Collaborative Approaches to Building a Canadian Spatial Data Infrastructure

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Summary

Canadian federal and provincial government organisations have long been engaged in building and maintaining extensive collections of digital topographic mapping datasets, road network files and property mapping databases in support of their own respective mandates and obligations. Beginning in the mid-1980s, cooperative spatial data-sharing and cost-sharing arrangements at both the federal and federal-provincial levels were developed in support of accelerating several of these mapping programs.

Since 1996, the Canadian Council on Geomatics (CCOG) and its federal counterpart, the Inter-Agency Committee on Geomatics (IACG), have been instrumental in establishing and developing the Canadian Geospatial Data Infrastructure (CGDI) initiative. 'Partnerships' is one of the five major planks of the CGDI initiative. To this end, considerable emphasis has been placed on developing and promoting examples of collaborative agreements and projects among the federal government, provincial governments and industry to enhance the availability of geospatial data.

This paper will examine the nature and status of selected partnerships and institutional arrangements designed – either directly or indirectly – to help build the Canadian Geospatial Data Infrastructure. After developing a framework within which to classify selected cooperative efforts past and present, the author will identify some key challenges facing federal and provincial efforts aimed at strengthening the vertical integration between selected mapping programs and databases. As well, five important myths will be identified which currently act as either constraints or important technical factors governing the ultimate effectiveness of such vertical integration efforts. The paper concludes with a brief discussion of important new developments or metaphors which may drive subsequent refinements to existing spatial data infrastructure efforts in Canada and beyond.

Institutional arrangements

Particularly over the past forty years, Canada has built a strong collection of institutions to govern (at least implicitly) surveying and mapping activities at the federal and provincial levels. Each of these organisations has evolved over time in the face of changing political and socio-economic conditions in their respective environments. At the same time, the federal and national coordinating committees have been faced with similar changes in composition and challenges to their continued relevance, and have each time been forced to respond in a flexible yet (hopefully) effective manner. This section outlines the major bodies that define the institutional framework for longer term Canadian geomatics programs in place at this time.

Inter-Agency Committee on Geomatics (IACG)

The Inter-Agency Committee on Geomatics (IACG) was founded in 1988 by what is now known as Geomatics Canada. The Committee was established to encourage coordination of federal geomatics activities through:

- shared development and exchange of geomatics data;
- documentation and dissemination of information about geomatics activities by federal agencies;
- cooperation in data collection, development of databases and dissemination of geographically referenced information; and
- consultation on research and educational programs.

The IACG currently comprises 17 government agencies, with Committee activities grouped into three different levels. At the top level, the IACG Steering Committee is composed of Assistant Deputy Ministers of IACG member agencies. This Committee meets once a year, in the Spring, to approve the IACG's work plan and budget. Funding for IACG activities is agreed to on a shared basis for each government fiscal year, and these shared funds are then transferred to and administered by Geomatics Canada (FGB 1989).

The second level of the IACG has representatives from participating federal agencies and meets several times a year to share information, prepare project proposals and make recommendations to the Steering Committee. Detailed work of the IACG is undertaken at the third level by technical subcommittees or working groups. In 1996, the IACG decided to focus its efforts exclusively on CGDI-related issues, as these were seen as overarching, and so the group reorganised under the 5 thrusts of the CGDI.

A recent summary of activities of IACG members is contained in Evangelatos et al. (1998). More recent information may be found through links from the GeoExpress Web page found at http://nrcan.gc.ca/geoexpress/geofed-e.htm.

Canadian Council on Geomatics (CCOG)

In 1971, the Canadian Council on Surveys and Mapping (CCSM) was established to provide a forum for formal discussions and mutual support among the directors of the surveying and mapping programs across Canada. Renamed the Canadian Council on Geomatics in 1996, its thirty-four members include representatives from key federal agencies, as well as from topographic mapping programs in every provincial and territorial government. General policies promoting collaboration between federal and provincial geomatics organisations are coordinated through the CCOG.

An excellent comparative summary of the respective characteristics, accomplishments and contact information for the provincial government members of CCOG may be found in MacNaughton, 1998. Links to the Web Pages of most provincial government CCOG members may be found at http://nrcan.gc.ca/geoexpress/geoprv-e.htm.

A separate organisation – the Geomatics Industry Association of Canada – is a lead organisation in coordinating activities within the private sector.

Examples of collaborative approaches to spatial data collection and maintenance

Geomatics Canada and related provincial organisations hold sometimes overlapping responsibilities for maintenance of the survey control framework and systematic topographic base mapping.

In the case of control surveys, the Geodetic Survey Division of Geomatics Canada has held responsibility for the zero- and 1st-order networks while provinces and municipalities have maintained 2nd-and, where applicable, 3rd-order control networks. Especially with the advent of GPS and active control systems, the distinction between such responsibilities has become blurred.

To reduce the amount of ambiguity and confusion present, Geomatics Canada has developed shared funding and/or cooperative production arrangements with some provinces (for example, the four Atlantic Provinces) for the establishment and maintenance of new GPS control points designed to strengthen both federal and provincial control frameworks. However, since provincial policies and levels of industrial participation in such activities varies from province to province, no consistent arrangements for establishing new control points, maintaining existing ones or implementing active control systems are in place across the country.

In the case of mapping – and especially in terms of medium-scale digital mapping (that is, produced to a horizontal resolution of 1 metre and a positional accuracy of ±5-10 metres) – there is now perceived in some quarters to be a considerable degree of overlap between specific federal and provincial programs.

Since the respective hardcopy products were different and served different users, this overlap in effort was often ignored. However, with the institutional conversions to digital map production through the 1980s, the similarities between the underlying source photography, accuracy tolerances and production specifications became increasingly apparent. In an effort to coordinate efforts – or at least streamline cooperation towards the common goal of full and up-to-date coverage – a variety of different strategic arrangements were developed and implemented through the 1980s and 90s. For example:

- In some provinces (for example, Newfoundland and Saskatchewan), federal-provincial agreements have been put in place to cost-share the production and sharing of a single medium-scale digital basemap series (MacNaughton 1998).
- Other provinces have undertaken more involved co-production projects, where data collected for a provincial program is translated and generalised as required, and then incorporated into the National Topographic Series dataset covering the same area. An early example of such cooperation in Atlantic Canada was documented in Pearson and Gareau (1986).
- Through until the early 1990s, the Federal Geographic Information and Technology Development Program (or GITDP) provided federal funds which were, in turn, leveraged to encourage cooperative production and data exchange between the federal government and provincial counterparts across the country. The program funded the cooperative scanning of hardcopy maps for both provincial and federal use in a number of provinces, the purchase of provincial digital files for federal use and, in particular, the acceleration of medium-scale map production in regions south of the 50˚ North parallel (Jolicoeur 1999).

- More recently, Geographic Data BC in British Columbia reached agreement with Geomatics Canada on a multi-year program aimed at delivery of updated road network and selected attribute information. Produced originally for the provincial resource mapping program, the road centreline information is being updated through additional mobile GPS work as part of a larger, multi-partner initiative for provincial emergency response planning. The same information will be used by Geomatics Canada to update their road information in the National Topographic Data Base (NTDB). Similar on-going agreements concerning federal use of provincially-prepared road network datasets are either in place or under discussion in Alberta, Saskatchewan, New Brunswick, Nova Scotia and Newfoundland.
- On both the Pacific and the Atlantic coasts, digital mapping of coastlines has been undertaken by Geomatics Canada, provincial mapping organisations and the Canadian Hydrographic Service (the federal agency responsible for nautical chart production). Not surprisingly, considerable duplication of effort has been incurred in producing and maintaining these three sets of coastline data, and some degree of data sharing is now taking place between federal and provincial topographic mapping programs as indicated above. However, fundamental differences in:
  (a) the respective requirements of key users;
  (b) program mandates; and
  (c) liability constraints associated with each of these datasets,
  have made it difficult to agree on a single, common representation of shoreline on the two products, much less any on-going cooperative production effort.

Such multi-level data sharing initiatives are not restricted to the topographic mapping community. In an effort to collect and update address-matched street network information for the Census purposes, Statistics Canada has long employed a collection of 'one-off' data purchase or sharing agreements with a variety of government departments (at all levels), private companies and community organisations across the country**.** In partnership with Elections Canada and Canada Post Corporation, Statistics Canada is now taking a leading role in development of a National Street Network, which will be a seamless collection of the nation's roads, including all road names and address ranges. Using updated road centreline information available through Geomatics Canada, its own sources and its existing network of contacts, Statistics Canada will be providing customers across Canada with a more up-to-date and reliable version of its own road network than previously available.

The Canadian Geospatial Data Infrastructure (CGDI) Initiative

The Canadian Geospatial Data Infrastructure is an initiative by the IACG and CCOG to assemble the many governmental and commercial interests related to the production, application and dissemination of geospatial information (Loukes et al, 1996). The CGDI vision is '... to enable timely access to geospatial data holdings and services in support of policy, decision making and economic development through a co-operative interconnected infrastructure of government, private sector and academia participants'. The basic 'Principles for Data Partnership' implicit in CGDI include the following from Labonte et al. (1998):

- Data should be collected once, closest to the source and in the most efficient way possible, with a view towards increasing the vertical integration of the data.
- Geospatial data should be as seamless as possible, with coordination across jurisdictions and boundaries when possible.
- Data should be collected, processed and maintained according to international standards to maintain data integrity across databases, and to enable the addition of value, further enhancement, and easy access and use.

- Upon agreement, partners should contribute equitably to the costs of collecting and managing the data, and should be allowed to integrate the resulting information into their own databases, for their own use and for further distribution to their stakeholders.
- There should be an attempt to harmonise terms and conditions for use where practical. In the absence of such agreement, each agency should be free to establish its own terms and conditions for such information.
- Agreements between agencies will normally be negotiated on a case-by-case bilateral or multilateral basis, according to these principles of partnership.
- Partnerships between agencies should be simple and support the principles of the CGDI, open to the participation of interested stakeholders within any level of government, the education communities or the private sector.
- A group or agency within each province and within the federal government should be designated to promote and co-ordinate the development of a common geospatial data infrastructure, both within its jurisdiction and between jurisdictions.
- CGDI is national in scope, and must meet the needs of a wide range of geospatial user communities, data producers, and different areas of the private sector.
- CGDI must consist of a set of coordinated and interrelated policies, practices and possibilities that build on the vision.

As will be discussed in Shaw (1999), the five key thrusts of CGDI include:

1 **easy on-line access to government information** which is built on;

2 common national **framework data;**

3 using international **standards;**

4 collected through **partnerships** between federal and provincial organisations, and

5 distributed within a **supportive policy environment**.

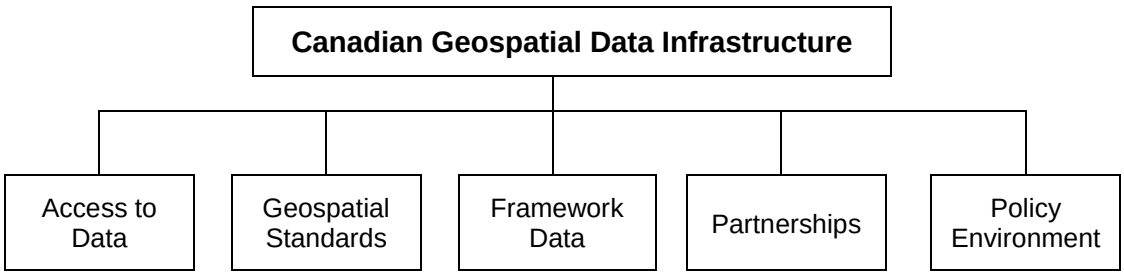

Figure 1: Five thrusts of CGDI

CGDI Working Groups have been formed to tackle specific challenges associated with each of these areas, and follow-on national workshops have taken place in all five of these thrusts since January 1998. A complete discussion of the CGDI initiative may be found in Labonte et al. (1998), with a more recent progress report presented at the 1999 Cambridge Conference contained in Shaw (1999).

Discussion

Stresses in building horizontal and vertical linkages

One of the objectives of CGDI is that it be a truly **national**, as opposed to a **federal**, data infrastructure. All participants desire a **horizontal** infrastructure that permits the rapid usage and/or exchange of geospatial information between federal government departments. However, several of the core values mentioned in the previous section also imply the parallel implementation of a **vertical** infrastructure that is continually maintained and refreshed through a program of periodic or, eventually, transactional updates from provincial government organisations.

At first glance, one may believe that creating this should be easier in Canada than, say, the USA since there are so many fewer institutional players involved in base mapping in Canada. While larger-scale municipal mapping programs do fall under the jurisdiction of local, metropolitan or regional government organisations across the country, responsibility for comprehensive medium-scale topographic mapping programs rests with only the ten provincial government mapping organisations. By comparison, there are literally thousands of state, county and local government involved in surveying and mapping activities in the United States.

However, perhaps because of the strong institutional structures in place, the diversified collection of interests across a large country, and conflicting political and economic priorities in different provinces, reaching any kind of binding, nation-wide consensus among all the partners involved has been difficult to achieve. At least seven different types of constraints have slowed negotiations in this regard:

1 conflicting map coverage priorities;

2 conflicting user requirements and/or technical specifications governing map content, feature classification and representation, proprietary data formats, and so on;

3 respective production schedules and government program funding cycles out-of-phase with one another, making it difficult to cost-share very expensive, multi-year projects;

4 data pricing and licensing policies which inhibit:
(a) economical sharing;
(b) regular updating of datasets or, more likely, specific themes within datasets (for example, road centrelines); or
(c) extensive third-party usage of the datasets;

5 government cost-recovery and revenue distribution policies which cause federal and provincial data suppliers to view portions of each other's information product line as 'competing offerings' in the same marketplace;

6 existing arrangements with other government or industry partners which may inhibit or preclude other cooperative efforts between federal or provincial counterparts in a specific jurisdiction; and

7 differences in heretofore unrelated political/economic policies or initiatives which have repercussions in a variety of other bilateral agreements (including geospatial data production and distribution).

As a result of such constraints, concrete examples of partnerships, supportive policies and cooperative efforts at framework data collection and maintenance have been limited to date by a series of 'one-of' projects and specific agreements with individual provinces.

Common definitions for shared terminology

Through the CGDI workshops conducted through 1998, it became clear that the lack of understanding and agreement on common terminology was a barrier to reaching a consensus on a national approach. Terms like ‘framework data’, ‘core data’, ‘foundation data’ and ‘base data’ were being used almost (but not quite) interchangeably, as were ‘data framework’ and ‘data architecture’.

In an effort to reduce the confusion, the following definitions of key CGDI terminology were developed and agreed upon at a workshop on framework data held 9 February 1999 in Ottawa (Evangelatos 1999). These included:

- **Framework data***:* A collection of geospatial data layers that are subject specific and support applications and value-added products using a common geospatial referencing system.
- **Core data***:* A subset of framework data needed by most users, accessible by all, and maintained as the common geospatial referencing system.
- **Framework architecture***:* The models, standards, technologies, specifications, and procedures used to represent, transform and generally accommodate the integration, maintenance and use of framework data.

While there is still confusion over the breadth and implications of these terms in practice – one must expect the acceptance and understanding of terminology to take time – these definitions will provide the basis for development of a prototype framework architecture to serve temporarily as a basis for future discussions between federal and provincial stakeholders (Saylam, Nichols and Coleman, 1999).

Five 'myths' influencing attitudes towards vertical integration in CGDI

Presentations by – and discussions with – participants at the same CGDI framework data workshop revealed a series of 'myths' concerning the creation, maintenance and usage of geospatial data at both federal and provincial levels. Five such 'myths' include, in no particular order:

- **Federal government agencies make and use generalised smaller-scale datasets, while provincial organisations produce and use more detailed medium- to large-scale datasets**.

  Government users at both levels need 'overview'-scale datasets. More significantly, organisations like Statistics Canada, Canada Post and Elections Canada need road and street network data down to the individual address level – the same resolution required by many provincial government users.

- **Federal government users have no requirement for parcel-based information.**

  Based on a review of provincial government customer lists across the country, such information is used national police (that is, the RCMP) and security forces, as well as organisations interested in the higher-resolution demographic data offered by parcel-based products.

- **Framework datasets are consistent across a jurisdiction**.

  Many occasional users and most non-technical managers in one organisation may view the digital data holdings of another organisation as being monolithic in nature. Nothing could be further than the truth.
  Depending on the size of the jurisdiction involved, it may have taken (or **be taking**) five to ten years or longer to complete even the initial round of digital map coverage. Prevailing technologies and paradigms governing both hardware and software evolved, user requirements and expectations (particularly with respect to topological structuring of selected features) were continuously clarified and modified, and product limitations were reported and addressed through upgraded specifications. In very few cases have the financial and production resources been available to upgrade the content, structure and format of all digital map files in a given dataset to a single common specification.
  As a result – at least in the medium-term – the wholesale exchange and integration of datasets from different sources may be fraught with a large number of relatively minor problems. In effect, a variety of slightly-differing sets of transformations may be required when exchanging digital data between series on a jurisdiction-wide basis.

- **Updates to a given dataset come the fastest from original collectors or custodians of that dataset, and usually flow up the 'vertical highway' from lower levels of government**.

  Organisations responsible for collection of a dataset often may have neither the mandate, the funding nor the production resources to keep it regularly updated (Palmer 1984). In some jurisdictions, mapping organisations already rely on selected end-users to provide regular updates to a given theme or themes. Particularly since the advent of low-cost GPS receivers, the collection of even large amounts of medium-accuracy, geo-referenced digital point- and centreline data can be carried out quickly and inexpensively by personnel from any organisation.

- **Users (those dealing with thematic overlays to the base data) will gladly employ the most accurate and up-to-date base mapping available. When a better basemap becomes available, users will simply slip the old framework data out and slide the new data in**.

  This view simply does not hold up under examination. Yet, users often must relate their thematic information to specific features or themes in the framework datasets. Forest polygons surround a lake, land use polygons may be broken at a major roadway, and even parcel boundaries of waterfront properties are partially defined by shorelines. Many applications or GIS implementations now exist in which boundaries or edges of features in one theme either share or help define boundaries of features in another theme. In a broad sense, users may become as tied to the framework datasets as originally represented in their system as they are to the capabilities and architecture of the software itself.
  At least in light of the current state of the art with respect to GIS support for advanced data transformation and conflation, the high near-term costs involved in upgrading to a new base – however much improved – may simply outweigh the incremental (and longer-term) benefits to be gained. This becomes increasingly true as the investment in collection and maintenance of the thematic data increases over the life of a project or program.

While these claims may be justified in certain cases where invoked, they cannot be considered 'universal truths'. When generalised and introduced into project budgeting and negotiation postures, they promote and sustain some distracting misconceptions and may lead to some incorrect (and potentially expensive) decisions. If need be, these myths need to be 'debunked' over and over again in order to develop a truly constructive and workable model of both a horizontally- and vertically-integrated CGDI.

New metaphors for geospatial data infrastructure

There is a growing realisation that one of the driving metaphors of geospatial data infrastructure efforts in other countries – that of the 'On-line Map Library' (or 'Data Download Store', as the case may be) – may be unnecessarily limiting as technology changes. This is evident in two respects.

First, the use of geospatial data is changing as people move 'on-line'. (See figure 2.) Prior to widespread use of the Internet, most map users would order digital map files by mail, fax or telephone, receive the data, and then use it on their own computer (Type I behaviour as shown in figure 2.) With the introduction of Web-based interfaces to on-line data stores, map users have simply automated this 'get it and bring it home' practice (Type II behaviour).

The increasing popularity and growing routine usage of sites utilising more transactional approaches – geared to everything from real property information services (Arseneau et al., 1997) to trip route planning (Mapquest 1999) –indicate a fundamental shift (or at least extension) in usage patterns towards a 'use it, then lose it' mentality. In such a scenario – classified in figure 2 as Type III behaviour – customised views of a given map/image file and associated attribute information are either accessed or created transactionally. Each view becomes a disposable commodity, employed for a given purposes and then deleted. Since such transaction-based applications may be financed in a variety of different ways and, to some degree, make a clear distinction between access services and the product itself, it will be interesting to see if current arguments over data pricing policies remain intact or become moot over the next 5-10 years.

Data Usage	Data Access	
	Off-Line	**On-Line**
Off-Line	**Type I Behaviour** Data ordering by mail, fax or telephone, followed by usage on customer's internal computer system(s). **Examples:** • Traditional 'Map Order-Desk' operations	**Type II Behaviour** 'Web-ifying' Type I behaviour, where data files are accessed on-line, downloaded to user's computer, and then used there. **Examples:** • GeoGratis (http://geogratis.cgdi.gc.ca/) • LandData BC (http://www.landdata.gov.bc.ca/) • U.S. Geological Survey (http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html) • GIS Data Depot (http://www.gisdatadepot. com) • Microsoft Terraserver (http://www.terraserver.com)
On-Line		**Type III Behaviour** Transaction-based approaches to discovery, access and on-line usage of geospatial data and related attribute information. **Examples:** • New Brunswick and Nova Scotia Real Property Information Servers (http://www.gov.nb.ca/snb/english/newen.htm) and (http://www3.nsgc.gov.ns.ca/) • Mapquest and Tripquest Services (http://www.mapquest.com)

Figure 2: Changes in patterns of spatial data usage

Second, we are just beginning to see the convergence of:
(1) the ubiquitous positioning capabilities of GPS; with
(2) widely available and increasingly intelligent spatial datasets (particularly address-matched street networks); in combination with
(3) increasingly powerful network computers capable of handling requests for advanced modelling operations from hundreds of users at a time; all conducted through the medium of
(4) high-speed digital wireless communication systems.
Recognition of this impending convergence is already leading to development of new appliances and applications dealing with location, routing and tracking of people and things.

Figure 3 represents an attempt to crudely classify the possibilities emerging as a result of this convergence. It shows that most widespread applications today still employ the technology to enable **people** to know their own location or that of specific objects. Future applications will move beyond this to provide **things** with the same knowledge.

	Know the location of these...	
These...	**People**	**Things**
People	**Examples:** • Use of personal GPS for sporting and recreation purposes.	**Examples:** • Use of GPS for control and cadastral surveying. • Use of GPS for vehicle tracking and fleet management. • Use of GPS in 'anti-theft' applications
Things	**Examples:** • A next-generation cell-phone service that can determine where you are and, through automatic communication with a central server, provide walking or driving instructions to your next destination. • A special monitoring service for sick or special needs people that can sense when they are lost or in danger, and direct appropriate help to the location.	**Examples:** • A spray-control mechanism for crop-dusting or forestry programs that can sense the position of the spray aircraft, compare it with the mapped boundaries of specified spray blocks, and suggest turning the spray controls on and off at the appropriate times. *and many others to come...*

Figure 3: A taxonomy of GPS applications within a geospatial data infrastructure

Both these developments will have a significant impact on the nature and direction of future partnerships between federal and provincial government data suppliers, as well as potential third-party distributors and strategic industrial partners.

Continuing developments

Two important policy initiatives promise to smooth the roads towards more widespread use and cooperative maintenance of government datasets in Canada:

- A Statistics Canada-led CGDI initiative (supported by an external consultant) is now developing a draft policy to provide potential value-added data resellers with a single, consistent set of terms and conditions for data acquisition which could be used as a model by all member agencies. (Evangelatos 1999)
- At a Federal/Provincial Workshop on data sharing/coordination held in Ottawa in February 1999, representatives from a group of provinces tabled a series of draft proposals outlining new federal/provincial institutional arrangements for a new organisation devoted to the implementation and management of the CGDI (Vanstone et al., 1999). As of March, 1999, it is still unclear whether or not these proposals will receive support from all ten provinces. Even if they do, there is little doubt that the final terms will be different than those originally proposed.

Finally, in the Federal Budget announced in mid-February, 1999, the CGDI effort (renamed 'GeoConnections') was awarded tangible support with an injection of $60 million Cdn. in new government funding over a five year period. It is envisioned that these funds will be further leveraged through contributions from provincial and industry sources to support, implement and accelerate specific CGDI-related projects across Canada.

Conclusion

Even though originally a Canadian concept (McLaughlin 1991), conditions in place at the beginning of Canada's CGDI effort were very different than those in place earlier at the beginning of the US NSDI initiative. At first glance, Canadians had far more comprehensive digital base mapping and property mapping coverage already available than their American counterparts. As well, a relatively small number of strong institutions across the country were responsible for production and maintenance of key datasets.

In spite of this – and the best efforts of important supporters and a small but well-qualified support staff at the federal level – progress on CGDI development has been slow and it has been difficult to reach consensus on key components defining CGDI. Perhaps it is some of the same strengths, traditions and policies of the institutions which helped define the Canadian geomatics community that are now contributing to this slow progress.

In this paper, the author has attempted to provide a snapshot of the current challenges, activities and opportunities facing federal and provincial government partners in the cooperative creation of a Canadian Geospatial Data Infrastructure. While much has yet to be done, leaders within the IACG and CCOG leadership **have** used the last two years to initiate the dialogue, build support and develop the core principles of the initiative, The Canadian effort did not begin with the executive-level, 'top-down' support which gave the American NSDI effort valuable credibility across governments. While sometimes frustrating, it is the continuation of this consensus-building dialogue among key stakeholders that will be critical if Canadians are to move beyond practices characterised by the first two metaphors mentioned earlier.

While the current willingness of the provinces and federal government to consider new institutions for CGDI governance is encouraging, it is the opinion of the author that the ultimate future of CGDI should not be tied to agreements requiring national consensus. Cooperative efforts are already taking place, and have been taking place for more than a decade. The degree to which the institutional and technological dimensions of successful individual partnership efforts can be reconciled, merged into a successful solution – and then integrated into routine production and distribution operations in a national context – will determine the real success of the CGDI effort. Stay tuned.

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