NTv2 (National Transformation Version 2)

Government of Ontario IT Standards (GO-ITS)

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Status: Approved

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MANAGEMENT BOARD SECRETARIAT
CORPORATE ARCHITECTURE BRANCH
TECHNICAL STANDARDS SECTION

Last Review Date: June 14, 2005

Foreword

Government of Ontario Information & Technology Standards are the official publications on the standards, guidelines, technical reports and preferred practices adopted by the Information Technology Standards Council under delegated authority of the Management Board of Cabinet. These publications support the Management Board Secretariat's responsibilities for coordinating standardization of Information and Technology in the Government of Ontario. Publications that set new or revised standards provide policy guidance and administrative information for their implementation. In particular, they describe where the application of a standard is mandatory and specify any qualifications governing its implementation.

Table Of Contents

Introduction

Applicability

Government of Ontario IT Standards and Enterprise Product Standards apply (are mandatory) for use by all ministries/clusters and to all former Schedule I and IV provincial government agencies under their present classification (Advisory, Regulatory, Adjudicative, Operational Service, Operational Enterprise, Trust or Crown Foundation) according to the current agency classification system. Additionally, this applies to any other new or existing agencies designated by Management Board of Cabinet as being subject to such publications.

Kindly refer to http://intra.pmed.mbs.gov.on.ca/mbc/pdf/Agency_Establishment&Accountability-Dir.pdf for a list of provincial government agencies with their classification under the current classification system, as well as their previous Schedule under the former Schedule system.

Requirement Levels

GO-ITS documents may combine **mandatory** and **non-mandatory** information as necessary to effectively describe the requirements of a standard.

It is important to indicate clearly when a requirement is mandatory.

Where indicated throughout this standard, the terms 'must' and 'should' will be interpreted as follows:

Must; is mandatory (new standards are not retroactive, but new standards must be complied with at the next procurement/project opportunity)

Should; is best practice, already vetted, advantage to use, expedites approval process

Purpose of the Standard

This standard describes the National Transformation version 2 (NTv2) methodology to be used to transform geospatial information between the North America Datum 1927 (NAD27) and the North America Datum 1983 (NAD83). It is not specific to a single ministry or agency.

Adopting the NTv2 as a provincial GO-ITS standard will:

a) provide a provincial standard for the transformation of geospatial information between NAD27 and NAD83,
b) enhance awareness that geospatial information is referenced to a horizontal geodetic datum,
c) enhance awareness that geospatial information is not directly compatible unless the data is consistently referenced to one horizontal geodetic datum, and
d) help ensure the integrity of geospatial information while promoting the sharing and exchange of data across ministries, agencies, and between the public and private sectors.

Recommended Versioning and/or Change Management

The impact on organizational arrangements, staff, customers and service delivery can be summarized as follows: OPS staff, clients and users need to be aware that geospatial information is referenced to a datum. If transformation between NAD27 and NAD83 is required the NTv2 methodology must be applied to accomplish this task.

Staff will be informed and involved by providing feedback to their managers who will in turn forward this feedback to the GSWG through the Chair.

Staff will continue their daily use of GIS software to transform coordinates.

Staff will be trained by reviewing the documentation regarding the NTv2 that is available on provincial (including the NRVIS site and in the future the GI [Geographic Information] Portal) and federal web-sites. Presentations will be provided to groups as required.

To ensure the project is implemented in a cooperative way, with the least disruption possible, the standard ITIL change management process for the LRC will be applied.

ITIL Change management process will also be applied to manage ongoing change related to the project.

Contact Information

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Type of Standard

Select the appropriate category for this standard.

Check One	Type of Standard
	Implementation or Process Standards – requirements or specifications, which may include best practices and guidance, for the implementation of a technology or the performance of an activity related to the use of technology, applicable throughout the provincial government. (e.g. mandatory O/S configuration requirements, security procedures, change management procedures, web page design requirements etc.).
√	Information Standard – specifications for a data format (e.g. XML schema, metadata, and/or related data models)
	Technical Standard - networking and communications specifications, protocols, interfaces (API's) (e.g. standards adopted from recognized standards development organizations such as W3C, OASIS or IETF such as TCP/IP, XML, SOAP, etc.)
	Architecture Standard – application patterns, architecture and standards principles governing the design and technology decisions for the development of major enterprise applications
	Product Standard – an enterprise-wide product which is mandatory for use such as a single corporate-wide application, which all ministries and agencies use to record and access their HR information.

Publication

Please indicate if this standard should be restricted to publishing on the Internal (Intranet) IT Standards web site or whether it is intended for publishing on the public (Internet) Government of Ontario IT Standards web site.

Check One	Publish as Internal or External
	Internal Standard
√	External Standard

Acknowledgements

Provide a list of individuals and stakeholder groups that contributed to the development of this standard, including those who helped write the standard and provided subject expertise as well as those groups or individuals contacted for input/comments. (see next table for list of governance bodies and other groups that had input)

Development Team

Name	Cluster/Ministry	Branch
J. Morgan Goadsby	LRC/MNR	Information Resource Management Branch
Anne Trudell	LRC/MNR	Science Information Branch
Dr. Carey Gibson	LRC/MNR	Information Resource Management Branch
Melanie Blamire	LRC/MNR	Information Resource Management Branch
Shawn Kelleher	LRC/MNR	Information Resource Management Branch
Ron Berg	Transportation/MTO	Engineering Standards Branch
Peter Hanmore	LRC/MNR	Information Resource Management Branch
Colleen Melanson	LRC/MNR	Information Resource Management Branch
Dr. Laura Kingston	Transportation/MTO	Engineering Standards Branch
Dennis Gertridge	LRC/MNR	Information Resource Management Branch
(All members of the	LRC/OPS	Geomatics Standards Working Group (GSWG))

Reviewers: in addition to the development team members listed above, please list others contacted for input/comments in the table below:

Check	Area	Date: (month/year)
☐	Technical Standards Unit, Corporate Architecture Branch, OCCTO	May 2005
	Corporate Architecture Branch (CAB Architects), OCCTO	
	Infrastructure Development Branch & iSERV, OCCSD	
	Corporate Security Branch, OCCS	
	Strategy, Policy, Planning and Management Branch (SPPM, OCCS)	
☐	Corporate ACT and Domain Working Groups	July 2004
	− Information Architecture Domain (IADWG)	
	− Technology Architecture Domain (TADWG)	
	− Application Architecture Domain (AADWG)	
	− Security Architecture Working Group (SAWG)	
☐	Cluster ACT/ARB (for cluster standards promoted to corporate standards)	April 2004
	ITSC members (*provide name*)	
☐	Interministerial Committee on Land Information (ICLI) Working Group	June 2003
☐	Information Resources Management Branch – Branch Leadership Team	May 2003
☐	Interministerial Committee on Land Information (ICLI) Working Group Member Ministeries (8 Ministries) – Education, Health, North Development and Mines, Agriculture and Food, Environment, Municipal Affairs and Housing, Justice (OPP), Transportation, and Natural Resources	January – Feb, 2004
☐	Ontario Road Network (ORN) Stakeholders List (50 Members)	January – Feb., 2004
☐	Ontario Geospatial Data Exchange (OGDE) Members – Technical Reps. (110 Members)	January – Feb., 2004

Impacts to Standards

List any existing GO-ITS that may be impacted or associated with this standard.

GO-ITS #	Describe Impact	Recommended Action (or page number where details can be found)
GO-ITS 29	ORN already uses NAD83 as the standard geo-referencing system and would not need to transform geo-spatial information from NAD27 to NAD83.	None
GO-ITS 45.1 NAD83	NAD83 is the standard datum for Ontario. The NTv2 Standard prescribes the methodology to transform coordinate/geo-spatial information from NAD27 (the old datum) to NAD83 (the new standard datum/reference system).	None- Complimentary to
GO-ITS 45.3 Ontario Specification for GPS Control Surveys	The Ontario Specification for GPS Control Surveys sets the standards for the use of high-precision GPS to build onto the control survey reference framework in the NAD83 reference system.	None – Complimentary to
GO-ITS 72	Geo-spatial Metadata Standard has field for (geodetic) datum. NTv2 allows for transformation of geo-spatial information from NAD27 to NAD83.	None
GO-ITS 24	Omnibus Standard lists GO-ITS used by industry in Ontario. NTv2 is already the de facto standard used by the geomatics industry.	Add GO-ITS 45.2 NTv2 to list of GO-ITS used by Ontario Industry.

Impacts to Existing Environment

List any significant impacts this standard may have on the existing I&IT environment.

Application(s) or Infrastructure Impacted	Describe Impact	Recommended Action (or page number where details can be found)
GIS Systems	The NTv2 Standard methodology is already built into most major GIS vendor systems.	Ensure GIS users are aware that the NTv2 Standard is built into GIS systems and is the only methodology to be used when transformation from NAD27 to NAD83 is required.

NTv2 (National Transformation Version 2)

Abstract

This standard describes the National Transformation version 2 (NTv2) methodology to be used to transform geospatial information between the North America Datum 1927 (NAD27) and the North America Datum 1983 (NAD83). It is not specific to a single ministry or agency.

Category

This is a mandatory standard.

Only this standard shall be used when transforming geospatial information between the NAD27 datum and the NAD83 datum. Geospatial information includes point coordinate information, digital mapping information and GIS information. It is not the purpose of this standard to require transformation of geospatial information, but to provide the methodology when transformation between datums is required.

Related Documents

National Transformation version 2 (NTv2) User's Guide

This user's guide covers the operation of the NTv2 software, and the formats for input and output of coordinate data.

Qualifications

This standard does not require organizations to transform geospatial information, but stipulates that when geospatial data sets are converted between NAD27 and NAD83, the NTv2 methodology is used to achieve this conversion. Any organization which is implementing this standard must do so in accordance with the technical specifications and documents listed in the NTv2 Business Case (Appendix "A"), the NTv2 Developer's Guide (Appendix "B"), and the NTv2 User's Guide (Appendix "C"). The stand-alone NTv2 software package and approved software implementations incorporated in GIS software suites satisfy these requirements.

Implementation

The effective date of this standard is 2005/06/14.

Compliance with this standard will be achieved by procuring GIS software that implements the NTv2 or by obtaining the NTv2 software from Provincial Georeferencing, Geographic Information Ontario, MNR.

Where to obtain copies

Copies of related documents may be obtained as follows:

NTv2 Package and grid shift files (Stand-alone for conversion of coordinate data sets only)

Provincial Georeferencing, GIO, MNR
300 Water Street
Peterborough, ON K9J 8M5
Email: morgan.goadsby@mnr.gov.on.ca

Geodetic Survey Division
Natural Resources Canada
615 Booth Street
Ottawa, ON K1A OE9
Website: www.geod.nrcan.gc.ca

GOITS
Management Board Secretariat
Information and Technology Standards Unit
77 Wellesley Street West, 8th. Floor
Toronto, Ontario, Canada M7A 1N3

Email:

Telephone: (416) 327-2085

Errata

Created: April 08, 2005

Updated: Month Day, Year

- Approved by IT Standards Council May 18, 2005

- Approved by Corporate Architecture Review Board June 14, 2005

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Appendix A: NTv2 Business Case

National Transformation Version 2.0
BUSINESS CASE

for GO-ITS Publication

Land and Resources Cluster
Geomatics Standards Working Group

March 02, 2004
Version 1.7

A Business Case
for
National Transformation Version 2.0 (NTv2)

Version Number 1.7

Date: 2004/March/02

1.0 Executive Overview

1.1 Project Description

Standard Proponent/Standard Manager/Owner
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Standard Sponsor
Name: Brian Maloney
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Standard

The conversion of geospatial information between North American Datum 1927
(NAD27) and North American Datum 1983 (NAD83) shall be accomplished using the
NTv2 methodology.

For this standard, geospatial information includes point coordinate information, digital
mapping information and GIS information.

Justification Statement

The NTv2 is the Canadian National Standard for converting geospatial information
between NAD27 and NAD83. It was developed by the Geodetic Survey Division of
Natural Resources Canada in partnership with the provincial geodetic agencies of all
provinces.

Making the NTv2 a formal Government of Ontario Information & Technology Standards (GO-ITS) standard for Ontario will ensure that extremely valuable GIS and related geospatial data holdings are not damaged or polluted by inappropriate means of transformation between datums.   A provincial standard will ensure everyone uses the same methods to transform data and ensure future compatibility, accuracy, and ease in data sharing.

Value Proposition

Use of the NTv2 will ensure end users achieve the transformation of geospatial information using only one methodology (or tool set) which will result in transformations of known accuracy, with repeatable and consistent results that are compatible across jurisdictional boundaries.

The adoption of NTv2 as the standard for the conversion of geospatial data sets will permit internal and external clients to acknowledge, comprehend and understand the methodology employed by the LRC and OPS to transform between NAD27 and NAD83.

The NTv2 standard will promote geomatics standards at the provincial level while responding to and cooperating with the Canadian government's decision to create and adopt the NTv2.

Stakeholders – Primary

OPS
Ministry of Transportation (MTO)
Ministry of Environment (ENE)
Ministry of Natural Resources (MNR)
Ministry of Northern Development and Mines (NDM)
Ministry of Municipal Affairs and Housing (MAH)
Ministry of Health and Long-Term Care (MOH)
Ministry of Tourism and Recreation (MTR)
Ministry of Consumer and Business Services (CBS)
Ministry of Education (EDU)
Ministry of Training, Colleges and Universities (TCU)
Ministry of Attorney General (MAG) - Ontario Provincial Police (OPP)
Ministry of Agriculture and Food (OMAF)
Conservation Authorities

Federal

Natural Resources Canada (NRCan)	Department of National Defense (DND)
Transport Canada	Department of Fisheries and Oceans (DFO)
NAV Canada	Statistics Canada
Elections Canada	Environment Canada
Parks Canada	

Stakeholders – Secondary

GIS Software vendors
Geomatics Information Association Canada (GIAC)
Mapping / Surveying / Engineering firms
Forest Industry - Sustainable Forestry License (SFL) holders
                      - Forestry Information Manual (FIM)
Precision Farming
Mining Industry
Utilities   - Hydro
                      - Gas
                      - Phone
                      - Cellular
Municipalities

1.2 Standard Purpose and Objectives

Adopting the NTv2 as a provincial GO-ITS standard will:

a) provide a provincial standard for the transformation of geospatial information
    between NAD27 and NAD83;
b) enhance awareness that geospatial information is referenced to a horizontal geodetic
    datum;
c) enhance awareness that geospatial information is not directly compatible unless the
    data is consistently referenced to one horizontal geodetic datum; and
d) help ensure the integrity of geospatial information while promoting the sharing and
    exchange of data across ministries, agencies, and between the public and private
    sectors.

1.3 Standard Management Information
1.3.1 Project Management Overview

The NTv2 is now readily available without cost. It is available from Provincial
Georeferencing, MNR and is available for download from the NRVIS (Natural Resources
and Values Information System) web-site. It is also available from Geodetic Survey
Division of NRCan and through their web-site at www.geod.nrcan.gc.ca. It is
incorporated in major GIS vendor packages.

The NTv2 is the de facto standard for the transformation of geospatial information in
Ontario. The NTv2's performance, accuracy and suitability have been proven and
documented.

Provincial Georeferencing, MNR worked with the Provincial Geomatics Service Centre (PGSC) to transform Natural Resource and Values Information System (NRVIS) geospatial information between NAD27 and NAD83 in Ontario. The successful results are documented in the *NAD83 Conversion of NRVIS – Revised Draft Report - September 1999*. The senior management team of the LRC has now recommended that NTv2 be a proposed GO-ITS.

1.3.2 Project Budget/Resources Overview

The NTv2 as a stand-alone package is free of charge as per the licensing agreement between Natural Resources Canada (NRCan) and the OPS. The NTv2 is also available in vendor software packages at no additional cost.

It is estimated that the currently anticipated and future enhancements to the NTv2 can be accomplished with a project budget of $25,000 and current staffing levels within Provincial Georeferencing, MNR and Geodetic Survey Division of NRCan.

2.0 The Case for the Standard

2.1 Current Situation

The NTv2 is a standard methodology currently used in the OPS to transform geospatial information between the North America Datum 1927 (NAD27) and the North America Datum 1983 (NAD83).

2.2 Rationale for Standard

Developed as a joint federal/provincial initiative, the NTv2 is the most consistent method of transforming coordinates throughout the province between the NAD27 and NAD83 datums because it is based on over 40,000 control stations in Ontario and over 120,000 nationally.

Prior to the implementation of NAD83, NAD27 was the standard datum for referencing geospatial information for North America. Once NAD83 was developed and implemented, a standard methodology (or tool set) was required to transform between these datums.

The improvements within the NTv2 and its related implementations over its predecessor, the NTv1, provide the foundation for adoption of the NTv2 as a provincial standard. The improvements are:

a) addressing conversion functionality between NAD27-MAY76 Readjustment and NAD83 that was not incorporated in the NTv1;

b) allowing variable grid densities in the grid shift file to allow better accuracy in areas where denser grid networks are available;

c) ensuring accuracy statements for each transformed point provide realistic estimates for error budgeting; and

d) utilizing the algorithm for modeling the shifts in the intervals between control survey network points which have been improved beyond the capabilities of NTv1.

The NTv2 is a Canadian Federal Government Standard that is integrated into the majority of major Geographic Information System (GIS) vendors software to convert geospatial information between NAD27 and NAD83.

2.3 Relationship to Government Policy

The MNR is the lead agency in creating, developing, promoting and maintaining geomatics standards on behalf of the OPS. The NTv2 transformation standard will be closely linked to further standards such as NAD83.

This GO-ITS is for the National Transformation version 2 (NTv2) to promote uniformity across ministries and to improve communication among ministries and agencies, and from the government to the broader public sector and other external partners while retaining the flexibility for ministries to pursue program-specific objectives.

2.4 Value Proposition Analysis

The National Transformation version 2 (NTv2) is the standard methodology and tool set for transformation between the NAD27 and NAD83 datums that provides accurate, consistent, reliable and repeatable results across all of Canada.

End users will achieve the transformation of geospatial information using only one methodology and tool set which will result in transformations of known accuracy, with repeatable and consistent results that are compatible across jurisdictional boundaries.

The adoption of NTv2 as the standard for the conversion of geospatial data sets will permit internal and external clients to acknowledge, comprehend and understand the methodology employed by the LRC and OPS to transform between NAD27 and NAD83.

The NTv2 standard will promote geomatics standards at the provincial level while responding to and cooperating with the Canadian government's decision to create and adopt the NTv2.

The NTv2 allows for varying geodetic control point grid densities to allow increased accuracy. Regions in Ontario with high densities are provided with a higher accuracy than was attainable with the NTv1.

The NTv2 also provides accuracy estimates of transformed coordinates.

2.5 Impact on Stakeholders

NAD83 and NTv2 Stakeholder Consultation

- ICLI Working Group Member Ministries
  - Education, Health, Northern Development and Mines, Agriculture and Food, Environment, Municipal Affairs and Housing, Justice (OPP),Transportation, and Natural Resources

- ICLI Working Group Response
  - of the eight ministries involved in ICLI (besides MNR), all eight have provided responses on behalf of their ministries and they are all in favour of NAD83 and the NTv2 becoming GO-ITS
  - two ministries asked about the time-frame for conversion of legacy systems still on NAD27

- ORN Stakeholder Response from List of 50 Members
  - All 50 members have been contacted
  - about 10% response rate
  - responses have all been very positive
    - NRCan- CTI (Sherbrooke) indicates full support for initiative
    - Niagara Region has already adopted NAD83 and NTv2 and have reviewed all documentation provided and have no concerns with them becoming provincial standards

- OGDE Technical Reps Response from List of 107 Members
  - just over 100 technical reps in OGDE
  - about 15% response rate
  - responses have all been positive
    - Lake Simcoe Region CA has been using both NAD83 and NTv2 for last 4 years; fully agree with their adoption as standards
    - Lower Trent Conservation has been using NAD83 and the NTv2 and approve of these as accepted standards
    - Grand River CA has no concerns with adopting NAD83 and the NTv2 as provincial standards; they are the de facto standards already in use by them

- Summary of Impact of Proposals
  - NAD83 and the NTv2 are already the de facto standards for Ontario
  - the NAD83 datum and the NTv2 for conversion between datums are already built into major GIS vendor packages and are readily available
  - impacts upon the OPS and our clients will be very minimal
  - some agencies dealing with legacy based systems may have to accelerate their plans to move them to NAD83 using the NTv2 methodology

3.0   Information about the Proposed Standard

3.1   The Standard's Scope

3.1.1 The Standard Purpose

The purpose of this standard is to ensure the use of NTv2 as the methodology and tool set for transformation between the NAD27 and NAD83 datums providing accurate, consistent, reliable and repeatable results.

3.1.2 Planned Outcomes

Only this standard shall be used when transforming geospatial information between NAD27 and NAD83. It is not the purpose of this standard to require transformation of geospatial information, but to provide the methodology when transformation is required.

End users will achieve the transformation of geospatial information using only one methodology and tool set which will result in transformations of known accuracy, with repeatable and consistent results that are compatible across jurisdictional boundaries.

3.1.3 Standard Description

Within Ontario, the NTv2 grid shifts are spaced at 5 minute by 5 minute intervals in both longitude and latitude for northern areas. In south-central Ontario and certain municipal areas of northern Ontario, the grid shifts are spaced at 30 second by 30 second intervals in both longitude and latitude to provide higher accuracy.   Other features found with the NTv2 include:

a) handles NAD27-74 readjustment to NAD83 and reverse,
b) handles NAD27-MAY76 readjustment to NAD83 and reverse, and
c) provides accuracy estimates for transformed coordinates.

The NTv2 is the only officially endorsed methodology for conversion between NAD27 and NAD83 by federal and provincial government agencies, departments and ministries. The NTv2 is available as a standalone software package and is directly incorporated in major GIS vendor packages, thus allowing the transformation to be nearly transparent to end-users.

3.2   Implementation Plan

3.2.1 Project Management Arrangements

Responsibility Chain: Dennis Gertridge/Morgan Goadsby $\rightarrow$ GSWG $\rightarrow$ LRC ACT $\rightarrow$ LRC ARB $\rightarrow$ OPS ACT $\rightarrow$ ITSC $\rightarrow$ OPS ARB

Costs of Standard: the NTv2 as a stand-alone package is available free of charge from provincial and federal government agencies. The NTv2 methodology as implemented within major GIS vendors' software (see approved vendors list on NRCan web-site at www.geod.nrcan.gc.ca) suites is included at no additional cost. Costs to support development in Ontario as a GOITS standard will be funded by Provincial Georeferencing, Geographic Information Ontario (GIO) and the Land Information Ontario (LIO) initiative.

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3.2.2 Proposed Budget

The NTv2 as a stand alone package is free of charge as per the licensing agreement between Natural Resources Canada (NRCan) and the OPS. The NTv2 is also available in vendor software packages at no additional cost.

It is estimated that the currently anticipated and future enhancements to the NTv2 can be accomplished with a project budget of $25,000 and current staffing levels within Provincial Georeferencing, MNR and Geodetic Survey Division of NRCan.

3.2.3 Proposed Timeframe and Milestones

-   February 11, 2003: initial presentation of business case and standard to GSWG
-   February 26, 2003: presentation of revised business case and standard to GSWG
-   April 09, 2003: final editing of business case and standard for NTv2 with GSWG

- May 15, 2003: final review of business case and standard for NTv2 with GSWG
- February 20, 2004: stakeholder consultation complete
- March 02, 2004: update business case and standards form for stakeholder feedback
- April 07, 2004: presentation to LRC ACT

3.2.4 Internal Change Management and Training

The impact on organizational arrangements, staff, customers and service delivery can be summarized as follows: OPS staff, clients and users need to be aware that geospatial information is referenced to a datum. If transformation between NAD27 and NAD83 is required the NTv2 methodology must be applied to accomplish this task.

Staff will be informed and involved by providing feedback to their managers who will in turn forward this feedback to the GSWG through the Chair.
Staff will continue their daily use of GIS software to transform coordinates.

Staff will be trained by reviewing the documentation regarding the NTv2 that is available on provincial (including the NRVIS site and in the future the GI [Geographic Information] Portal) and federal web-sites. Presentations will be provided to groups as required.

To ensure the project is implemented in a cooperative way, with the least disruption possible, the standard ITIL change management process for the LRC will be applied. ITIL Change management process will also be applied to manage ongoing change related to the project.

3.2.5 Communications

The strategy for identifying and consulting with internal and external stakeholders, informing them of progress and changes, and managing the external impact of the project can be summarized as follows:

a) The Ontario Road Network (ORN) contact group,
b) Websites (LRC standards architecture, GO-ITS, GI Portal),
c) Provincial GIS Technical Team email distribution, and
d) contact with Interministerial Committee on Land-related Information (ICLI) Working Group Members and member ministries.

3.2.6 Maintenance

The NTv2 standard will be maintained by employing the standards maintenance process which is being developed by ITSC.

The NTv2 standard will be enforced by employing the standards enforcement process which is being developed by ITSC. OPS partners will be required to comply with OPS standards as part of data-sharing or other contractual agreements.

Client advice and support will be carried out through the NRVIS web-site and NRVIS support, LIO website, (the GI Portal in the future), and the GI/GIS community of practice.

3.2.7 Risk Assessment

Risks of not implementing NTv2 as a standard are:
a) Incompatible data sets,
b) Errors in integrating in-compatible data sets, and
c) Staff resources being wasted trying to resolve incompatible data sets.

Risks of implementing NTv2 as a standard are:
a) Transformation of curves within CAD data sets,
b) Future enhancement of the NTv2 to address newest version of NAD83 known as NAD83 Canadian Spatial Reference System or NAD83-CSRS,
c) Software vendors including the NTv2 methodology within their packages may not be examined as rigorously by NRCan as in the past, and
d) Pressure applied to geospatial information users to label their data sets as NTv2 compliant when they are not.

3.2.8 Risk Management

To reduce and manage the risks associated with making the NTv2 a provincial standard the following actions will be taken:

a) Ensuring through communications users are aware of the NAD27 and NAD83 datums and that the NTv2 is the OPS standard for transformation between those datums,
b) Identifying to CAD users the issues with curves and provide appropriate cautions,
c) Ensuring staffing levels and funds are sufficient to complete project with NRCan to enhance the NTv2 to address NAD83-CSRS,
d) Maintaining contact with NRCan and formally notify them of plan to adopt NTv2 within Ontario and the appropriate levels of support required, and
e) Putting in place support mechanisms for NTv2 implementation (e.g. NRVIS support group).

Appendix B: NTv2 Developer's Guide

National Transformation version 2 (NTv2) Developer's Guide

The developer's guide provides complete specifications for the hybrid grid shift file structure used in Version 2 of the National Transformation, and the procedures used to access and apply the data it contains

NTv2

National Transformation

Version 2

Developer's Guide

D.R. Junkins

S.A. Farley

Geodetic Survey Division

Geomatics Canada

September 1995

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Table of Contents

1. Introduction

This document provides complete specifications for the hybrid grid shift file structure used in Version 2 of the National Transformation, and the procedures used to access and apply the data it contains. The two major differences in the data provided by Version 2 are the inclusion of accuracy estimates for each of the predicted shift values, and grids of greater density in selected areas, corresponding to high densities of control survey networks.

The file structure devised for Version 2 allows multiple grid shift files at various densities. Each of these base files can have areas of densified grids, which in turn can themselves have densified areas. All of these grid areas are combined as sub-files of a single larger file. This hybrid file structure is transparent to the user because the selection of the appropriate grid area is automatic. Similar to Version 1, a utility to extract a smaller file for a selected area addresses the concerns that some users may have about file storage space or geographical area of operation.

This documentation is intended for third-party developers who are licensed to incorporate the NTv2 as a feature of their products, or for end users who integrate the NTv2 into their own systems or perform other custom modifications for in-house use. For direct users of the NT in its unaltered form, this document may be treated as non-essential background material, since it is not critical to understand it in order to use the system effectively. Version 1 specifications are also included for comparison.

A descriptive overview of the file structures and how they are used is given in Sections 2, 3, 4, and 5. Section 2 describes the elementary grid shift file as used in both Versions 1 and 2, with minor differences. Section 3 describes the hybrid grid shift file used in Version 2, with particular attention to the methodology of grid densification. Section 4 gives a description of the three essential processes to access the grid shift files, and Section 5 suggests various strategies for implementation into the developer's environment. Detailed descriptions of the three processes are given next. Finally, Appendices A and B contain detailed specifications of the record structures for Versions 1 and 2, respectively.

2. Elementary Grid Shift File Description

The National Transformation Version 1 was based on a grid shift file that is strictly regular in structure. It must cover a rectangular area bounded by unique values for each of the following: lower latitude, upper latitude, lower longitude, and upper longitude. The grid intervals are specified separately for latitude and longitude, and are fixed at these values throughout the file. Indexing of grid intersection points begins at the lower right-hand, or south-east, corner of the grid rectangle (Figure 1).

```
         Figure 1:  Grid Limits and Point Indexing
         ----------------------------------------


               Longitude
               Interval
                 dLon
               #-------#
                                                 Upper
      +-------+-------+-------+-------+   --  Latitude
   m*n|       |       |       |       |        Limit
      |       |       |       |       |          N
      |       |       |       |       |
      +-------+-------+-------+-------+
      |       |       |       |       |
      |       |       |       |       |
      |       |       |       |       |
      +-------+-------+-------+-------+   #
    3n|    ...|   2n+3|   2n+2|   2n+1|   |   Latitude
      |       |       |       |       |   |   Interval
      |       |       |       |       |   |     dLat
      +-------+-------+-------+-------+   #
    2n|    ...|    n+3|    n+2|    n+1|
      |       |       |       |       |       Lower
      |       |       |       |       |
      +-------+-------+-------+-------+   --  Latitude
     n     ...       3       2       1        Limit
                                                 S
      |                         |
    Upper                     Lower
   Longitude                 Longitude
    Limit                     Limit
      W                         E


   n = number of columns           m = number of rows


              W - E                            N - S
   n = integer( ----- ) + 1     m = integer( ----- ) + 1
               dLon                            dLat
```
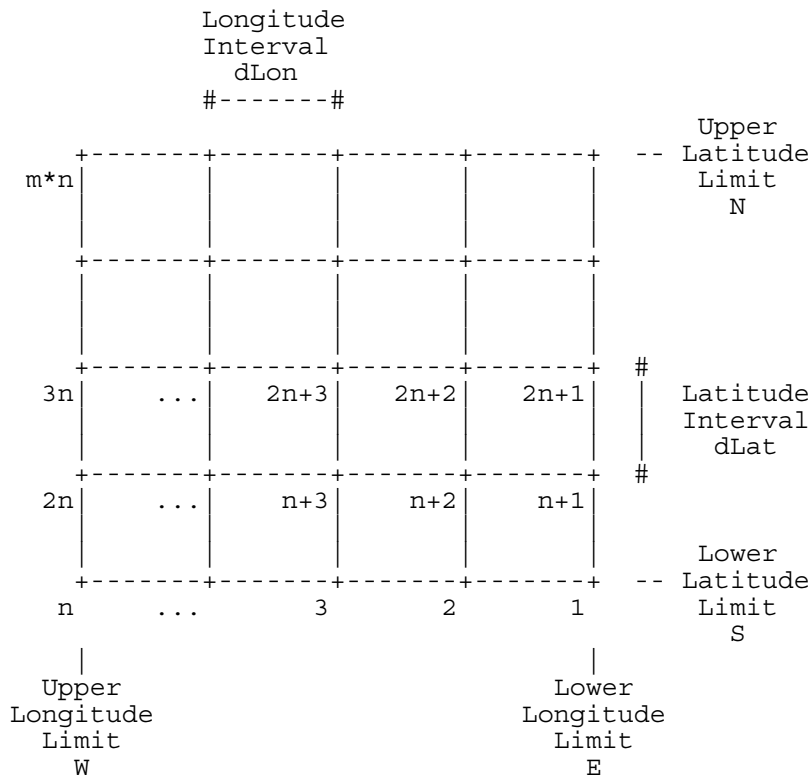
This type of structure allows the direct computation of the record indices for the four corners of the cell containing a point to be processed (Figure 2). Since no search algorithms are required, speed of retrieval is independent of file size. It also permits the reduction of file size by creating a subset covering a smaller rectangular area within the original, suiting users with a more regional interest.

```
            Figure 2:  Grid Cell Direct Indexing
            -----------------------------------


                              jth
                             column
                               |

              +-------+-------+-------+-------+
              |       |       |       |       |
              |       |       |       |       |
              |       |       |       |       |
              +-------●-------●-------+-------+
              |     D|     C|       |       |
              |       |  ●    |       |       |
              |       | P     |       |       |
              +-------●-------●-------+-------+  -- ith row
              |     B|     A|       |       |
              |       |       |       |       |
              |       |       |       |       |
              +-------+-------+-------+-------+
              |       |       |       |       |
              |       |       |       |       |
              |       |       |       |       |
              +-------+-------+-------+-------+
```
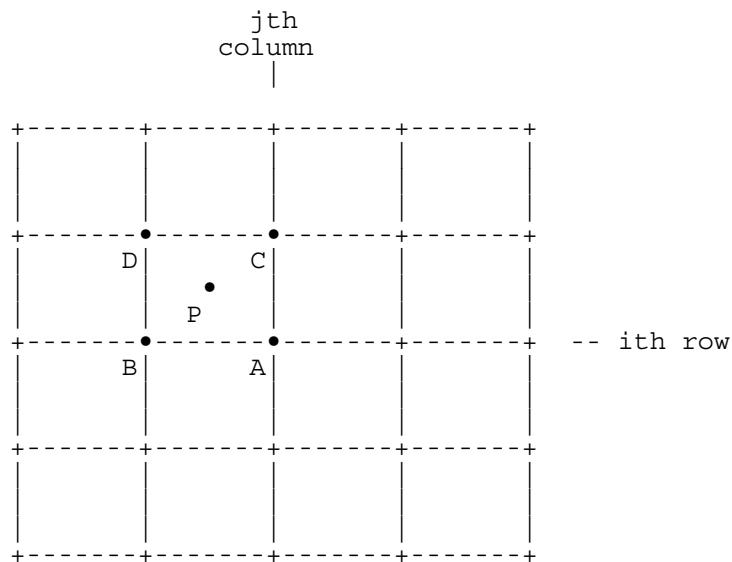
$$i = integer\left(\frac{Lat(P) - S}{dLat} \right) + 1 \qquad A = n(i-1) + j$$

$$B = A + 1$$

$$j = integer\left(\frac{Lon(P) - E}{dLon} \right) + 1 \qquad C = A + n$$

$$D = C + 1$$

The size of the file, as determined by the area it covers and the density of the grid, does not affect the software used to access and apply the data. All of the information required to describe the data is contained in a block of header records at the beginning of the file.

The header records are followed by the grid shift records which contain the predicted shifts at each point in the grid. The last record is a flag to indicate the end of file. Appendix A provides a more detailed description of the grid shift file as used in Version 1.

This elementary grid shift file is also used as the fundamental building block for Version 2. The major difference is that while the Version 1 grid shift records have two double precision variables for the latitude and longitude shifts, the Version 2 grid shift records contain four single precision values for the two shifts and their estimated accuracies.

3. Hybrid Grid Shift File Description

The hybrid grid shift file used for Version 2 of the National Transformation combines one or more base grids of various densities with grids of greater densities covering designated areas within each of the base grid areas. Different areas within the same base grid may be densified using different grid intervals, and each of these areas can themselves have areas that are further densified. Each grid area is compiled separately, and then all of the elementary grid shift files are combined into a single hybrid grid shift file. The rules for defining and selecting grid areas ensure that a unique determination will be made for any point to be transformed, with no dependency on the user to select the appropriate grid.

Rules for Densification

As with the specifications of the elementary grid shift file, a set of rules must be followed to enable the direct computation of the record indices for the four corners of the cell containing a point to be processed. These rules ensure that points falling on or near the densification boundary will have unique values, with no discontinuity between the parent and densified grid areas.

The first rule concerns the extent and grid intervals of the densified area (Figure 3):

1- i)   The densified area must be rectangular, with the extent in each dimension being a whole number (integer) of parent grid intervals.

1- ii) Densified grid intervals must be a whole number (integer) of divisions of the parent grid intervals.

1- iii) Densified area boundaries must be coincident with the parent grid, enclosing only complete cells.

1- iv) Densified areas may not overlap each other.

```
        Figure 3:  Valid Densified Grid Areas
        -------------------------------------


                Area A (valid)
        +-------+ + + + +-------+-------+
        |         + + + + +       |       |
        |         + + + + +       |   +++++  Area C
        |         + + + + +       |   +++++ (not valid)
        +-------+ + + + +-------+---+++++
        |         + + + + +       |       |
        |         + + + + +       |       |
        |         + + + + +       |       |
        +-------+ + + + +-------+-------+
        |       |       |       |       |
        |       |       |   + + + + + + +
        |       |       |   + + + + + + +
        +++++++++-------+---+ + + + + +  Area D
  Area B +++++++++       |   + + + + + + + (not valid)
  (valid) +++++++++      |   + + + + + + +
        +++++++++       |   + + + + + + +
        +++++++++-------+---+ + + + + +


    Areas A and B are valid

    - boundaries are coincident with parent grid cells


    Areas C and D are NOT valid

    - not all boundaries are coincident with parent grid cells
```
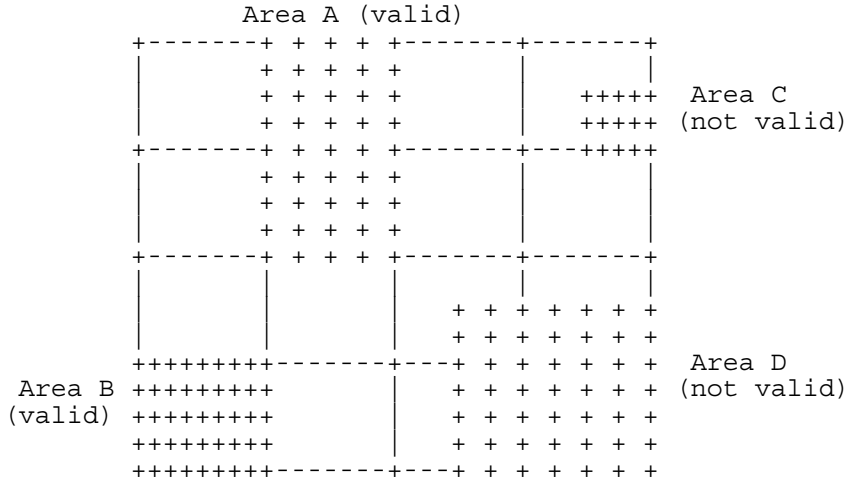
The second rule concerns the shift values assigned to the densified grid points (Figure 4):

2- i)   All grid points falling within the interior of the densified area have shifts determined by the model being implemented, i.e. the same one used to compute the parent grid.

2- ii) For grid points on the perimeter, the shift values are determined by linear interpolation between adjacent parent grid points.

2- iii) For grid points on a common perimeter segment between two adjoining densified areas of the same density, the shifts determined by the model (as in 2-i) above) are retained.

2- iv) For grid points on a common perimeter segment between two adjoining densified areas of different density, the shifts determined by the model (as in 2-i) above) are retained for the less dense grid, while the shift values for the more dense grid are determined by linear interpolation of the less dense grid. (This rule also applies to base grids of different densities.)

```
Figure 4:  Values at Perimeter Points
-------------------------------------


 P        P         P          P          P



 P        P # # # P # # # P          P
          # + + + + + + + #
          # + + + + + + + #
          # + + + + + + + #
 P        P + + + P + + + P          P
          # + + + + + + + #
          # + + + + + + + #
          # + + + + + + + #
 P        P # # # P # # # P          P



 P        P         P          P          P


 P  - parent grid points
    - retain original values

 +  - densified grid points
    - computed from same model as parent grid

 #  - densified grid perimeter points
    - interpolated from parent grid
```

File Construction

The hybrid file is a series of sub-files, each of which is a complete elementary file with header records and grid shift records. The header records contain information that is specific to the individual sub-file, such as file identifiers, creation and revision dates, grid limits and intervals, and the number of grid shift records.

The order of the sub-files is of no consequence, since an index table of the sub-files is built each time the hybrid file is opened. As with the elementary grid shift file, the order of the records within each sub-file is critical.

At the beginning of the hybrid file is an overview header block of information that is common to all sub-files. This includes the number of header records in the overview and sub-file header blocks, the number of sub-files, grid shift units, a version identifier, and reference system names and ellipsoid parameters. Overview header data is cross-checked during file construction.

At the end of the hybrid file is an end of file record signifying that there are no more sub-files.

4. Accessing the Hybrid Grid Shift File

To use the data from the grid shift file in a program, there are three steps involved. The first is to build an index of its contents each time the file is opened. Subroutine TABLE does this by reading the pertinent information from the overview header block and all of the sub-file header blocks. This provides a map in memory that can be quickly searched each time a coordinate is submitted for processing.

The second step is the search function performed by subroutine FGRID. Its algorithm is designed to uniquely select the appropriate sub-file, with particular care taken to ensure that the most dense grid containing the point is used. It also identifies cases in which the point falls on the upper limits of the area covered by each sub-file, so that special steps may be taken to handle it.

The third step is to select from the specified sub-file the records which correspond to the four corners of the cell containing the submitted point, and perform the bilinear interpolation to compute the shifts and their accuracies that apply to that point. This is done by subroutine GRIDINT.

Each of these subroutines is presented in the following sections using a mix of descriptive narrative, pseudo-code, and data dictionary style terminology. Many of the terms refer to the elements of the hybrid grid shift file detailed in Appendix B, while others are local to the processes themselves. Appendix A describes the file structure for Version 1, and is provided only for comparison by developers who have implemented this earlier format.

5. Implementing the Hybrid Grid Shift File

There are many ways in which a developer might adapt the NTv2 grid shift file and procedures for custom applications.

Some of the simpler approaches would be:

1) Port the software from DOS to another type of computer system, such as UNIX, VAX/VMS, or Mac/OS. The User's Guide section on program READDA gives details on this procedure.

2) Change the formats for the input and output records to conform to the user's requirements. The appropriate statements are found in subroutines GETGEO, GETUTM, GEOOUT, and UTMOUT.

3) Devise an operating-system-level procedure to convert the application to a total batch process for repetitive or "blind" application. The procedure would launch program INTGRID and supply all the necessary keystrokes to emulate an interactive session which selects and responds to the required options.

A more integrated approach would be to use the three subroutines TABLE, FGRID, and GRIDINT, to create an NTv2 feature of another existing system, such as a GIS or mapping or coordinate conversion package. These three routines form the heart of program INTGRID - the rest is user interface and input/output function. By using these routines, the end-users of the existing system would be provided with a standard conversion tool built in to the system with which they are already familiar. It would act directly on the data structures of that system, and not require any export/import activity, with its potential for problems.

The use of these routines is demonstrated in a special developer's program called NOFRILLS. This program operates in batch mode, with only the minimum of code required to open the appropriate files, call the three routines, and close the files on completion.

Subroutine TABLE

Build Grid_File_Index Tables

Subroutine TABLE builds the arrays of data that represent the Grid_File_Index by reading all of the Overview_Header_Block records and Sub_File_Header_Block records each time the Grid_Shift_File is opened.

To access the information from the various header blocks, the following algorithm is used:

1) The Overview_Header_Block at the beginning of the file provides the:

> Number_of_Overview_Header_Records
>   and
> Number_of_Sub_File_Header_Records in each Sub_File
>   and
> Number_of_Sub_Files

2) The Sub_File_Header_Block for each Sub_File provides the:

> Grid_Shift_Record_Count

3) The number of records preceding the start of the first Sub_File is:

> Sub_File_1_Offset   =   Number_of_Overview_Header_Records

4) The number of records preceding the start of the second Sub_File can be computed as:

> Sub_File_2_Offset   =   Number_of_Overview_Header_Records
>   +   Number_of_Sub_File_Header_Records
>   +   Sub_File_1_Grid_Shift_Record_Count

5) and subsequently, for each ith Sub_File:

$$\text{Sub\_File\_i\_Offset} = \text{Sub\_File\_(i-1)\_Offset}$$
$$+ \text{Number\_of\_Sub\_File\_Header\_Records}$$
$$+ \text{Sub\_File\_(i-1)\_Grid\_Shift\_Record\_Count}$$

The header block information is stored in arrays which are returned to the calling routine as formal parameters. The following lists indicate the data elements and the array variable names in which they are placed. More detail on variable types and length can be found in the file description. An array is also created for the Sub_File_Offsets as determined by the preceding algorithm.

From the Overview_Header_Block:

	Data Element Name	*Variable Name*
i)	Number_of_Overview_Header_Records	NORECS
ii)	Number_of_Sub_File_Header_Records	NSRECS
iii)	Number_of_Sub_Files	NFILES
iv)	Grid_Shift_Data_Type	TYPOUT
v)	Version_Number	VERSION
vi)	System_From	FDATUM
vii)	System_To	TDATUM
viii)	Semi_Major_Axis_From	FELLIPS(1)
ix)	Semi_Minor_Axis_From	FELLIPS(2)
x)	Semi_Major_Axis_To	TELLIPS(1)
xi)	Semi_Minor_Axis_To	TELLIPS(2)

From the Sub_File_Header_Block for each of the sub-files:

	Data Element Name	*Variable Name*
i)	Sub_File_Name	ANAMEG(I)
ii)	Parent_File_Name	APGRID(I)
iii)	Creation_Date	(not used)
iv)	Last_Revision_Date	(not used)
v)	Lower_Latitude_Limit	ALIMIT(I,1)
vi)	Upper_Latitude_Limit	ALIMIT(I,2)
vii)	Lower_Longitude_Limit	ALIMIT(I,3)
viii)	Upper_Longitude_Limit	ALIMIT(I,4)
ix)	Latitude_Grid_Interval	ALIMIT(I,5)
x)	Longitude_Grid_Interval	ALIMIT(I,6)
xi)	Grid_Shift_Record_Count	AGSCOUNT(I)

As computed from the algorithm described above:

Data Element Name	*Variable Name*
Sub_File_i_Offset	ASTART(I)

Subroutine FGRID

Find Grid_Shift_Sub_File

The proper Grid_Shift_Sub_File for any point to be processed is defined as the one:

- whose limits enclose the point,
  and
- which has no Densified_Grid_Shift_Sub_File whose limits also enclose the point.

The rules for defining grid areas prohibit a point from falling within the limits of more than one Grid_Shift_Sub_File at the same level, making the selection unique. The basic rule is that Grid_Shift_Sub_Files with the same Parent_Grid_Name cannot have overlapping boundaries.

If a point is **on** the limits of a Grid_Shift_Sub_File, then special conditions apply:

- if it is on the **lower** limits of latitude or longitude, it is considered as **within** the limits
- if it is on the **upper** limits of latitude or longitude, it is considered as **outside** the limits

This definition prevents a point from belonging to two or more Grid_Shift_Sub_Files that have adjoining boundaries and the same Parent_Grid_Name. The only exception is a point which is on either of the upper limits of a Grid_Shift_Sub_File, but not within any other. It will be considered as within that Grid_Shift_Sub_File.

The steps in the process are:

1. The Current_Grid_Name is initially set to 'NONE', which is the Parent_Grid_Name for all of the Base_Grid_Sub_Files.

2. All Grid_Shift_Sub_Files having a Parent_Grid_Name the same as the Current_Grid_Name are tested to determine whether any of them enclose the point.

3. If any Grid_Shift_Sub_File does enclose the point, its Sub_File_Name becomes the Current_Grid_Name, and Step 2 is repeated.

4. If no further Grid_Shift_Sub_File encloses the point, the Sub_File corresponding to the Current_Grid_Name is selected, and its Sub_File_Number is returned.

5. If no Grid_Shift_Sub_File encloses the point, a Sub_File_Number of zero is returned.

6. A flag indicating whether the point is on either of the upper limits is also returned. The flag values are set as follows:
   [1] point is within the limits
   [2] point is on upper latitude limit
   [3] point is on upper longitude limit
   [4] point is on both upper latitude and upper longitude limits

   A point may fall into one of these categories for one grid area, but may also fall into another of the categories for an adjacent grid area if both Grid_Shift_Sub_Files have the same Parent_Grid_Name. A point may even fall into three or four categories if it is on the junction of three or four adjoining grid areas. In these cases of multiple selections, the Grid_Shift_Sub_File corresponding to the lowest value of the flag is selected by default.

Subroutine GRIDINT

Grid_Shift_Interpolation

1. Retrieve Grid Shifts

If a specific grid point is to be retrieved, then the Record_Index of that point is computed by the following sequence (see Figures 1 & 2 in Section 2: Elementary Grid Shift File Description):

$$\text{Row\_Index} = \frac{\text{Point\_Latitude} - \text{Lower\_Latitude}}{\text{Latitude\_Grid\_Interval}} + 1$$

$$\text{Column\_Index} = \frac{\text{Point\_Longitude} - \text{Lower\_Longitude}}{\text{Longitude\_Grid\_Interval}} + 1$$

$$\text{Grid\_Points\_Per\_Row} = \frac{\text{Upper\_Longitude} - \text{Lower\_Longitude}}{\text{Longitude\_Grid\_Interval}} + 1$$

$$\begin{aligned}
\text{Record\_Index} = \ &(\text{Row\_Index} - 1) * \text{Grid\_Points\_Per\_Row} \\
+ \ &\text{Column\_Index} \\
+ \ &\text{Sub\_File\_Offset}
\end{aligned}$$

All division operations are truncated to integers. Thus, if the point coordinates are not exactly identical to coordinates of a grid point, the Record_Index will correspond to the lower right-hand corner of the grid cell which contains the point.

This means that if a point is on the lower limit of the cell, it is considered as in the cell, but if it is on the upper limit, it is considered as being in the next adjoining cell.

If the four grid points of the corners of the cell are to be retrieved, then the same sequence as above is used to first determine the Record_Index_LR. The Record_Indexes for each of the other three corners are determined as:

Record_Index_LL   =   Record_Index_LR + 1

Record_Index_UR   =   Record_Index_LR + Grid_Points_Per_Row

Record_Index_UL   =   Record_Index_UR + 1

If the coordinates of the point are exactly on either of the upper limits of latitude or longitude, as indicated by the limit flag returned by subroutine FGRID, then the cell is actually outside the area covered by the Grid_Shift_Sub_File. To address this situation, the grid is virtually extended by one cell beyond the upper limit. Grid shift values are assigned to the corners of the cell, according to the limit flag, as follows:

[1] point is within the limits - shift values for all four corners of the cell are used, no virtual cell is required

[2] point is on the upper latitude limit - shift values for the two available cell corners are used for both the lower and upper latitude corners of the virtual cell

[3] point is on the upper longitude limit - shift values for the two available cell corners are used for both the lower and upper longitude corners of the virtual cell

[4] point is on both upper latitude and upper longitude limits - shift values for the single available cell corner are used for all four corners of the virtual cell

```
Case 1: (point is within limits)
~~~~~~
          d          c              d          c
          +————————+              +————————+
          |        |              |        |
          |  P ●   |   no change  |  P ●   |
          |        |              |        |
          +————————+              +————————+
          b          a              b          a



Case 2: (point is on upper latitude limit)
~~~~~~
                                        b          a
                                        +......+
              P                         :      :
          +————●———+     becomes        :      :
          b          a                  :  P   :
                                        +———●——+
                                        b          a



Case 3: (point is on upper longitude limit)
~~~~~~
              c                      c          c
              +                      +......+
              |                      :      |
          P ●                becomes :   P ●
              |                      :      |
              +                      +......+
              a                      a          a



Case 4: (point is on both upper latitude and longitude limits)
~~~~~~
                                        a          a
                                        +......+
          P                             :      :
            ●               becomes     :      :
            a                           :    P :
                                        +......●
                                        a          a
```
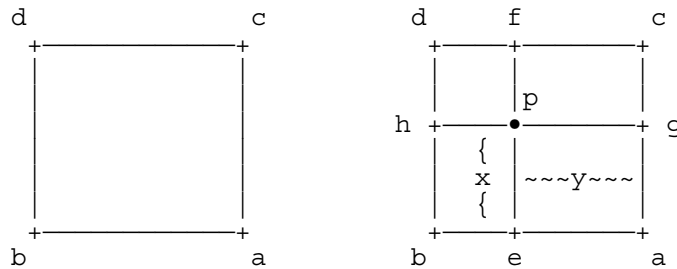
2. Interpolate Grid Shifts

The grid_shifts for the four corners of the cell containing the coordinates to be processed
are interpolated using the bilinear interpolation technique.

```
  d                 c        d       f           c
  +-------------+            +------+-------+
  |             |            |      |       |
  |             |            |      |p
  |             |         h  +------•-------+  g
  |             |            |     {
  |             |            |  x  |  ~~~y~~~
  |             |            |     {
  +-------------+            +------+-------+
  b                 a        b       e           a
```

Consider the unit square with shift values (a,b,c,d) at the corners, as illustrated above.
That is to say, the shifts are: a at (0,0), b at (1,0), c at (0,1), and d at (1,1).
The objective is to determine the shift p at (x,y), where 0<x<1, and 0<y<1.

To arrive at this unit square from the coordinate reference system of the grid, normalize
as follows:

$$x = \frac{latitude(p) - latitude(a)}{latitude\_interval}$$

$$y = \frac{longitude(p) - longitude(a)}{longitude\_interval}$$

where

$$latitude(a) = (row\_index - 1) * latitude\_interval$$

$$longitude(a) = (column\_index - 1) * longitude\_interval$$

and thus

$$x \;=\; \frac{\text{latitude(p)}}{\text{latitude\_interval}} \;-\; (\text{row\_index} - 1)$$

$$y \;=\; \frac{\text{longitude(p)}}{\text{longitude\_interval}} \;-\; (\text{column\_index} - 1) \;\;.$$

Next, determine the shift **e** at (0,y) by linear interpolation between **a** and **b**, and the shift **f** at (1,y) by linear interpolation between **c** and **d**.

$$e \;=\; a \;+\; (b - a)\,y$$

$$f \;=\; c \;+\; (d - c)\,y$$

Similarly, determine the shift **p** at (x,y) by linear interpolation between **e** and **f**.

$$p \;=\; e \;+\; (f - e)\,x$$

By substituting the expressions for **e** and **f** into the expression for **p**, we get

$$p \;=\; (a + (b - a)\,y) \;+\; ((c + (d - c)\,y) - (a + (b - a)\,y))\,x$$

$$\;=\; a \;+\; (c - a)\,x \;+\; (b - a)\,y \;+\; (a - b - c + d)\,xy$$

The result would be identical if the first interpolations were computed for the shifts **g** at (x,0), and **h** at (x,1), and then the shift **p** at (x,y) interpolated between them.

Appendix A

Version 1 Grid_Shift_File

The Version 1 Grid_Shift_File consists of a Header_Block, a series of Grid_Shift_Records, and an End_of_File_Record (see Figure 3).

It is a FORTRAN 77 unformatted, direct-access file type, with a fixed record length of 16 bytes. Each record contains two data elements.

For the first 10 of the 12 Header_Records, the first data element is a Header_Element_Name which describes the data in the second data element. Header_Records 11 and 12 do not have descriptive Header_Element_Names.

There is a Grid_Shift_Record for each point in the grid. The two data elements are the shifts in the two directions of the grid. The number of Grid_Shift_Records is given by the calculation:

$$\text{Grid\_Points\_Per\_Row} = \frac{\text{Upper\_Longitude} - \text{Lower\_Longitude}}{\text{Longitude\_Grid\_Interval}} + 1$$

$$\text{Grid\_Points\_Per\_Column} = \frac{\text{Upper\_Latitude} - \text{Lower\_Latitude}}{\text{Latitude\_Grid\_Interval}} + 1$$

$$\text{Number\_of\_Grid\_Shift\_Records} = \text{Grid\_Points\_Per\_Row} * \text{Grid\_Points\_Per\_Column}$$

The last record in the Grid_Shift_File is an End_of_File_Record. This is used to ensure that no attempt is made to read beyond the end of data.

The following table specifies the contents of the Grid_Shift_File.

Record #	First Data Element	Second Data Element

Header Records

1	'HEADER' Character*8	Number_of_Header_Records Integer*4
2	'S LAT ' Character*8	Lower_Latitude_Limit Real*8
3	'N LAT ' Character*8	Upper_Latitude_Limit Real*8
4	'E LONG ' Character*8	Lower_Longitude_Limit Real*8
5	'W LONG ' Character*8	Upper_Longitude_Limit Real*8
6	'N GRID ' Character*8	Latitude_Grid_Interval Real*8
7	'W GRID ' Character*8	Longitude_Grid_Interval Real*8
8	'TYPE ' Character*8	Grid_Shift_Data_Type Character*8
9	'FROM ' Character*8	System_From Character*8
10	'TO ' Character*8	System_To Character*8
11	Semi_Major_Axis_From Real*8	Semi_Minor_Axis_From Real*8
12	Semi_Major_Axis_To Real*8	Semi_Minor_Axis_To Real*8

Grid Shift Records

| 13 ...
...n+12 | Latitude_Shift
Real*8 | Longitude_Shift
Real*8 |

End of File Record

| n+13 | 'END   '
Character*8 | End_Of_File
Real*8 |

Appendix B

Version 2 Grid_Shift_File

The Version 2 Grid_Shift_File consists of an Overview_Header_Block, and one or more Grid_Shift_Sub_Files. Each Grid_Shift_Sub_File consists of a Sub_File_Header_Block and a series of Grid_Shift_Records. An End_of_File_Record follows the last Grid_Shift_Sub_File.

The Grid_Shift_File is a FORTRAN 77 unformatted, direct-access file type, with a fixed record length of 16 bytes. Each Header_Block_Record and the End_of_File_Record contain two data elements, while each Grid_Shift_Record contains four data elements.

For each Header_Block_Record, the first data element is a Header_Element_Name which describes the data in the second data element.

There is a Grid_Shift_Record for each point in the grid of each sub-file. The first two data elements are the shifts in the two directions (dimensions) of the grid. The next two data elements are the accuracies of the two shifts. The number of Grid_Shift_Records is given by the calculation:

$$\text{Grid\_Points\_Per\_Row} = \frac{\text{Upper\_Longitude} - \text{Lower\_Longitude}}{\text{Longitude\_Grid\_Interval}} + 1$$

$$\text{Grid\_Points\_Per\_Column} = \frac{\text{Upper\_Latitude} - \text{Lower\_Latitude}}{\text{Latitude\_Grid\_Interval}} + 1$$

$$\text{Number\_of\_Grid\_Shift\_Records} = \text{Grid\_Points\_Per\_Row} * \text{Grid\_Points\_Per\_Column}$$

After the last sub-file is an End_of_File_Record. This is used to ensure that no attempt is made to read beyond the end of data.

The following table specifies the contents of the Version 2 Grid_Shift_File.

Record #	*First Data Element*	*Second Data Element*

Overview Header Records

Record #	First Data Element	Second Data Element
1	'NUM_OREC' Character*8	Number_of_Overview_Header_Records Integer*4
2	'NUM_SREC' Character*8	Number_of_Sub_File_Header_Records Integer*4
3	'NUM_FILE' Character*8	Number_of_Grid_Shift_Sub_Files Integer*4
4	'GS_TYPE' Character*8	Grid_Shift_Data_Type Character*8
5	'VERSION' Character*8	Version_ID_of_Distortion_Model Character*8
6	'SYSTEM_F' Character*8	Reference_System_From Character*8
7	'SYSTEM_T' Character*8	Reference_System_To Character*8
8	'MAJOR_F' Character*8	Semi_Major_Axis_From Real*8
9	'MINOR_F' Character*8	Semi_Minor_Axis_From Real*8
10	'MAJOR_T' Character*8	Semi_Major_Axis_To Real*8
11	'MINOR_T' Character*8	Semi_Minor_Axis_To Real*8

Record #	First Data Element	Second Data Element

Sub-File Header Records

1	'SUB_NAME' Character*8	Sub_File_Name Character*8
2	'PARENT' Character*8	Parent_File_Name Character*8
3	'CREATED' Character*8	Creation_Date Character*8
4	'UPDATED' Character*8	Last_Revision_Date Character*8
5	'S_LAT' Character*8	Lower_Latitude_Limit Real*8
6	'N_LAT' Character*8	Upper_Latitude_Limit Real*8
7	'E_LONG' Character*8	Lower_Longitude_Limit Real*8
8	'W_LONG' Character*8	Upper_Longitude_Limit Real*8
9	'LAT_INC' Character*8	Latitude_Grid_Interval Real*8
10	'LONG_INC' Character*8	Longitude_Grid_Interval Real*8
11	'GS_COUNT' Character*8	Number_of_Grid_Shift_Records Integer*4

Grid Shift Records

12 ... n+11   (NOTE: 4 elements per record)

Latitude_Shift	Longitude_Shift	Latitude_Accuracy	Longitude_Accuracy
Real*4	Real*4	Real*4	Real*4

End of File Record

n+12	'END' Character*8	End_of_File Real*8

Appendix C: NTv2 User's Guide

National Transformation version 2 (NTv2) User's Guide

This user's guide covers the operation of the NTv2 software, and the formats for input and output of coordinate data.

NTv2

National Transformation

Version 2

User's Guide

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Geodetic Survey Division

Geomatics Canada

September, 1995

Copyright

Introduction

The National Transformation Version 2 (NTv2) software and data package provides a national standard for transforming coordinates between the NAD27 and NAD83 reference systems.

Version 2 contains new features which ensure the most reliable results for users seeking compatibility among various data sets. These new features include:

- shifts modelled on more comprehensive control survey networks
- variable grid density to reflect network density
- accuracy estimates for predicted shifts

Shifts between the NAD27 and NAD83 coordinates for control survey markers form the basis for the transformation. They result not only from the adoption of a new reference system, but also vary significantly due to local and regional distortions in NAD27. Recent integration computations have produced NAD83 coordinates for extensive networks, most of which are municipal surveys. With their availability, the transformation is now based on the same control as most municipal GIS data, providing the necessary accuracy and compatibility in areas of large-scale mapping and GIS projects.

Introduction (cont'd)

The density of the NTv2 grid is adapted to the density of control surveys. The base grid density is increased in areas of dense municipal survey control, typically by reducing the spacing from 5 minutes of arc to 30 seconds, or just under 1 km. A hybrid density grid shift file combines all grid areas, and the software automatically selects the correct grid for each point to be transformed. Densified grids allow for improved modelling of local variations in shifts at control survey points, resulting in greater consistency with the local positioning infrastructure.

Accuracies of predicted shifts can be computed, based on the local consistency of the shifts at the control survey markers. Consistent control survey networks result in very accurate predictions of a few centimetres or less, whereas problem networks are reflected in lower accuracy estimates of up to a metre or more. Accuracy estimates enable the user to assess the impact of conversion on the integrity of the GIS data, and allow a tangible contribution to the error budget of the transformed coordinates.

This User's Guide covers the operation of the NTv2 software, and the formats for input and output of coordinate data. The NTv2 is comprised of a suite of three programs, and an automated look-up table called the grid shift file, to which all three programs refer. The structure of the grid shift file and methods to access it are documented in detail in the **NTv2 Developer's Guide**.

The first part of the User's Guide is the **Getting Started Section**. It provides a quick look at how to install and use the software, with sample sessions for the elementary operation of each of the three programs.

The second part of the User's Guide is the **Reference Section**. It contains detailed explanations of all functions and options of the three programs. It also contains complete specifications of the formats for input and output coordinates, along with examples.

Table of Contents

Table of Contents (cont'd)

REFERENCE SECTION

Table of Contents (cont'd)

REFERENCE SECTION (cont'd)

4) Program READDA

Getting Started

Quick Overview

of

Software Installation

and

Program Operation

GETTING STARTED: 1) Installation

System Requirements

The National Transformation is a suite of three programs and an accompanying data file that operates on any IBM/PC compatible computer running MS-DOS Version 3.0 or later.

The executable code is not large, and the memory (RAM) requirements for execution are also minimal, since none of the processes hold vast amounts of data in memory during execution.

A math co-processor is not required to run the NTv2 software, but it does speed program execution. Two versions of the executable code are supplied. The first requires a math co-processor, the second will take advantage of a co-processor if it is present, but does not require one.

The **grid shift file**, on which computations are based, does require a large amount of disk space - about 14 megabytes (Mb) for the complete Version 2.0 coverage of Canada. This binary file is constantly accessed during processing, and must be present at all times, but remains on disk and does not require any special memory (RAM) capacity.

Smaller subsets of the grid shift file can be created if the use is concentrated on a more local area, reducing the amount of data required to be kept on disk. Little or no advantage in processing speed is gained by this. Many users may already have received a subset of the complete grid shift file from a provincial government agency.

Additional disk space is required to store the transformed coordinate files. This space is at least equal in size to the input file. A variety of other output files are also created by the suite of programs, such as report listings, tabulations, and an alternate ASCII format of the grid shift file. They range from very small - a few lines for some report listings - to extremely large - 25 megabytes for the complete ASCII grid shift file - depending on the options selected.

Installing the Software and Data

From Compact Disk

If the National Transformation was supplied on a Compact Disk (CD-ROM), the grid shift file and executable programs can simply be copied onto the local hard disk. It is even possible to leave the files on CD-ROM and access it there during execution, but performance will be significantly diminished.

GETTING STARTED: 1) Installation (cont'd)

Installing the Software and Data (cont'd)

From Floppy Disks

If the National Transformation was supplied on PC floppy disks, the first thing to do is write protect the disks, make backup copies, and store the original disks in a safe location. The copies can be used to install the software and data.

The executable programs can simply be copied directly from the NTv2 Programs Disk to the local hard drive.

The grid shift file is too large to fit on one floppy disk, so the DOS COPY command will not work. Instead, the DOS BACKUP command has been used to permit this single file to span several floppy disks. The DOS RESTORE command is used to copy it back onto the local hard disk.

The following DOS (Version 5.0) BACKUP command was used to create the multi-disk copy from the main level hard disk directory:

```
BACKUP C:\NTV2_0.GSB A:
```

To install the grid shift file from this set of floppy disks, the DOS (Version 5.0 or higher) RESTORE command must be used <u>exactly</u> as follows:

```
RESTORE A: C:\*.*
```

The RESTORE command will copy the data file from the **A:** drive to the main level directory of the **C:** drive. Ensure that enough disk space is available before beginning. The <u>only</u> variation permissible on the syntax is the drive letters - any legitimate combination of floppy and hard drive may be used. <u>Do not</u> attempt to restore into another directory - this can be done by moving the file after the restore is complete.

Once the programs and the grid shift file have been copied to your hard disk, it helps to place them in a directory that has been pathed in the AUTOEXEC.BAT file. This can eliminate the use of cumbersome directory paths when supplying programs with file names.

GETTING STARTED: 1) Installation (cont'd)

Checking the Installation

To test the installation of the NTv2 programs and grid shift file, the test data used in the documentation examples is supplied. Results obtained from test runs can be compared with the sample output files which are also supplied.

The programs run in DOS, or in a DOS window. To initiate execution, type the program name at the DOS prompt, while residing in the software directory.

Installing on Platforms Other Than PC

The National Transformation software can be compiled and run on computer platforms other than the PC, such as various UNIX systems, VAX/VMS and Mac/OS.

Refer to the **Reference Section** for program READDA, and to the **Developers' Guide** for more information on porting software and grid shift file.

GETTING STARTED: 2) Menu Conventions

Common Operations for Running Programs

All National Transformation programs use similar menus, providing an interactive dialogue with the user. The menus are based on the command-line interface, in which each line is written sequentially to the screen, and the cursor placed on the next line to await user input in the familiar terminal screen style (see NOTE at the end of this section).

Upon starting a program, a series of brief information screens is displayed. After reading the message on each screen, respond with a carriage return [CR] to view the next screen, or type a [Q] to proceed directly to the main menu, which will appear after the last information screen has been dismissed.

Each line (item) of the menu consists of three elements:

 1) A brief description of the menu item
 2) A character enclosed in square brackets [ ] which is used to designate the menu item
 3) The default or user selected status of the menu item

The menus allow the user to specify options prior to execution of the operation.
The following **sample menu** is from program INTGRID:

<div align="center">

Description   **Designator**   **Status**

</div>

```
NTV2 - Program INTGRID - Main Menu
----------------------------------
Input  - Grid Shift File        [G]
Input  - Coordinate File        [C] Keyboard
Output - Report Listing         [R]
Output - Coordinate File        [N]
Output - Coords Not Transformed [M]
----------------------------------
Input  - Coordinate Type        [T] GEO
Input  - from Keyboard          [K] YES
Input  - Formatted/Delimited    [I] GHOST Records
Output - Screen / File / Both   [S] Screen
Output - Formatted/Delimited    [O] GHOST Records
Direction of transformation     [D]
----------------------------------
Go to Analysis Option Menu      [A]
View Header Blocks              [V]
Go to Information Screen        [H]
Quit and exit from program      [Q]
Proceed - Transform coordinates [X]
----------------------------------
Select a menu item
```

GETTING STARTED: 2) Menu Conventions (cont'd)

Common Operations for Running Programs (cont'd)

The user chooses an option by entering the designator character followed by a carriage return [CR]. Some options automatically toggle between two available options, not requiring any further user response. For others, a dialogue is presented to allow the user to make an appropriate selection, to which the user enters a response, followed by a carriage return. For many of these dialogues, the default can be selected by a carriage return only, without the need to enter any designator characters or text. Examples of the various types of dialogues and responses are shown in the following "Getting Started" sections on programs INTGRID, INTTAB, and READDA. After the option has been entered or modified, the revised menu is displayed.

This option selection continues until the user selects the option to proceed with program execution or exits from the program. After execution, the menu is re-displayed, and the entire process repeated. Most option settings are retained.

A special comment about the file specification dialogue that is used to open all new and existing files - the file name alone can be submitted if the file is in the current working directory, or the file path can be used to access files in other directories. The path can either be a relative path from the current working directory (e.g. `../ntv2data/ntv2_0.gsb`), or a complete path starting from the drive specification (e.g. `C:\ntv2/ntv2data/ntv2_0.gsb`).

NOTE:

The software has been developed with the command-line interface deliberately to avoid any system dependencies, such as would be required for a Windows environment. This facilitates the porting of the software to other platforms and operating systems. The FORTRAN77 source code is ANSI standard, and recompiles easily on most systems (e.g. PC/MS/DOS, UNIX, VAX/VMS, MAC/OS, etc.). For more information on porting, see the **Reference Section** on program READDA, and the **Developer's Guide**.

GETTING STARTED: 3) Program INTGRID

Software for Transforming Coordinates

Program **INTGRID** (**Int**erpolate **Grid**) is used to convert geographic coordinates (latitude & longitude) or transverse Mercator (TM) coordinates (Northing & Easting) from one reference system to another. The program also generates various analytical information, such as coordinate shifts, accuracies of the shifts, and grid cell distortion.

This overview is a quick look at the basic operation of the program. For more complete detail on the variety of functions and their operation, see the **Reference Section** for program INTGRID and the related data formats.

The main menu for program INTGRID appears as follows:

```
NTV2 - Program INTGRID - Main Menu
----------------------------------
Input  - Grid Shift File       [G]
Input  - Coordinate File       [C] Keyboard
Output - Report Listing        [R]
Output - Coordinate File       [N]
Output - Coords Not Transformed [M]
----------------------------------
Input  - Coordinate Type       [T] GEO
Input  - from Keyboard         [K] YES
Input  - Formatted/Delimited   [I] GHOST Records
Output - Screen / File / Both  [S] Screen
Output - Formatted/Delimited   [O] GHOST Records
Direction of transformation    [D]
----------------------------------
Go to Analysis Option Menu     [A]
View Header Blocks             [V]
Go to Information Screen        [H]
Quit and exit from program     [Q]
Proceed - Transform coordinates [X]
----------------------------------
Select a menu item
```

The following is a list of the key menu items for basic operation:

[G]   Specifies the **grid shift file** to be used (e.g. **NTv2_0.gsb**)

[T]   **Type** of data coordinates (geographic or TM coordinates - **geographic** is default)

[D]   **Direction** of transformation (from **NAD27 to NAD83** is default)

[X]   Proceed with **execution**.

Software for Transforming Coordinates   (cont'd)

The **grid shift file** is provided together with the software, and must be opened before any program operations can proceed. It is a binary direct-access file (an elementary type of data base) that contains a table of the shifts and their accuracies (see the **Developer's Guide** for more detailed information).

After opening the grid shift file by selecting the [G] designator and responding with the name of the grid shift file, the user can start to transform coordinates interactively by selecting the [X] designator. INTGRID gives an opportunity to go back to the menu to check the selected options before proceeding with execution. Prompts will appear for any necessary files that have not been opened.

The following is part of a sample session, starting from selection of the [X] option, after specifying the grid shift file (user responses are highlighted in **bold**):

```
        Any last changes?
        -----------------

        Press [CR] to proceed with execution
              [M] to return to Main Menu


           PROCESSING RECORDS

        Enter station number (MAXIMUM 40 CHAR.)
        [CR] to exit

     ABCD

     Enter Lat  (dd mm ss.ssssss)

     45 0 0

        Enter Long (ddd mm ss.ssssss)

     75 0 0

        POINT IN SUBFILE #  94    ONottawa


                                 Latitude           Longitude
                                 --------           ---------
        [IN ] ABCD             45  0   .00000     75  0   .00000
        [OUT] ABCD             45  0   .17527     74 59 58.74103

        Enter station number (MAXIMUM 40 CHAR.)
        [CR] to exit
```

GETTING STARTED: 4) Program INTTAB

Software for Windowing the Grid Shift File

The primary purpose of program **INTTAB** (**Int**erpolation **Tab**le) is to produce a table showing the coordinate shifts and the accuracies of the shifts at the grid points in a user-specified window. INTTAB may also be used to create a smaller sub-set of the **grid shift file** based on the user-specified window.

This overview is a quick look at the basic operation of the program. For more complete detail on the variety of functions and their operation, see the **Reference Section** for program INTTAB.

The menu for program INTTAB appears as follows:

```
       National Transformation
       Program INTTAB V2 Menu
     -----------------------------------
       Transformation grid file      [G]
       Output Listing File           [O]
     -----------------------------------
       Create a new grid file        [N] NO
       Window grid file              [W] NO
       Print grid table              [P] YES
     -----------------------------------
       View header records           [V]
       Proceed - Continue execution  [X]
       Exit from program             [Q]
       Information Screens           [H]
     -----------------------------------
       Select a menu item
       =================
```

The following is a list of the key menu items for basic operation:

[G]   Specifies the **grid shift file** to be used (e.g. **NTv2_0.gsb**)

[O]   Specifies the output **listing file** to be opened.

[W]   Requests that a **window** of the grid shift file be printed as a table.

[X]   Proceed with **execution**.

Software for Windowing the Grid Shift File   (cont'd)

After specifying the grid shift file and an output file, the user can proceed by selecting the [X] designator. INTTAB gives an opportunity to go back to the menu to check the selected options before proceeding with execution. Prompts will appear for any necessary files that have not been opened, and for the window limits.

The following is part of a sample session, starting from selection of the [X] option, after specifying the grid shift file (user responses are highlighted in **bold**):

```
 Any last changes?
 -----------------

 Press [CR] to proceed with execution
        [M] to return to Main Menu


 WORKING


 The program will use the nearest grid points
 beyond the limits supplied by the user if the
 defining points do not fall on a grid line in
 the grid file.

 Enter lower latitude in Deg,Min,Sec
45 0 0
 Enter upper latitude in Deg,Min,Sec
45 30 0
 Enter lower longitude in Deg,Min,Sec
75 0 0
 Enter upper longitude in Deg,Min,Sec
75 30 0



          User entered limits

  Lower lat    45  0    .000000
  Upper lat    45 30    .000000
  Lower long   75  0    .000000
  Upper long   75 30    .000000

 Do you want to change any values  [Y/N/Q]
 n

                    Window Limits

        User entered limits        Limits used by program

  Lower lat   45  0   .000000        45  0   .000000
  Upper lat   45 30   .000000        45 30   .000000
  Lower long  75  0   .000000        75  0   .000000
  Upper long  75 30   .000000        75 30   .000000
```

GETTING STARTED: 4) Program INTTAB (cont'd)

Software for Windowing the Grid Shift File   (cont'd)

```
                2 Subfile(s) have been selected

    Subfile  Num   Include   Lower/Upper Lat      Lower/Upper Long    Lat/Long Int.

    CAeast    1    Yes      40  0   .000000    44  0   .000000    0  5   .000000
                            60  0   .000000    88  0   .000000    0  5   .000000

    ONottawa  94   Yes      44 15   .000000    74 20   .000000    0  0 30.000000
                            45 55   .000000    76 10   .000000    0  0 30.000000


    Do you want all selected files [Y/N/Q]

n

    CAeast    1    Yes      40  0   .000000    44  0   .000000    0  5   .000000
                            60  0   .000000    88  0   .000000    0  5   .000000

    Do you wish to use this subfile    Yes      [CR]
                                       No       [N]

n

    ONottawa  94   Yes      44 15   .000000    74 20   .000000    0  0 30.000000
                            45 55   .000000    76 10   .000000    0  0 30.000000

    Do you wish to use this subfile    Yes      [CR]
                                       No       [N]


                2 Subfile(s) have been selected

    Subfile  Num   Include   Lower/Upper Lat      Lower/Upper Long    Lat/Long Int.

    CAeast    1    No       40  0   .000000    44  0   .000000    0  5   .000000
                            60  0   .000000    88  0   .000000    0  5   .000000

    ONottawa  94   Yes      44 15   .000000    74 20   .000000    0  0 30.000000
                            45 55   .000000    76 10   .000000    0  0 30.000000


    Do you want all selected files [Y/N/Q]

y


    WORKING

      JOB HAS COMPLETED. DO YOU WISH TO RUN ANOTHER
      EXIT                    [CR]
      RETURN TO MAIN MENU     [Y]
```

Software for Windowing the Grid Shift File   (cont'd)

The following is part of the table created representing the shifts and accuracies in the user-selected window:

```
                        Natural Resources Canada                              PAGE   2
                        Geodetic Survey Program INTTAB Version 2              DATE  7-Jul-95
                        =========================================

         Add shifts to NAD27    to get NAD83              Grid File  : NTv2_0.gsb
         Upper value is Latitude Shift, Accuracy          Subfile    : ONottawa
         Lower value is Longitude Shift, Accuracy         Lat int.   :   0 00 30
         ** indicates a densified cell                    Long int.  :   0 00 30


LONGITUDE ->    75 03 00      75 02 30      75 02 00      75 01 30      75 01 00      75 00 30      75 00 00
        ===================================================================================================
        ]  Shift   +/-    Shift   +/-    Shift   +/-    Shift   +/-    Shift   +/-    Shift   +/-    Shift   +/-
LATITUDE]  (sec)   (m)    (sec)   (m)    (sec)   (m)    (sec)   (m)    (sec)   (m)    (sec)   (m)    (sec)   (m)
        ===================================================================================================
        ]
45 06 00]    .176   .008    .176   .008    .176   .008    .176   .008    .176   .007    .176   .007    .176   .007
        ] -1.256   .003  -1.257   .003  -1.258   .003  -1.259   .003  -1.260   .003  -1.261   .003  -1.262   .003
        ]
45 05 30]    .176   .008    .176   .008    .176   .008    .176   .008    .176   .007    .176   .007    .176   .005
        ] -1.256   .003  -1.257   .003  -1.258   .003  -1.259   .003  -1.260   .003  -1.261   .003  -1.261   .005
        ]
45 05 00]    .176   .008    .176   .008    .176   .007    .176   .006    .176   .005    .176   .005    .176   .005
        ] -1.255   .003  -1.256   .003  -1.257   .004  -1.258   .005  -1.258   .005  -1.259   .005  -1.260   .005
        ]
45 04 30]    .175   .004    .176   .004    .176   .004    .176   .004    .176   .005    .176   .004    .176   .005
        ] -1.254   .005  -1.255   .005  -1.256   .004  -1.257   .004  -1.258   .004  -1.259   .002  -1.260   .002
        ]
45 04 00]    .176   .003    .176   .003    .176   .004    .176   .004    .176   .004    .176   .004    .176   .005
        ] -1.254   .001  -1.255   .001  -1.256   .002  -1.257   .002  -1.258   .002  -1.259   .002  -1.260   .002
        ]
45 03 30]    .175   .003    .176   .003    .175   .003    .176   .004    .176   .004    .176   .004    .176   .004
        ] -1.253   .001  -1.254   .001  -1.256   .001  -1.257   .002  -1.258   .002  -1.259   .002  -1.259   .002
        ]
45 03 00]    .175   .004    .175   .004    .175   .003    .175   .004    .176   .004    .176   .004    .176   .004
        ] -1.253   .001  -1.254   .001  -1.255   .001  -1.256   .002  -1.257   .002  -1.258   .002  -1.259   .002
        ]
45 02 30]    .175   .003    .175   .003    .175   .003    .175   .003    .175   .004    .175   .004    .176   .004
        ] -1.253   .001  -1.254   .001  -1.255   .001  -1.256   .001  -1.257   .002  -1.258   .002  -1.259   .002
        ]
45 02 00]    .175   .002    .175   .003    .175   .003    .175   .003    .175   .004    .175   .004    .176   .004
        ] -1.253   .001  -1.254   .001  -1.255   .001  -1.256   .001  -1.257   .002  -1.258   .002  -1.259   .002
        ]
45 01 30]    .175   .002    .175   .002    .175   .003    .175   .003    .175   .003    .175   .004    .175   .004
        ] -1.253   .001  -1.254   .001  -1.255   .001  -1.256   .001  -1.257   .001  -1.258   .002  -1.259   .002
        ]
45 01 00]    .175   .002    .175   .002    .175   .002    .175   .003    .175   .003    .175   .004    .175   .005
        ] -1.253   .001  -1.254   .001  -1.255   .001  -1.256   .001  -1.257   .001  -1.258   .002  -1.259   .002
        ]
45 00 30]    .175   .001    .175   .002    .175   .002    .175   .003    .175   .004    .175   .005    .175   .003
        ] -1.253   .001  -1.254   .001  -1.255   .001  -1.256   .001  -1.257   .002  -1.258   .002  -1.259   .002
        ]
45 00 00]    .175   .002    .175   .003    .175   .002    .175   .002    .175   .005    .175   .003    .175   .002
        ] -1.253   .001  -1.254   .001  -1.255   .001  -1.256   .001  -1.257   .002  -1.258   .001  -1.259   .001
```

GETTING STARTED: 5) Program READDA

Software for Migrating the Grid Shift File

The primary use for program **READDA** (**Read D**irect **A**ccess File) is to convert the Grid Shift File from binary to ASCII format and then back again. This is usually only done when porting the Grid Shift File from one computer platform to another, such as from DOS to UNIX. It is mainly a developers' tool, and most users will not have any need for it.

READDA will also provide a summary list of file contents, or perform some rudimentary integrity checks on the sub-files.

The FORTRAN source code for programs INTGRID, INTTAB, and READDA is provided, and must be compiled on the destination platform. After doing this, use READDA to convert the Grid Shift File from binary to ASCII format. Then copy it to the new platform, and convert it back to binary format using READDA in that location.

This overview is a quick look at the basic operation of the program. For more complete detail on the variety of functions and their operation, see the **Reference Section** for program INTTAB.

Upon starting the program, a series of brief information screens is displayed. After reading the message on each screen, respond with a carriage return [CR] to view the next screen, or type a [Q] to proceed directly to the main menu, which will appear after the last information screen has been dismissed.

The menu for program READDA appears as follows:

```
        National Transformation
        Program READDA V2 FILE Menu

        ----------------------------------------
        Input Grid Shift File (      )        [G]
        Output Listing File                   [O]
        ----------------------------------------
        List Header Information               [L] No
        Convert Binary to ASCII               [C] No
        ----------------------------------------
        View Header Information               [V]
        Execute READDA                        [X]
        Exit from program                     [Q]
        Information Screens                   [H]
        ----------------------------------------
        Select a menu item
```

GETTING STARTED: 5) Program READDA (cont'd)

Software for Migrating the Grid Shift File

The following is a list of the key menu items for basic operation:

[G]   Specifies the **grid shift file** to be used (e.g. **NTv2_0.gsb**)

[O]   Specifies the output **listing file** to be opened.

[C]   **Converts** the grid shift file between binary and ASCII formats.

[X]   Proceed with **execution**.

When the [G] option is selected, a prompt will appear requesting the user to indicate whether the grid shift file to be opened is binary or ASCII format, as follows:

```
Opening Grid Shift File
=======================

Is this file Binary    [CR]
             ASCII     [1]
```

After specifying the grid shift file and the output file, the user can proceed by selecting the [X] designator. READDA gives an opportunity to go back to the menu to check the selected options before proceeding with execution. Prompts will appear for any necessary files that have not been opened.

Reference Section

Detailed Information

on

Programs

and

Data Formats

REFERENCE: 1) Data Formats

Input Formats for Program INTGRID

The National Transformation program **INTGRID** will accept input either from the **Keyboard** or from a **File**.

Keyboard input can be in the form of geographic coordinates (latitude & longitude) in degrees, minutes, and seconds or transverse Mercator (TM) coordinates (Northing & Easting) in metres. Prompts are issued to enter coordinate information. As with menu items, responses are entered in free format, with commas as separators if necessary, followed by a carriage return to complete the entry.

File input must be in one of the built-in formats that INTGRID recognizes. Formats may not be mixed in the same file. The following five record formats are available:

1) GHOST format geographic coordinate records (degrees, minutes, seconds) **(Default)**
2) GHOST format transverse Mercator coordinate records (metres)
3) Delimited ASCII geographic coordinate records (degrees, minutes, seconds)
4) Delimited ASCII geographic coordinate records (decimal degrees)
5) Delimited ASCII transverse Mercator coordinate records (metres)

Users wishing to accommodate other formats may modify the INTGRID source code to their own specifications (see **Developer's Guide** for more information).

For **GHOST formatted records**, if column one is non-blank then the record is treated as a comment or other data, and written "as is" to the output file. Program INTGRID also looks for blanks and data in specific columns to validate a record. Although the GHOST format is very strict, this requirement only applies to the coordinate fields - all other fields are treated as descriptive information, and are reproduced on the output record.

Delimited ASCII records have fields in strings with separators between them, and are not required to be in specific column ranges. This permits greater freedom and flexibility for handling data from other systems. All fields must be supplied on the delimited ASCII record, and separated by one of the standard FORTRAN delimiters, such as:

- comma   ' , '
- slash   ' / '
- blanks   ' '

REFERENCE: 1) Data Formats (cont'd)

Input Formats for Program INTGRID (cont'd)

Alpha (character) fields must be enclosed by single quotes for input. This applies only to the Station ID field (first field) for each of the three delimited ASCII formats. If the Station ID is completely numeric, the quotes may be omitted. Extra blank spaces may be inserted for readability, as done by INTGRID on the output records. No comment records are permitted with the delimited ASCII file formats.

Each of the five formats is described in more detail on the next few pages, followed by a summary of the possible combinations of input and output formats.

REFERENCE: 1) Data Formats (cont'd)

Input Formats for Program INTGRID (cont'd)

1) GHOST format geographic coordinate record

GHOST is the least-squares survey network adjustment system of the Geodetic Survey Division. The coordinate record used here is the standard one used by all GHOST library routines. Some users may wish to modify the format specifications in the source code to suit their own data.

Although the complete record specification is given, **only the latitude and longitude fields are used to transform the point**. All other column ranges (i.e. columns 1-40 and 71-80) are reproduced on output, and are given only for completeness of the GHOST format specification**.** Latitude and longitude must be in the stipulated columns or the record will not be processed. Decimal points should be included in the "seconds" fields to prevent misinterpretation based on the default decimal offset.

Columns			Field Description
2	-	3	Coordinate record type (Default is 04)
4	-	6	Coordinate data type
7	-	15	Station number (unique identifier of point)
16	-	30	Station name (descriptive)
32			Station classification (survey accuracy)
33	-	38	Associated network (survey project)
40			Latitude North/South indicator (Default is North)
41	**-**	**42**	**Latitude degrees**
43	**-**	**45**	**Latitude minutes**
46	**-**	**54**	**Latitude seconds**
55			Longitude East/West indicator (Default is West)
56	**-**	**58**	**Longitude degrees**
59	**-**	**61**	**Longitude minutes**
62	**-**	**70**	**Longitude seconds**
71	-	79	Station elevation (sea-level or ellipsoidal height)
80			Elevation type indicator

REFERENCE: 1) Data Formats (cont'd)

Input Formats for Program INTGRID (cont'd)

    1) **GHOST format geographic coordinate record (cont'd)**

Example Records:

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
  4   A9423                            50 58 19.85940 114 00 01.98630
  4   538134                           62 10 57.36448 136 18 09.96039
  4   D23865                           44 54 36.46115  79 46 24.05018
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

REFERENCE: 1) Data Formats (cont'd)

Input Formats for Program INTGRID (cont'd)

2) GHOST format transverse Mercator coordinate record

The GHOST format transverse Mercator (TM) coordinate record is the same as used by the Geodetic Survey GHOST library program GSRUG, which converts coordinates between geographic and TM expressions. In addition to the Northing and Easting coordinates, the record has a field for the zone number, which facilitates the use of the two common standard forms of the TM projection:

    i)   **Universal Transverse Mercator** (UTM)
- global application
- 6 degree zone widths
- standard zone numbers
- standard central meridians of zones
- scale factor at central meridian is 0.9996
- false Easting is 500 000 metres
- false Northing is 0 metres

    ii)   **Modified Transverse Mercator** (MTM or 3TM)
- unique Canadian application
- 3 degree zone widths
- standard central meridians of zones
- scale factor at central meridian is 0.9999
- false Easting is 304 800 metres
- false Northing is 0 metres

For other non-standard forms of the TM projection, the zone number is not used, and the Zone field may be left blank. All of the projection parameters must be specified explicitly in the INTGRID Transverse Mercator sub-menu (see Reference Section on program INTGRID for more details).

Although the complete record specification is given, **only the Zone, Easting, and Northing fields are used to transform the point**. All other column ranges (i.e. columns 1-50) are reproduced on output, and are given only for completeness of the GHOST format specification. Northing and Easting must be in the stipulated columns or the record will not be processed. Decimal points should be included to prevent misinterpretation based on the default decimal offset.

REFERENCE: 1) Data Formats (cont'd)

Input Formats for Program INTGRID (cont'd)

2) GHOST format transverse Mercator coordinate record (cont'd)

Columns	Field Description
2 - 3	Coordinate record type (Default is 04)
4 - 6	Coordinate data type
7 - 15	Station number (unique identifier of point)
16 - 30	Station name (descriptive)
51 - 52	**Zone number**
57 - 68	**Easting (metres)**
69 - 80	**Northing (metres)**

Example Records:

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
  4   A9423                                        11        710583.087 5650796.659
  4   538134                                        8        432173.928 6895003.176
  4   D23865                                       17        596832.904 4973481.600
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

REFERENCE: 1) Data Formats (cont'd)

Input Formats for Program INTGRID (cont'd)

3) **Delimited ASCII geographic coordinate record (degrees, minutes, seconds)**

Delimited ASCII geographic coordinate records must contain <u>all</u> of the following fields for the sexagesimal (degrees, minutes, seconds) format:

<u>Field</u>	<u>Data Type</u>
Station ID (up to 40 char.)	CHARACTER
Degrees latitude	INTEGER
Minutes latitude	INTEGER
Seconds latitude	REAL
Degrees longitude	INTEGER
Minutes longitude	INTEGER
Seconds longitude	REAL

<u>Example Records</u>:

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
'A9423',50,58,19.85940,114,0,1.98630
'538134',62,10,57.36448,136,18,9.96039
'D23865',44,54,36.46115,79,46,24.05018
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
'A9423'                                 , 50, 58, 19.85940,114,  0,  1.98630
'538134'                                , 62, 10, 57.36448,136, 18,  9.96039
'D23865'                                , 44, 54, 36.46115, 79, 46, 24.05018
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

Note that each record is shown twice - once in compressed form and once expanded for readability. The expanded form is the standard output from INTGRID.

REFERENCE: 1) Data Formats (cont'd)

Input Formats for Program INTGRID (cont'd)

4) Delimited ASCII geographic coordinate record (decimal degrees)

Delimited ASCII geographic coordinate records must contain <u>all</u> of the following fields for the decimal degrees format:

Field	Data Type
Station ID (up to 40 char.)	CHARACTER
Latitude (decimal degrees)	REAL
Longitude (decimal degrees)	REAL

<u>Example Records</u>:

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
'A9423',50.972183167,114.000551750
'538134',62.182601244,136.302766775
'D23865',44.910128097,79.773347272
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
'A9423'                                 ,      50.972183167,     114.000551750
'538134'                                ,      62.182601244,     136.302766775
'D23865'                                ,      44.910128097,      79.773347272
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

Note that each record is shown twice - once in compressed form and once expanded for readability. The expanded form is the standard output from INTGRID.

REFERENCE: 1) Data Formats (cont'd)

Input Formats for Program INTGRID (cont'd)

5) Delimited ASCII transverse Mercator coordinate record

Delimited ASCII transverse Mercator coordinate records must contain <u>all</u> of the following fields:

<u>Field</u>	<u>Data Type</u>
Station ID (up to 40 char.)	CHARACTER
Zone Number	INTEGER
Easting (metres)	REAL
Northing (metres)	REAL

Two common standard forms of the TM projection are implemented (see details in *GHOST format transverse Mercator coordinate record*, above). For other non-standard forms of the TM projection, the zone number is not used. The zone field may be left blank, but must be included on the record (blank separators will not work in this case - use a dummy zone number). All of the projection parameters must be specified explicitly in the application program.

<u>Example Records</u>:

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
'A9423',11,710583.087,5650796.659
'538134',8,432173.928,6895003.176
'D23865',17,596832.904,4973481.600
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
'A9423'                             ,11,  710583.087, 5650796.659
'538134'                            , 8,  432173.928, 6895003.176
'D23865'                            ,17,  596832.904, 4973481.600
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

Note that each record is shown twice - once in compressed form and once expanded for readability. The expanded form is the standard output from INTGRID.

REFERENCE: 1) Data Formats (cont'd)

Output Formats for Program INTGRID

Coordinate output can be written to the **terminal screen**, a **file**, or **both**, depending on the options selected by the user.

Output coordinate type will always be the same as input type:

    i.e.   Geographic input gives Geographic output, and
              Transverse Mercator input gives Transverse Mercator output.

If output is written to a file, some data format conversion is allowed as indicated by the following table:

INPUT		OUTPUT	
Type	Format	Type	Format
Geographic	Keyboard (dms)	Geographic	GHOST format Delimited ASCII (dms) Delimited ASCII (ddeg)
Geographic	GHOST format	Geographic	GHOST format Delimited ASCII (dms) Delimited ASCII (ddeg)
Geographic	Delimited ASCII (dms)	Geographic	GHOST format Delimited ASCII (dms)
Geographic	Delimited ASCII (ddeg)	Geographic	GHOST format Delimited ASCII (ddeg)
TM	Keyboard (metres)	TM	GHOST format Delimited ASCII
TM	GHOST format	TM	GHOST format Delimited ASCII
TM	Delimited ASCII	TM	GHOST format Delimited ASCII

REFERENCE: 1) Data Formats (cont'd)

Output Formats for Program INTGRID (cont'd)

The following examples show the output that corresponds to the examples from the five data formats described in the preceding sections. None of the examples incorporate a change in format between input and output. In each case, some analysis data has been appended to the output. These are only some of the possible combinations.

Example of Format 1:   input file: geo_gho.dat
                                               output file: geo_gho.new
                                               appended: accuracies(m)

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
  4   A9423                          50 58 19.85940 114 00 01.98630
  4   538134                         62 10 57.36448 136 18 09.96039
  4   D23865                         44 54 36.46115  79 46 24.05018
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
  4   A9423                          50 58 20.05899 114  0  5.54952               .005      .006
  4   538134                         62 10 56.39768 136 18 17.20148              1.571     1.114
  4   D23865                         44 54 36.64956  79 46 23.43112               .005      .004
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
```

Example of Format 2:   input file: utm_gho.dat
                                               output file: utm_gho.new
                                               appended: accuracies(m)

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
  4   A9423                          11      710583.087 5650796.659
  4   538134                          8      432173.928 6895003.176
  4   D23865                         17      596832.904 4973481.600
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
  4   A9423                          11      710506.330 5651018.486      .006      .005
  4   538134                          8      432071.338 6895176.579     1.114     1.571
  4   D23865                         17      596843.538 4973704.707      .004      .005
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
```

Example of Format 3:   input file: geo_dms.dat
                                               output file: geo_dms.new
                                               appended: shifts(sec) & accuracies(m)

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
'A9423',50,58,19.85940,114,0,1.98630
'538134',62,10,57.36448,136,18,9.96039
'D23865',44,54,36.46115,79,46,24.05018
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
A9423                             , 50, 58, 20.05899,114,  0,  5.54952,    .19959,   3.56322,     .005,     .006
538134                            , 62, 10, 56.39768,136, 18, 17.20148,   -.96680,   7.24109,    1.571,    1.114
D23865                            , 44, 54, 36.64956, 79, 46, 23.43112,    .18841,   -.61906,     .005,     .004
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
```

REFERENCE: 1) Data Formats (cont'd)

Output Formats for Program INTGRID (cont'd)

Example of Format 4:   input file: geo_ddeg.dat
                                       output file: geo_ddeg.new
                                       appended: shifts(m) & accuracies(m)

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
'A9423',50.972183167,114.000551750
'538134',62.182601244,136.302766775
'D23865',44.910128097,79.773347272
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
A9423                                  ,    50.972238608,  114.001541534,     6.168,    69.524,     .005,     .006
538134                                 ,    62.182332689,  136.304778190,   -29.931,   104.768,    1.571,    1.114
D23865                                 ,    44.910180432,   79.773175312,     5.816,   -13.580,     .005,     .004
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
```

Example of Format 5:   input file: utm_asc.dat
                                       output file: utm_asc.new
                                       appended: shifts(m) & accuracies(m)

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
'A9423',11,710583.087,5650796.659
'538134',8,432173.928,6895003.176
'D23865',17,596832.904,4973481.600
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
A9423                                  ,11,  710506.330, 5651018.486,   -76.757,   221.827,     .006,     .005
538134                                 , 8,  432071.338, 6895176.579,  -102.590,   173.403,    1.114,    1.571
D23865                                 ,17,  596843.538, 4973704.707,    10.634,   223.107,     .004,     .005
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8----+----9----+----0----+----1----+----2
```

REFERENCE: 2) Program INTGRID

Function

Program **INTGRID** (**INT**erpolate **GRID**) is used to convert geographic coordinates (latitude & longitude) or transverse Mercator (TM) coordinates (Northing & Easting) from one reference system to another.

To accomplish this, it refers to a **grid shift file**, which contains the coordinate shifts (differences) between the two systems for points at regular intervals of latitude and longitude. After determining which grid cell a point to be transformed falls within, the program looks up the shifts at the four corners of the cell, and uses bilinear interpolation to estimate the shift at the supplied point. The shifts have been modelled by a previous external procedure, and the model has been sampled at regular intervals to produce the grid shift file.

This type of procedure is appropriate for conversion between reference systems that do not have a simple systematic relationship, and thus cannot be computed by a geometric formula, such as the seven-parameter geodetic datum transformation (ΔX, ΔY, ΔZ, rX, rY, rZ, ΔS). By employing a table, shifts that are irregular, with significant local and regional variation, can be accommodated.

Transverse Mercator coordinates are handled by a multi-step procedure. The grid shift file contains shifts in arc seconds of latitude and longitude, and can only be applied directly to geographic coordinates. On input, TM coordinates are converted to geographic coordinates using the projection specifications selected by the user, and the ellipsoid parameters for the "from" reference system. The shifts are computed and applied to the geographic coordinates as described above. Then the transformed geographic coordinates are converted back to TM using the same projection specifications, but the ellipsoid parameters for the "to" reference system.

In addition to the shifts, estimated accuracies are provided for each point in the grid shift file. These accuracies are based on the consistency of the shifts at the control survey network points nearby each grid point. If the agreement among the surrounding control points is good, then good accuracy can be expected, reflected by low numerical values. If the agreement is poor, then poor accuracy can be expected, reflected by high numerical values. Like the grid shifts, the accuracy at the point to be transformed is estimated by bilinear interpolation within the four corners of the cell.

REFERENCE: 2) Program INTGRID (cont'd)

Function (cont'd)

Another type of analytical function is also available - the maximum distortion for any selected cell. The distortion is determined by computing the gradient of the plane defined by three of the four corners of the cell. Four such planes can be defined, and the steepest gradient is used to characterize the greatest distortion that might be encountered in the grid shifts. A similar distortion computation is performed for the accuracies of the shifts, which may be interpreted as the rate of change of the accuracies for the selected cell.

Analytical data, such as shifts and accuracies, are optionally appended to the output coordinate record. Either the shifts and accuracies may be appended, or the distortion of the shifts and accuracies.

Operation

Program INTGRID will do batch processing from a file or interactive processing from the keyboard. In either case, control of the many options and functions is provided by an interactive menu.

The menu and dialogue screens are based on the command line interface. The complete main menu is displayed, and the user selects a menu item by typing the indicated character, followed by a carriage return [CR]. After responding to any query generated by the selection, the user is returned to the main menu where the change is reflected, and another item may be selected. Once satisfied with all settings, the user proceeds with the computations by selecting the execute item [X].

The **main menu** provides operational control for all items necessary to specify the files and the functions to be performed. The **analysis options menu**, which is accessed as a function from the main menu, allows the user to select the type of data to be written to the output record.

REFERENCE: 2) Program INTGRID (cont'd)

Main Menu

The main menu is broken down into three sections: **File Selection**, **Data Options**, and **Action Items**. Each is described in detail. The main menu appears as follows when the program is launched:

```
NTV2 - Program INTGRID - Main Menu
----------------------------------
Input  - Grid Shift File        [G]
Input  - Coordinate File        [C] Keyboard
Output - Report Listing         [R]
Output - Coordinate File        [N]
Output - Coords Not Transformed [M]
----------------------------------
Input  - Coordinate Type        [T] GEO
Input  - from Keyboard          [K] YES
Input  - Formatted/Delimited    [I] GHOST Records
Output - Screen / File / Both   [S] Screen
Output - Formatted/Delimited    [O] GHOST Records
Direction of transformation     [D]
----------------------------------
Go to Analysis Option Menu      [A]
View Header Blocks              [V]
Go to Information Screen        [H]
Quit and exit from program      [Q]
Proceed - Transform coordinates [X]
----------------------------------
Select a menu item
```

REFERENCE: 2) Program INTGRID (cont'd)

Main Menu (cont'd)

File Selection Section

This section of the main menu controls the selection of all input and output files. The program can operate completely in interactive mode without any files, with the exception of the grid shift file, which is mandatory input. If an output file is requested for transformed coordinates and analysis data, all three output files must be specified. When proceeding with execution, the program will prompt the user for any required file that has not been opened.

Input files are opened as read-only and left unaltered after execution. Output files are opened as new files. The user is given the opportunity to re-use existing file names by appending to or over-writing the existing file.

The details of the file selection section are as follows:

```
------------------------------------
Input  - Grid Shift File       [G]
Input  - Coordinate File       [C] Keyboard
Output - Report Listing        [R]
Output - Coordinate File       [N]
Output - Coords Not Transformed [M]
------------------------------------
```

[G]   Specifies the *grid shift file*, which must be opened before any transformation computations can be performed. It is a binary file containing the shifts and accuracies between two coordinate reference systems, and is supplied with this software.

[C]   Specifies the *input coordinate file*, from which coordinates to be transformed are submitted if data entry from the keyboard is <u>not</u> selected. **Default** is **Keyboard**.

Coordinate records may be in any of the formats described in the Data Formats topic of the Reference Section, but the formats may not be mixed. Format selection is made in the Data Options section of the main menu.

The root of this file name (i.e. the part before the extension) will be used as a base file name with the appropriate extensions as suggested file names in subsequent prompts for output files to be created. Using a common name helps to identify all of the output files from one run of INTGRID. This is for convenience only, and any file names may be used as desired.

REFERENCE: 2) Program INTGRID (cont'd)

Main Menu (cont'd)

File Selection Section (cont'd)

[R]   Specifies the *report listing file*, to which all messages and tabulations generated during the execution of INTGRID are written. It must be opened if file output is selected. The **default extension** applied to the base file name is **.lis**.

[N]   Specifies the *output coordinate file*, to which the transformed coordinate records are written. It must be opened if file output is selected. Any of the formats described in the Data Formats topic of the Reference Section may be selected in the Data Options section of the main menu. The **default extension** applied to the base file name is **.new**.

[M]   Specifies the *output missing coordinate file*, to which all coordinate records are written for points that are <u>not</u> transformed because they fall outside the limits of the grid shift file. This file is deleted if empty at the end of execution. It must be opened if file output is selected. The record format will be the same as selected for the output coordinate file. The **default extension** applied to the base file name is **.mis**.

Main Menu (cont'd)

Data Options Section

This section of the main menu controls the formatting and disposition of input and output files.

The details of the data options section are as follows:

```
-----------------------------------
Input  - Coordinate Type        [T] GEO
Input  - from Keyboard          [K] YES
Input  - Formatted/Delimited    [I] GHOST Records
Output - Screen / File / Both   [S] Screen
Output - Formatted/Delimited    [O] GHOST Records
Direction of transformation     [D]
-----------------------------------
```

[T]   Toggles between the two input coordinate types: **GEO** for geographic coordinates, or **TM** for transverse Mercator coordinates. If TM is selected, a sub-menu is presented to specify the projection parameters. This sub-menu is described in detail below. Output coordinates will be the same type. **Default** is **GEO.**

[K]   Toggles between the two options for data entry: **YES** for keyboard input, or **NO** for file input. This option changes automatically to NO when an input coordinate file is specified (see File Selection Section, above). A previously opened input coordinate file is closed when this option is switched back to keyboard. **Default** is **YES**.

[I]   Toggles between the two input record formats, **GHOST records** or **Delimited ASCII**. Delimited ASCII format for geographic coordinate input can be either **Sexagesimal** (degrees, minutes and seconds) or **Decimal Degrees** - a prompt is given to provide the choice, which applies to both input and output files. **Default** is **GHOST records.**

[S]   Selects where output data will be written**:** to **File**, to the **Screen**, or to **Both** - a prompt is given to provide the choice. **Default** is **Screen**.

REFERENCE: 2) Program INTGRID (cont'd)

Main Menu (cont'd)

Data Options Section (cont'd)

[O]   Toggles between the two output record formats, **GHOST records** or **Delimited ASCII**. Delimited ASCII format for geographic coordinate input can be either **Sexagesimal** (degrees, minutes and seconds) or **Decimal Degrees** - a prompt is given to provide the choice, which applies to both input and output files. **Default** is **GHOST records.**

[D]   Toggles the direction of the transformation, which is expressed in terms of the two reference systems between which the shifts are given (i.e. "from" System A "to" System B). The direction of the transformation is embedded in the grid shift file itself, and is displayed with this option once the grid shift file has been opened (see File Selection Section, above).

The transformation can be applied in the opposite direction (i.e. "from" System B "to" System A) by changing the sign of the shift as a first approximation, and iterating the solution. This is necessary because the shifts are given with respect to System A. The corresponding System B coordinates are different by the amount of the shift, and thus the shift will be slightly different if System B coordinates are used to determine it. **Default** is the **embedded direction from the grid shift file**.

REFERENCE: 2) Program INTGRID (cont'd)

Main Menu (cont'd)

Transverse Mercator Sub-Menu

When the [T] option is selected to toggle to TM coordinates, a sub-menu is presented to specify the projection parameters.

The default values initially displayed are for the standard **Universal Transverse Mercator** (UTM) projection, which is a family of zones in six degree bands of longitude around the globe. The other standard embedded in this program is the 3-degree **Modified Transverse Mercator** (MTM or 3TM) projection. Both have standard zone numbers which must be submitted on input along with the Northing and Easting coordinates. Any other specification must supply the central meridian in this menu in lieu of submitting the zone on coordinate input.

When transverse Mercator coordinates are processed, there are actually two projection conversions that take place in addition to computing the shifts between reference systems. First, the input coordinates are converted to the corresponding geographic expression using the ellipsoid parameters of the "from" system. The shifts are computed and applied to the geographic coordinates. The transformed geographic coordinates are then converted back to the transverse Mercator projection using the new ellipsoid parameters of the "to" system.

The details of the transverse Mercator options are as follows:

```
        Select options

        Zone width                  [W]              6
        Scale factor                [S]      0.9996000
        False easting               [E]      500000.00
        False northing              [N]           0.00
        Central meridian            [C]
        Keep original zone          [K]            Yes

        End selection          [CR][Q]
```

[W]   Specifies the **Zone Width**, in degrees of longitude. If the central meridian has not been specified, 6 degrees automatically selects UTM and 3 degrees automatically selects MTM. **Default** is **6 degrees**.

REFERENCE: 2) Program INTGRID (cont'd)

Main Menu (cont'd)

Transverse Mercator Sub-Menu (cont'd)

[S]   Specifies the **Scale Factor** at the central meridian. The scale factor changes automatically to the standard value of 0.9996 for UTM if the zone width is 6 degrees, or to 0.9999 for MTM if the zone width is 3 degrees. **Default** is **0.9996**.

[E]   Specifies the **False Easting** at the central meridian. The false easting changes automatically to the standard value of 500 000 metres for UTM, or to 304 800 metres for MTM. **Default** is **500 000 metres**.

[N]   Specifies the **False Northing** at the central meridian. The false northing changes automatically to the standard value of 0 metres for UTM if the zone width is 6 degrees, and also to 0 metres for MTM if the zone width is 3 degrees. **Default** is **0 metres**.

[C]   Specifies the longitude for **Central Meridian** of the zone. The central meridian changes automatically to the standard value for the UTM zone supplied with each coordinate if the zone width is 6 degrees, or to the standard value for the MTM zone if the zone width is 3 degrees. If a value is specified for the central meridian, it overrides the standard values and any zone specification supplied with the coordinates is ignored. **Default** is **blank**, i.e. no central meridian specified.

[K]   Toggles between **keeping (Yes)** and **not keeping (No)** the same zone on output as on input, when standard projections (UTM or MTM) are used. After the shift is applied to the geographic coordinates, some points that are near zone boundaries may be shifted into the adjacent zone. This option permits either forcing the projection to take place on an extension of the original zone, or allowing it to be computed in the new default zone. The appropriate zone number is output with the coordinates. **Default** is **Yes**, i.e. keeping the original zone.

REFERENCE: 2) Program INTGRID (cont'd)

Main Menu (cont'd)

Action Items Section

Rather than selecting options, this group of commands allows the user to indicate to the program what action is to be taken next. After performing any of these actions, control of the program is always returned to the main menu. Each has its own set of dialogues and prompts.

The details of the action items section are as follows:

```
----------------------------------
Go to Analysis Option Menu      [A]
View Header Blocks              [V]
Go to Information Screen        [H]
Quit and exit from program      [Q]
Proceed - Transform coordinates [X]
----------------------------------
```

[A]   Activates the **Analysis Options Menu**, which controls the data written to the output records, such as shifts and accuracies. This sub-menu is described in detail below.

[V]   Activates the **Header Records Viewer**. It first displays the contents of the Overview Header Block, which contains data common to the entire grid shift file. It then displays a list of all the sub-file names and sequence numbers, and prompts for which Sub-file Header Block is to be viewed next. The Sub-file Header Blocks contain specific data about the contents of each sub-file. This second step is repeated until no more displays are requested.

[H]   Re-activates the series of **Information Screens** that are displayed when the program starts up. They provide a basic description of the program functions and operations.

[Q]   **Quits** and exits the program and returns control to the operating system after saving any relevant files that have been created.

[X]   Instructs the program that all option selection is complete, and to proceed to **Execute** the specified operations. Prompts will be issued for any required files that remain unopened. If coordinate input is from a file, the entire file will be processed before control is returned to the main menu.

REFERENCE: 2) Program INTGRID (cont'd)

Analysis Options Menu

The coordinate records that are output to file each have four fields at the end into which analytical data may be written. This applies to both GHOST formatted and delimited ASCII record types (see Reference Section on Data Formats). The fields are filled in pairs, corresponding to latitude and longitude. One or two pairs of data may be appended. **Default** is **Nothing added**.

Analytical data available include the coordinate shifts, accuracies of the shifts, and cell distortion. (See the Function description at the beginning of this INTGRID reference section for more information).

There is also a provision to output the same coordinates as input, which may be useful when only the analytical data is required at the input points, and not the transformed coordinates. **Default** is transformed coordinates (**Trans**).

The Analysis Options Menu is divided into two main sections, dealing with the analytical data and the output coordinates. In each section, selection of a menu item supersedes the previous selection, and the result is displayed at the top of the section. The details are as follows:

```
Analysis Option Menu
-----------------------------------
Append to Coordinate Record       Nothing added
    (units)
      Accuracy                  [A]
      Grid Shifts               [S]
      Both Shifts and Accuracy  [B]
      Cell Gradients            [G]
      Remove Append Option      [R]
-----------------------------------
Output Coordinate Record          Trans
      Transformed Record        [T]
      Input Record              [I]
-----------------------------------
Exit to Main Menu               [X]
-----------------------------------
```

[A]   Appends the **accuracies** of the latitude and longitude shifts at the input point. The accuracies are expressed in metres at the one-sigma (one standard deviation) level.

Analysis Options Menu (cont'd)

[S]   Appends the coordinate **shifts** at the input point. For geographic coordinates, the shifts may be expressed in either seconds or metres. For transverse Mercator coordinates, the shifts are expressed in metres.

             Note: Geographic coordinate shifts in metres are converted from arc seconds, and are merely an alternate expression of the shifts in latitude and longitude. They are not the same as the shifts in transverse Mercator coordinates at the same point. These differences arise from various properties of the projection which change when the reference ellipsoid is changed, including relative orientation of the plane grid due to convergence of the meridians, and the distance along the meridian from the equator on which the Northing is based.

[B]   Appends **both** the coordinate shifts and accuracies at the input point, as described above.

[G]   Appends the maximum distortion of latitude and longitude in the form of **cell gradients**, expressed in parts-per-million (ppm), for the grid cell in which the input point resides.

[R]   Cancels the selected option for appending analytical data, and reverts to the **default** of **Nothing added**.

[T]   Selects the **default** of **transformed** coordinates for output.

[I]   Selects the **input** coordinates for output.

[X]   **Exits** the Analysis Options Menu and returns to the Main Menu.

REFERENCE: 3) Program INTTAB

Function

Program **INTTAB** (**INT**erpolation **TAB**le) produces a tabular view of the **grid shift file**. For an area within a user-specified window, a table of coordinate shifts and shift accuracies at the grid points is formatted into pages with row and column headings for reference. The table is useful for gaining an appreciation of the magnitude and variability of the shifts and their accuracies over a small area of concern, and for estimating the shifts in instances where the automated form of NTv2 is not available.

The user-specified window feature of INTTAB may also be used to create a sub-set of the grid shift file. Such a sub-set has all of the properties of the original, and can be used in the same way with all of the NTv2 software. This allows a reduction in the size of the grid shift file for situations where the user's activities are concentrated in a local area. This feature has also been used by the provincial control survey agencies, partners in the development and distribution of the NTv2, to produce sub-sets just large enough to cover their provincial territory. The provincial sub-sets are more easily distributed on floppy disk.

Operation

The functions of program INTTAB are essentially a batch process, with an interactive menu which provides operational control for all items necessary to specify the files and the functions to be performed.

The menu and dialogue screens are based on the command line interface. The complete main menu is displayed, and the user selects a menu item by typing the indicated character, followed by a carriage return [CR]. After responding to any query generated by the selection, the user is returned to the main menu where the change is reflected, and another item may be selected. Once satisfied with all settings, the user proceeds with the computations by selecting the execute item [X].

After proceeding with execution, the program will prompt for the limits of the window to be used. If a user-specified limit does not fall exactly on a row or column of the grid shift file, INTTAB will automatically round the limit value up (for an upper limit) or down (for a lower limit). The specified limits must also be within the limits of the input grid shift file. The results are presented for user acceptance or modification before processing continues.

REFERENCE: 3) Program INTTAB (cont'd)

Operation (cont'd)

Once the window limits have been established, INTTAB determines which sub-files of the grid shift file are affected. If any part of a sub-file falls within the window, that portion of the data will be included. For the print table option only, any of the sub-files may be specifically omitted by the user. A summary of the affected sub-files is presented, with the option to accept all of them or to modify the list. This feature is not available for creating a sub-set of the grid shift file, since the omission of any of the sub-files will result in a loss of compatibility with the standard.

WARNING:

1) The size of the window for a tabulation and the sub-files to be included should be carefully selected to avoid producing unreasonably large listing files. For a grid with 5 minute intervals, a one-degree by one-degree quad takes two pages to present. For a densified grid with 30 second intervals, the same one-degree quad takes two hundred pages.

2) When using a table to determine shifts, careful attention is required to ensure that the proper sub-file is being used. If further densification is available, a pair of asterisks (**) appears in the table to indicate that the four grid points adjacent to the asterisks enclose a densified cell. In such a case, the table is presenting the parent grid, which is useful for a general impression only. The table for the densified grid is required for the greater detail necessary to maintain compatibility with the standard, as established by the grid shift file.

REFERENCE: 3) Program INTTAB (cont'd)

Main menu

The main menu is broken down into three sections: **File Selection**, **Function Selection**, and **Action Items**. Each is described in detail. The main menu appears as follows when the program is launched:

```
National Transformation
Program INTTAB V2 Menu
------------------------------------
Transformation grid file         [G]
Output Listing File              [O]
------------------------------------
Create a new grid file           [N] NO
Window grid file                 [W] NO
Print grid table                 [P] YES
------------------------------------
View header records              [V]
Proceed - Continue execution     [X]
Exit from program                [Q]
Information Screens              [H]
------------------------------------
Select a menu item
==================
```

REFERENCE: 3) Program INTTAB (cont'd)

Main menu (cont'd)

File Selection Section

This section of the menu controls the selection of the input and output files. The program requires the grid shift file as input, an output listing file for writing the job summary and the tabulation, and a second output file for the grid shift file sub-set. When proceeding with execution, the program will prompt the user for any required file that has not been opened.

The input file is opened as read-only and left unaltered after execution. Output files are opened as new files. The user is given the opportunity to re-use existing file names by appending to or over-writing the existing file.

The details of the file selection section are as follows:

```
-------------------------------------
 Transformation grid file        [G]
 Output Listing File             [O]
 New grid file name              [F]
-------------------------------------
```

[G]   Specifies the *grid shift file*, which must be opened before any functions can be performed. It is a binary file containing the shifts and accuracies between two coordinate reference systems, and is supplied with this software.

[O]   Specifies the *output listing file*, to which all messages and tabulations generated during the execution of INTTAB are written. The **default file name** is **INTTAB.lis**.

[F]   Specifies the *new grid shift file*, to which the windowed grid shift file is written. This option line only appears in the menu if the **Create a new grid file** option **[N]** has been selected.

REFERENCE: 3) Program INTTAB (cont'd)

Main menu (cont'd)

Function Selection Section

This section of the menu controls which of the two INTTAB functions are to be performed. Either option [N] or option [P] can be selected, but not both. This avoids generating unwanted large listing files when creating a subset of the grid shift file (see WARNING above). Option [W] works with either.

The details of the function selection section are:

```
------------------------------------
Create a new grid file        [N] NO
Window grid file              [W] NO
Print grid table              [P] YES
------------------------------------
```

[N]   Toggles the function to create a **new grid shift file** which is a subset of the input grid shift file. **Default** is **NO**.

[W]   Toggles the application of a user-specified window to control the output generated by INTTAB. This option is automatically set to **YES** when option **[N]** is selected. After option **[X]** has been selected from the action items**,** the user is prompted for the window limits and which grid shift sub-files to include (see description with WARNING in Operation Section above). **Default** is **NO**.

[P]   Toggles the function to **generate a print table** of the coordinate shifts and their accuracies. **Default** is **YES**.

REFERENCE: 3) Program INTTAB (cont'd)

Main menu (cont'd)

Action Items Section

Rather than selecting options, this group of commands allows the user to indicate to the program what action is to be taken next. After performing any of these actions, control of the program is always returned to the main menu. Each has its own set of dialogues and prompts.

The details of the action items section are as follows:

```
------------------------------------
View header records           [V]
Proceed - Continue execution  [X]
Exit from program             [Q]
Information Screens           [H]
------------------------------------
Select a menu item
==================
```

[V]   Activates the **Header Records Viewer**. It first displays the contents of the Overview Header Block, which contains data common to the entire grid shift file. It then displays a list of all the sub-file names and sequence numbers, and prompts for which Sub-file Header Block is to be viewed next. The Sub-file Header Blocks contain specific data about the contents of each sub-file. This second step is repeated until no more displays are requested.

[X]   Instructs the program that all option selection is complete, and to proceed to **Execute** the specified operations. Prompts will be issued for any required files that remain unopened. Once processing is complete, control is returned to the main menu.

[Q]   **Quits** and exits the program and returns control to the operating system after saving any relevant files that have been created.

[H]   Re-activates the series of **Information Screens** that are displayed when the program starts up. They provide a basic description of the program functions and operations.

REFERENCE: 4) Program READDA

Function

Program **READDA** (**READ D**irect **A**ccess File) was originally conceived as a utility to check the contents of the grid shift file, which is a FORTRAN binary direct-access format that cannot be viewed with a normal text editor. It performs this function in two ways: first, the information from the overview header block and all of the sub-file header blocks can be written to the output listing; and second, the entire binary file can be converted to an equivalent ASCII sequential file.

It is this second feature that makes READDA beneficial to users who wish to run NTv2 on a computer system other than the IBM/PC (MS-DOS) compatible platform for which it is delivered. The ASCII file can be easily migrated to the destination platform, where READDA can again be used to convert it back into the binary direct-access format that is usable by other NTv2 software.

NOTE: Even though it is possible to transfer binary files to other platforms that are binary-compatible with DOS (e.g. FTP/binary to UNIX), the grid shift file data will not be accessible by FORTRAN direct-access procedures. READDA <u>must</u> be used for this purpose.

Operation

The functions of program READDA are essentially a batch process, with an interactive menu which provides operational control for all items necessary to specify the files and the functions to be performed.

The menu and dialogue screens are based on the command line interface. The complete main menu is displayed, and the user selects a menu item by typing the indicated character, followed by a carriage return [CR]. After responding to any query generated by the selection, the user is returned to the main menu where the change is reflected, and another item may be selected. Once satisfied with all settings, the user proceeds with the computations by selecting the execute item [X].

REFERENCE: 4) Program READDA (cont'd)

Operation (cont'd)

In addition to converting the grid shift file for migration using READDA, the NTv2 software must also be converted. For this purpose, source code for the programs is supplied for compilation on the destination platform. This must be done for READDA before the grid shift file can be converted back to binary in that location. The source code is FORTRAN ANSI77 compliant. It has been compiled and tested on several platforms, including various UNIX systems, VAX/VMS and Mac/OS.

There are some differences that the ANSI standard does not address, such as time and date functions, and record size specification. The source code contains descriptive comments at the end of every line which is known to require changes between platforms. The comments begin with the two characters **!***, followed by a list of the platforms to which they apply. Alternate lines of code are already included for systems that have been tested.

The source code is converted by searching for the characters **!***, removing the disabling comment character **C** from the beginning of the each line for the destination platform, and placing a **C** at the beginning of each corresponding line of the original platform to disable it. The software is supplied originally as IBM/PC (MS-DOS) compatible.

The supplied changes may also be compiler-dependent, and may not work with compilers other than those tested. Consult the compiler reference manuals if problems arise. For modifications beyond porting the software "as-is" to a new platform, see the **Developer's Guide** for more information.

REFERENCE: 4) Program READDA (cont'd)

Main Menu

The main menu is broken down into three sections: **File Selection**, **Function Selection**, and **Action Items**. Each is described in detail. The main menu appears as follows when the program is launched:

```
National Transformation
Program READDA V2 FILE Menu

-----------------------------------------
Input Grid Shift File (      )        [G]
Output Listing File                   [O]
-----------------------------------------
List Header Information               [L] No
Convert Binary to ASCII               [C] No
-----------------------------------------
View Header Information               [V]
Execute READDA                        [X]
Exit from program                     [Q]
Information Screens                   [H]
-----------------------------------------
Select a menu item
```

REFERENCE: 4) Program READDA (cont'd)

Main menu (cont'd)

File Selection Section

This section of the menu controls the selection of the input and output files. The program requires the grid shift file as input, an output listing file for writing the job summary and the header block data, and a second output file for the converted grid shift file, either binary or ASCII. When proceeding with execution, the program will prompt the user for any required file that has not been opened.

The input file is opened as read-only and left unaltered after execution. Output files are opened as new files. The user is given the opportunity to re-use existing file names by appending to or over-writing the existing file.

The details of the file selection section are as follows:

```
----------------------------------------
Input Grid Shift File (binary)      [G]
Output Listing File                 [O]
Converted file (ASCII )             [T]
----------------------------------------
```

[G]   Specifies the *grid shift file*, which must be opened before any functions can be performed. Before it can be opened, the user must respond to a prompt inquiring whether it is a binary or an ASCII file. The binary file containing the shifts and accuracies between two coordinate reference systems is supplied with this software. An ASCII file would be one that the user has created from the binary file using READDA on another type of computer platform. The file type appears in the menu after the file has been opened.

[O]   Specifies the *output listing file*, to which all messages and data summaries generated during the execution of READDA are written. The **default file name** is **READDA.lis**.

[T]   Specifies the *converted file*, to which the ASCII (or binary) counterpart of the input grid shift file is written. This option line only appears in the menu if the **Convert binary to ASCII** option **[C]** has been selected.

REFERENCE: 4) Program READDA (cont'd)

Main menu (cont'd)

Function Selection Section

This section of the menu controls which of the two READDA functions are to be performed. Either option [L] or option [C] can be selected but not both. When one is selected, the other is deselected.

The details of the function selection section are:

```
-----------------------------------------
List Header Information              [L] No
Convert Binary to ASCII             [C] No
-----------------------------------------
```

[L]   Toggles the function to list the information from the overview header block and all of the sub-file header blocks. **Default** is **NO**.

[C]   Toggles the function to convert the grid shift file between its binary and ASCII equivalents. If the input file is binary, the output will be ASCII, and vice versa. **Default** is **NO**.

REFERENCE: 4) Program READDA (cont'd)

Main menu (cont'd)

Action Items Section

Rather than selecting options, this group of commands allows the user to indicate to the program what action is to be taken next. After performing any of these actions, control of the program is always returned to the main menu. Each has its own set of dialogues and prompts.

The details of the action items section are as follows:

```
----------------------------------------
View Header Information              [V]
Execute READDA                      [X]
Exit from program                   [Q]
Information Screens                 [H]
----------------------------------------
```

[V] Activates the **Header Records Viewer**. It first displays the contents of the Overview Header Block, which contains data common to the entire grid shift file. It then displays a list of all the sub-file names and sequence numbers, and prompts for which Sub-file Header Block is to be viewed next. The Sub-file Header Blocks contain specific data about the contents of each sub-file. This second step is repeated until no more displays are requested.

[X] Instructs the program that all option selection is complete, and to proceed with the specified operations. Prompts will be issued for any files necessary for basic operation that remain unopened, and a final prompt allows the user to return to the menu.

[Q] **Quits** and exits the program and returns control to the operating system after saving any relevant files that have been created.

[H] Re-activates the series of **Information Screens** that are displayed when the program starts up. They provide a basic description of the program functions and operations.