THE MAP MAKERS

From foot-slogging surveys
to satellites and digital bits

By Eric Harris

THEY ARE THE torn and tattered occupants of the glove compartment, keeping company with dog-eared owner’s manuals, expired car-wash coupons and worn-down pencils. They are invaluable when required and disregarded when not.

Many are encountered on a daily basis, some so taken for granted that they may not be recognized for what they are. Consider the directory at the shopping centre, conveniently informing us that “you are here”. Or the beginning of The National, CBC’s nightly television news broadcast, where a silver video map unrolls and soars across the screen, finally forming a shining backdrop for the events of the world.

Then there is the handcrafted map given to prospective visitors, usually drawn on a paper napkin. This becomes an object of disdain when unmarked exit ramps are missed, when cloverleafs confuse, when cartography simply does not reflect reality.

“A map may lie, but it never jokes,” wrote poet Howard McCord. Accuracy and clarity determine quality; if incorrect or cluttered, a map fails.

Good maps show the earth’s features graphically, to scale, on a two-dimensional surface. Many are widely distributed and affordably priced. They may be topographic, showing natural and man-made features of the land, or navigational, showing hydrographic, aeronautical or automotive routes. They may be thematic, showing geology, soil, vegetation, weather, wildlife, human activity, pollution, or countless combinations thereof. All are extraordinary forms of communication, conveying our vast knowledge of the world. Whatever they contain, producing them is a feat requiring creativity and precision, a merger of art and science.

It has been said that Canadians are good map makers because there is so much here to map. Over the last 60 years, mapping in Canada has gone from a question of extent to one of scale and quality. At the same time, map compilation, production and usage the world over have undergone remarkable changes. Through it all, Canadian cartographers have stayed in the forefront, applying new tools, techniques and ideas as they evolve.
In Canada, cartography began with aboriginal mapping. Indian and Inuit bands across the continent drew their villages, waterways, trade routes and battle plans on the ground, snow and on animal skins; one Ottawa chief sketched his nation’s territory on bark with charcoal for Champlain in 1615. For the most part, aboriginal maps have survived only as copies drawn by explorers and priests.

The Vikings visited Helissand, Markland and Vinland on our East Coast a thousand years ago but left no cartographic evidence of their stay. It was the later European explorers who surveyed, mapped and charted the New World, in pen-and-ink.

John Cabot sailed from England to the northeast coast of North America in 1497, but departed believing he had reached Asia. His landfall is still uncertain, though most likely it was at Cape Bonavista in Newfoundland. The map he drew disappeared.

Maps by Jacques Cartier and John Davis were also lost, but the discoveries of these explorers soon appeared on 17th-Century European charts that showed the Atlantic coast in ever-increasing detail. The first world map showing a solid land barrier in the west was drawn by Columbus’ pilot, Juan de la Cosa, in 1500; the first to label Canada was printed in 1556. With Champlain, Cook, Vancouver, the La Vérendrye, Mackenzie, Thompson and Franklin, the coasts, waterways and colonies of French and British North America took shape, cartographically.

Between discovery and settlement came the survey, the monumental task of measuring a nation. The government, that prolific cartographer, delimits its territory physically and abstractly with boundary markers and maps. Both require geodetic surveys.

“We have one vast system of surveys for the whole of it,” said Sir John A. Macdonald after the Dominion Land Survey was established in 1871. For Canada, a young country facing encroaching American settlement in the West, the surveys — and the maps drawn from them — permitted quiet and orderly occupation of the Prairies.

Dauntless came the surveyors, each one seemingly with the stamina to traverse vast and varied wilderness for months at a time. Through heat and cold, by horseback, canoe, raft and foot they journeyed, measuring distance and angles all the way. They surveyed cities and homesteads, forests and fields, mud-laden roads and bug-infested bogs. They used chains to measure distance and transit for angles. They established benchmarks by the stars and built monuments on borders. They triangulated the heights of hills and sounded the depths of coastal waters. Moving roughly west and northward, they skirted rivers, photographed mountains, pounded posts, and packed and unpacked camp. Just getting to camp was arduous enough, even in the 1920s.

We went in through Peace River, followed the ice downstream in two barges to Fort Vermilion, travelled by wagon and pack horse to Upper Hy River, and then proceeded by pack horse to our starting point at the 60th parallel of north latitude. Over the last 20 miles there was neither feed nor trail, so that the horses were completely played out. Meanwhile, we spent a very anxious time until we found our first supply cache six miles to the north. From here on we man-packed.

That recollection of a 1922 survey party was made by its leader, Bruce W. Waugh. In 1938, Waugh’s team completed the Saskatchewan-Alberta boundary, then the world’s longest surveyed straight line.

What a difference from the survey of 1922! In that year, we were 15 days reading our work from the railway. This time we left the railway at noon, did some survey work, and had supper in our own camp that evening. The airplane had made it possible. The bush pilot was becoming the surveyor’s best friend, and aerial photography was about to take Canadian map making off the ground.

Cameras were sent aloft on air force
reconnaissance missions during World War II to supplement verbal and written reports by pilots. Oblique pictures taken with cameras mounted in cramped and drafty cockpits revealed much the pilots could not see, but military commanders and cartographers could.

Between the wars and despite the Depression, optics, cameras and plotting instruments were improved. All the while, topographers with the federal and provincial governments were methodically mapping the towns and farmlands of the Maritimes, Quebec, Ontario and the Prairies, and the mountains of British Columbia. The North, however, remained very poorly mapped. Many bush pilots, without charts to guide them, resorted to maps torn from textbooks.

By 1930, two editions of the Atlas of Canada had been published; topographic and hydrographic map series, at a variety of scales, had been established; a prototype aeronautical chart, of an area surrounding airports at Winnipeg and Laun du Bonnet, Man., had been printed; and an aeronautic air route series started.

With World War II came an unprecedented demand for maps and map makers, and both the air force and the topographic survey played an admirable role in filling it. In the war zone and in Canada, maps of targets and terrain were of primary interest.

By this time, cameras were mounted, facing straight down, on planes flown in grid patterns at constant altitudes. In clear weather, this provided images with the optical axis in the preferred perspective for mapping: perpendicular. Some cameras were even designed to take three pictures at once, one vertical and two side-looking obliques, to cover a swath from horizon to horizon at right angles to the flight path.

Taking the pictures required much skill, especially when old explorers’ maps were the only available aid to navigation. Flying the plane smoothly was a challenge. But devising methods for accurately measuring air photos—a process called photogrammetry—required cartographic and mathematical wizardry.

The stereoscope used a novel combination of optics and overlapping air photos to create a three-dimensional picture of the terrain. The photogrammetric stereoplotter carried this concept a giant step further by enabling the cartographer to measure precisely the elevation of features in air photos and transfer them to a paper map manuscript.

After the war, a legion of military pilots, surveyors and cartographers found work with expanding federal, provincial and municipal agencies, and with private industry. Companies such as Spartan Air Services and Canadian Aero Services flew Lancasters, Mosquito-35s and bubble-nosed P.38 Lightnings over the frontiers of the nation in the 1950s, feeding map makers with an endless stream of new information. They were back to surveying, systematically accumulating a mass of knowledge about the land — particularly in the North. In 1945, only one-quarter of the country had been photographed from the air; by 1957, aerial photo coverage was complete.

Aside from cameras, surveyors and map makers carried a variety of nonphotographic sensors, such as telleurometers, which measure distance by timing radio waves transmitted between points up to 30 kilometres apart, and radar, which measures radar elevation along flight lines; magnetometers, which record variations in the earth’s magnetic field that might identify ore deposits; and scintillometer counters, to measure gamma rays emitted from uranium deposits. From these precision instruments came maps packed with information, both topographic and thematic.

One more innovation, Shoran (short-range navigation), was an electronic distance-measuring system first used to guide bombers. It was adopted in 1947 by air mappers to find the position of an aircraft in relation to two ground stations as the camera snapped each air photo. In the mid-1950s, a network of Shoran survey stations was installed across the Arctic.

To erect the radio tower for a station near Ross Bay, N.W.T., a crew made a 270-kilometre round trip in near-zero visibility from the airfield at Repulse Bay. They carried 1,500 kilograms of radio and camp gear, using that tried-and-true method of arctic transport: the dog sled. Canadian cartography had entered the electronic age, in indomitably Canadian style.

In 1957, the Soviet satellite Sputnik I joined the moon in orbit around the earth. It operated for 21 days, just long enough to change the space race and its concurrent burst of new technology. Some of Spavetz’s successors—Rebound, Echo, Pageos, Transit, Landsat, Spot, TDRS and Navstar—have carried cartography into the space age.

Pageos I, launched by the United States in 1966, was the first satellite with an instrument package specifically designed for geodetic surveying. In 1968, the Americans created the Satnav system, consisting of six Transit satellites forming a positioning network based on the Doppler effect (the apparent change in radio waves as the source moves toward or away from the observer). Satnav, used by Canadian surveyors since 1973, will be phased out in 1996.

Six other equally spaced satellites now orbit the earth at an altitude of 24,000 kilometers. (By the mid-1990s, at least 18 will be doing so.)
They form Norsat, the U.S. military’s global-positioning system. Today, ground surveyors packing global-positioning receivers can do in an hour what once took months: determine geodesic position, accurate within millimetres, anywhere on earth.

Sensitive scanners on a group of earth-observation satellites are painting yet another new portrait of the planet. From altitudes of up to 900 kilometers, Landsat-5 (U.S.), Spot-1 (France) and MOS-1 (Japan) continuously measure visible, infrared, ultraviolet and microwave radiation reflected from the earth’s surface. They transmit their observations back to earth as data that can be reconstructed into vividly detailed pictures showing as much as 34,000 square kilometres of the surface.

In 1994, they will be joined in orbit by Canadian-designed and built Radarsat. Unlike the others, Radarsat will provide its own source of “illumination” by beaming microwaves down to the surface and measuring their return. Sunlight will not be required, so it will be able to scan the earth’s surface through clouds and in darkness.

Radarsat will provide clear images for ice navigation, marine weather forecasting, disaster assessment, agricultural-planting, forest depletion monitoring and arctic surveillance. Images of particular areas will be available within hours of the satellite’s orbit overhead.

Like other remote-sensing satellites, Radarsat’s polar orbit will allow it to scan all parts of the earth’s surface, thus establishing Canada as a major provider of global earth-observation data. It is expected to operate for five years.

Despite the attention given to those striking eye-in-the-sky views, and their value in updating maps, it is a new generation of earthbound instruments that is leading Canadian cartographers into the information age.

Some very fancy computer hardware has been designed, and software programs written, to let map makers enter, store and process the trillions of bits of information, cartographic and otherwise, available today. The new criterion for cartographers is an ability to work with a geographic information system.

A GIS uses geographic position as a common thread. It is loaded with topographic information — rivers, lakes, roads, contours and place names — scanned from existing sheets and updated from new surveys. Maps, surveys, air photos, satellite images, municipal plans, architectural blueprints, forest inventories, even socio-economic statistics can be scanned, entered, plotted and stored as digital electronic messages on magnetic tapes or computer disks.

All this can be updated, revised and manipulated in infinite ways on a computer’s video terminal (usually with an electronic “mouse”) to create a virtually custom-made map every time. With a GIS, the traditional distinction between map producer and map user begins to fade.

For example, a map of an urban neighbourhood can be brought up on the screen. By zooming in or out, certain details — streets, property lines, vegetation, buildings, sidewalks, street lamps, bus stops, traffic lights, sewers, power and telephone lines — can be displayed. From a database containing census information, the number of occupants per house can be shown; from land registry records, ownership and property values can be listed. Almost any information about a specific place can be superimposed on the map. Its use, of course, depends on the user.
A paper copy may be made by a laser printer if time is short, or if top-quality linework is called for, a computer-directed drafting table may be used. Today’s mechanical leakers and scribes can draw, arguably, more accurately than a draftsman. No craft, it seems, is immune to the advances of technology.

From the start, Canadians have been pioneers of digital mapping and geographic information systems. Prof. Raymond Boyle of the University of Saskatchewan obtained the first patent for a cartographic digitizer in 1961. To computerize the Canada Land Inventory, the Canada Geographic Information System was set up by Environment Canada in 1990. It is now the world’s largest database of information on agricultural, forestal and recreational land use and wildlife habitat.

Large-volume mappers — Energy, Mines and Resources Canada, the Canadian Hydrographic Service and the provincial topographic map departments — first used computers to automate map production in the mid-1970s. Provincial, municipal, educational and private mappers were quick to add an array of computers to their cartographic arsenals.

Canada’s largest mapping agency, the Surveys, Mapping and Remote Sensing Sector of EMR, is building a digital topographic database of the whole country at two scales, expected to be completed by the year 2000. An electronic prototype of the fifth edition of the National Atlas of Canada also is well underway.

The Alberta Department of Forestry, Lands and Wildlife uses a GIS called Mascot for land inventory and survey control. Similarly, at the University of Regina, soil degradation in southern Saskatchewan is analysed using a GIS.

Ontario Hydro uses a GIS to direct crews to transformers needing servicing; each is listed in the database. Engineering specifications, right of ways and environmental concerns at any transmission tower can be seen on the computer screen.

In the near future, a GIS will be linked to Toronto’s traffic-control system. By using up-to-the-minute maps, dispatchers will direct the balance of drivers around road construction or rush-hour traffic to emergencies on newly named streets in newly mapped subdivisions.

Hay production for dairy farms will be managed using a GIS developed at the University of British Columbia. Transport companies will be using satellite positioning and GIS together to track and direct their trucks as they speed along the nation’s expressways. Partnerships between governments, industry and research institutions are stimulating the evolution of geomatics, as this new branch of mapping is being called. Once described as a solution looking for a problem, geomatics is limited only by the imagination — and money.

In the last 60 years, the quantity and variety of maps of Canada have increased exponentially. The range can only be fully appreciated by browsing through indices, catalogues, libraries, archives and bookshops anywhere from coast to coast. All offer an ever-growing selection of Canadian cartography, some of it available on computer disks. Indeed, our whole concept of what a map is has changed. Nowadays it is just as likely to be a fleeting image on a video screen as a neglected sheet of paper in the glove compartment.

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