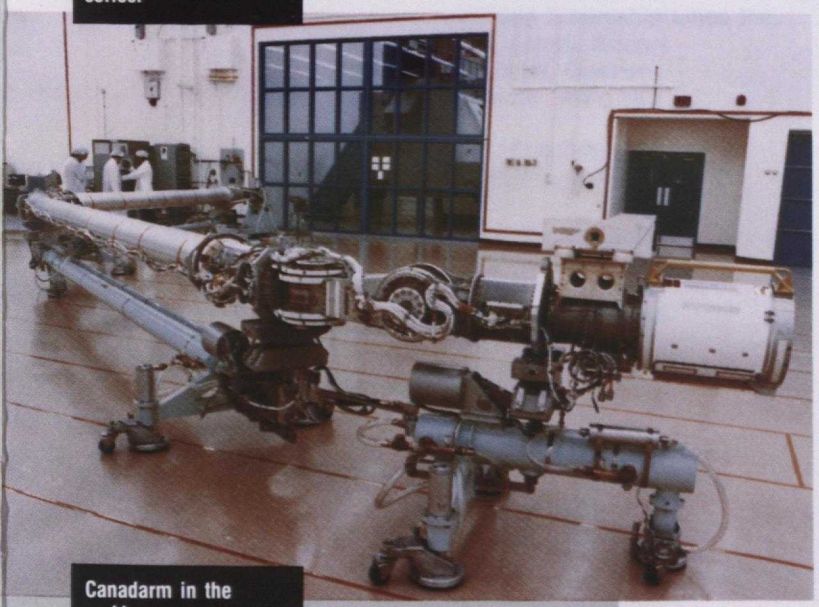
Unique Canadian agricultural equipment such as tractors manufactured by Versatile Farm Equipment, Manitoba, have been sold throughout Canada, the United States and Australia. This company's *Model No. 256* is completely bi-directional with a seat and steering wheel which can be fully turned from front to back. Using this tractor, the farmer can cultivate and seed simultaneously.

Farming is easy with Versatile Farm Equipment's Model No. 256, which can handle two operations simultaneously.

Space



Construction of a satellite in the powerful Anik C series.



Canadarm in the making.

Canada became the third nation in space with the launch of *Alouette 1* in 1962 — and the third to design and build satellites. Several more followed and, in 1972, the first of a series of *Anik* communications satellites launched into geostationary orbit provided a Canada-wide communications network. The *Hermes* satellite, launched in 1976 into geostationary orbit above the equator, was used to test supra high frequency signal transmissions and reception, which are fundamental to the development of direct broadcasting, as well as to the development of telehealth, where satellites are used to extend health services to remote communities; teleconferencing; and tele-education, where students and teachers thousands of kilometres apart communicate via satellite.

SARSAT, a satellite system developed by Canada, the United States and France, has been in service since 1982, and is especially important in Canada, where search and rescue operations are difficult and expensive because of the vast size of the country.

The space shuttle program is known throughout the world. For Spar Aerospace Limited, and CAE Electronics Ltd., it was an opportunity to put Canadian space and robotics technology to work in developing a computer-controlled remote manipulator arm called *Canadarm*. Deployed during the second flight of the space shuttle *Columbia*, Canadarm operates much like a human arm with six rotating joints, two at the shoulder, one at the elbow and three at the wrist. An on-board computer can guide Canadarm through 20 movements. Delicate and fragile on the ground, Canadarm cannot support its own weight unassisted. But in outer space, in the absence of gravity, it can grapple payloads as big as a satellite that may weigh as much as three tonnes.

New developments, such as *Smartarm*, will allow Canadarm to "see" as well as touch.

Spar Aerospace is also adapting its remote manipulator systems to other industrial applications, such as underwater or nuclear reactor work. And in the field of space travel, CAE Electronics Ltd. is building specialized manned manœuvring units that allow astronauts greater freedom when moving outside their space vehicles.

More details of Canada's involvement with space can be found in *Satellites: The Canadian Experience*, another publication in this series.

Conclusion

Canadarm in space.

Anik C-2, launch from space shuttle. (Photo courtesy of NASA)

From outer space to the land to the sea; from permanent ice to sweltering heat; from tropic-like rains to dust bowl dryness — each of these conditions is found in Canada. Each presents its own challenge. Each requires a specific response.

To a world of varied and complex transportation problems, Canada offers its ingenuity, its resourcefulness and its proven technology in keeping people and goods in motion.

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Gulf Canada's *Terry Fox* icebreaker bends and breaks the ice with the help of its "spoon bow." (Photo by Ranson Photographers Ltd., Edmonton)

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