Guidelines for Transition to GDA2020

SIR Environment and Related Tools

1. Overview

DNRME is making our spatial infrastructure ready to support GDA2020. Testing of data transformations in the SIR Management Development environment has been completed and we have updated the SIR Prod environment where you are encouraged to explore your datasets in GDA2020 datum.

Activities within the SIR environment which are affected due to the transition to GDA2020 relate to:

- SIR Management (Oracle Spatial database)
- SIR Presentation (ArcGIS Server Web Services)
- Client Software (ArcGIS desktop, ArcGIS Pro, MapInfo, QGIS, other systems e.g. MMOL or tools)

The audience for these guidelines includes those who interact with SIR environment through:

1. Managing spatial data (e.g. MER data, topographic or image data etc.)
2. Providing/ managing web services (e.g. manage DCDB web service)
3. Using desktop GIS or web based tools (e.g. ArcGIS, ArcPro, Qld Globe, QSpatial etc.) to transform data.

The structure of this guidelines (Figure 1) contains SIR Management (refer to Section 2), SIR Presentation (refer to Section 3) and Datum Transformation which includes general information about datum transformation (refer to Section 4).

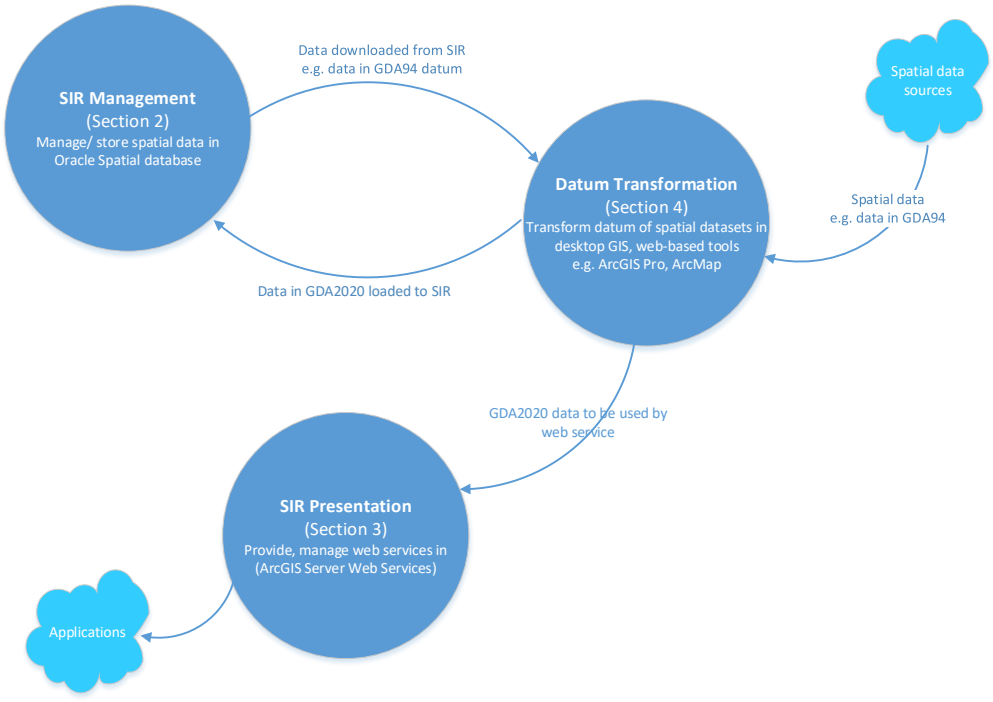

Figure 1: The structure of this guidelines.

2. SIR Management (Managing Data)

The SIR database required an Oracle upgrade to support GDA2020 including the SIR Prod environment.

2.1. Storing data in GDA94 or GDA2020?

Data will be stored in GDA94 and/or GDA2020. Currently, all data is accepted in GDA94 by default but the upgraded SIR will accept data in GDA2020 datum.

Existing datasets can remain in GDA94 (or in other datum as currently stored) until the next major update or when there is a specific business need to transform datasets to GDA2020. It is expected that datasets will be replaced with a permanently transformed GDA2020 version on next major update to the dataset. New datasets would be created in GDA2020. The capabilities of GIS will be used to view or edit the data in the desired projection (maps will be made in GDA2020).

See section 2.5 'Metadata' for more information about position accuracy criteria for deciding which data to be transformed to GDA2020.

Each business area will have to make a decision if they need to keep datasets in both datums - GDA94 and GDA2020. However, there should be a valid reason (e.g. justified by the specific business or system related needs) to store data in both datums (resulting in two datasets).

Data owners will need to develop their own processes to manage transitions to GDA2020 data and this needs to consider users of the data, including web services. It is expected that data owners will not only consider the impacts on their business teams but will also take into account all clients who access their data to ensure the approach is suitable for all where possible.

If the intention is to replace the data under the same name, then deleting and recreating the data and the arrangement of a downtime/redeployment of web services using the data will be required.

An alternative approach of loading the GDA2020 data as a new feature class/ layer with a new name (e.g. append '_GDA2020') is ***not*** recommended. (See the 'Naming convention' section below for further details)

2.2. Where will transformation occur?

No datum transformation will be performed in the SIR Management database environment (it is not configured in Oracle Spatial). Transformations between datums must be performed in the client software environment e.g. by the ESRI desktop software (generally, before data upload or after download from SIR - see Figure 1).

Refer to section '4. Datum Transformation' for more information about transformation methods and processes applicable to different spatial data types.

2.3. Loading data into SIR

In general, two methods are in use to load spatial data to SIR: using ESRI products or utilising other ETL processes.

2.3.1. Using ESRI products

In this method, data is transformed to GDA2020 and loaded using ESRI products (e.g. Project Tool or Copy Tool in ArcGIS Desktop).

DB-tune keywords

When loading spatial data which creates a new feature class in SIR's Oracle Spatial, consideration must be given to using 'dbtune keywords' in the advanced options to ensure the correct projection information is attached to the data at both the Oracle spatial level and the ArcGIS level (e.g. if loading a GDA2020 Lat/Long Oracle Spatial 2D layer into SIR the "SDO_GDA2020_2D" keyword should be used).

The list below includes the latest keywords that apply to data in GDA2020 datum loaded into the SIR environment.

Note that defining the projection information into the load tool does not remove the need to select the appropriate keyword.

The following keywords must be used for GDA2020 datasets which are in 'geographic', 'projected' or 'X, Y, Z' coordinates:

Keyword	**Description**	**EPSG code (Projected CRS)**
DEFAULTS *	"Default Keyword - SDO Geometry Storage"	_
Geographic		
SDO_GDA2020_2D	"SDO Geographic 2D GDA2020"	7844
SDO_GDA2020_3D	"SDO Geographic 3D GDA2020"	7843
Projected		
SDO_MGA52_GDA2020	"SDO MGA Zone 52 GDA2020"	7852
SDO_MGA53_GDA2020	"SDO MGA Zone 53 GDA2020"	7853
SDO_MGA54_GDA2020	"SDO MGA Zone 54 GDA2020"	7854
SDO_MGA55_GDA2020	"SDO MGA Zone 55 GDA2020"	7855
SDO_MGA56_GDA2020	"SDO MGA Zone 56 GDA2020"	7856
SDO_MGA57_GDA2020	"SDO MGA Zone 57 GDA2020"	7857
X,Y,Z		
SDO_GDA2020** *(Please read the note ** below before using this keyword)*	"SDO Geocentric GDA2020"	7842

**Definition of datum/ projection will be taken from the existing layer/ dataset.*

***** NOTE that this keyword is for the geocentric coordinate system ONLY. There must be a valid reason if you intend to store your data in XYZ (3D Cartesian) coordinate system. Currently there is no data in this coordinate system stored in SIR.*** *It refers to the geocentric coordinate system as a sphere or spheroid in a right-handed XYZ (3D Cartesian) system measured from the centre of the*

earth - coordinates are stored as 'X, Y, Z'. The geocentric coordinate system is used internally as a transient system. It is used as a framework for calculations as part of several geographic (datum) transformation methods. (Source: ESRI).

2.3.2. Using ETL processes

In this method, data will be transformed using outside transformation tools and loaded to SIR using Java or Python (e.g. used in daily process to bring DCDB data to SIR).

Geospatial Data Abstraction Library (GDAL) Java development software required upgrading to support GDA2020 in the Java libraries and enable transformations in Extract Transfer Load (ETL) scripts (data from systems into SIR).

If applicable, PROJ version 6 in GDAL library is recommended. The new functionality introduced in PROJ version 6 is now fully ready to accurately handle transformations involving the GDA2020 reference systems.

ArcPy libraries and toolboxes outputting data to GDA2020 need to be running on ArcGIS 10.6.1 or greater.

2.4. Creating geometry objects from Lat and Long before loading to SIR

When creating a new point feature class based on 'X, Y, Z' coordinates from a table the default coordinate system of the output feature class is the geographic coordinate system WGS 1984. The appropriate projected coordinate system must be specified if the fields in the source table contain projected coordinates. If projection is not specified the default keyword will be assigned.

When a 'Z' field is specified, the default coordinate system also includes the vertical coordinate system WGS 1984. If the 'Z' values are not in meters, the coordinate system must be changed to use the correct elevation unit.

If any of the input 'X' or 'Y' (or 'Z' if specified) coordinates for a feature are null or non-numeric values, the corresponding feature will be a null geometry.

2.5. Metadata

Data which was captured with positional uncertainty/ accuracy >3m does not need to be transformed (data is GDA2020 compatible). Instead, an update of metadata from the current datum to 'GDA2020' and recording that it is 'compatible' is required. This will indicate that coordinate values within the dataset were not transformed. However, if the dataset is transformed to GDA2020, therefore moved (data is GDA2020 'compliant'), it should be recorded in the metadata as such.

If a new layer is created due to datum transformation in ESRI software, the 'Update Metadata Automatically' option is enabled under 'ArcMap Options' to update the spatial reference within metadata. Users with change permission will need to be aware that automatic update will perform other updates. For example, if the user accidently opens the description tab on a layer that will also trigger an update that was not intended such as changing dates.

2.6. Naming convention

Currently, in the SIR database, some filenames have the projection definition included in the filename e.g. MGA. A filename without a projection definition indicates that the data in the file is provided as latitudes and longitudes. However, there is no indication in the feature class name of what datum this dataset is in. For example, it may be in GDA94 or other datum.

When transiting to GDA2020, coordinate reference system and datum information should be stored as a metadata for that feature class. This approach will also be applicable in future where for example, features are collected using a dynamic datum (ITRF) at an epoch and then more features are captured a year or two later using a different epoch – this information should be described in metadata.

It is recommended ***not*** *to implement datum names* into the feature class name (filename). There are only 32 characters available in a filename - the most important information the feature class name conveys is about the feature class not about the datum/ CRS.

An approach where the existing layer is replaced under the same name will require a web service redeployment. This will make the transition more complex.

2.7. Latitude and longitude in non-spatial database table

If the latitude and longitude coordinates are stored in the non-spatial database table (e.g. SCDB) an additional field will need to be created to record which datum latitude and longitude are recorded in. If coordinates need to be recorded in both GDA94 and GDA2020 their datums need to be recorded in the separate fields e.g. lat_94, long_94, lat_2020, long_2020 or, lat, long, datum (containing 'GDA94' or 'GDA2020').

If latitude and longitude values are stored in a database table but no datum information is available, either assume that all data is in GDA94 or resurvey and input new data in GDA2020.

3. SIR Presentation (Providing & Managing Services)

SIR Presentation required an upgrade to ArcGIS Server/ Enterprise 10.7.1 to include support for GDA2020 in the software so that services can be made available in GDA2020.

All shared access/open data web services will stay in WGS84 datum, Web Mercator Auxiliary Sphere projection (EPSG: 3857, WKID: 102100). The GDA94 and GDA2020 transformations to Web Mercator datum/projection is being defined as:

- Zero (no/ null) transformation from GDA94 to WGS84 then to Projection to Web Mercator Aux Sphere
- 2 hop (single step) transformation from GDA2020 through GDA94 to WGS84 then to Projection to Web Mercator Auxiliary Sphere.

This approach means that the different coordinates for the same real world point captured in GDA94 and GDA2020 transformed and projected to EPSG 3857 in web services will be co-incident and not offset.

3.1. Impact on web service users

Web service users will largely see no change as web services are deployed in Web Mercator Auxiliary Sphere on WGS84 by default.

Note that if the default datum (EPSG: 3857, WKID 102100) of a web service is overridden by requesting map images/ query data in a different datum (e.g. GDA94 or GDA2020) then an offset of 1.7m between layers stored in GDA94 and GDA2020 may occur unless a specific transformation is nominated in the web request to the service (this issue is still being investigated).

3.2. Impact on web service developers

Web service developers will need to be aware of the impacts on their services as data custodians/ owners transition the storage datum of data in SIR to GDA2020. This will generally require a redeployment of the web service, regardless of the approach being taken by the data manager.

Duplicate or new web services to handle the GDA2020 transition will not be supported unless there is a valid business reason. It is not recommended that the datum be used in the name of a web service.

Web service name should not be changed.

When building web service which uses data in GDA2020 in ESRI software:

- Datum transformation and projection will need to be selected correctly; for example, option 'GDA_1994_To_GDA2020_NTv2_3_Conformal + GDA1994_To_WGS1984' may be used when transforming two dimensional data between GDA2020 and WGS84
- Two different datums can be included in one web service e.g. GDA94 and GDA2020; data in GDA2020 will be transformed back to GDA94 and then to WGS84
- Web service developers will need to use at least ArcGIS 10.6.1 or preferably version 10.7.1 to ensure support for GDA2020 in the software.

4. Datum Transformation

4.1. Transformation methods

Two methods are available when transforming datum from GDA94 to GDA2020. These are *conformal grid* and *7 parameter transformation.* The table below specifies which method should be applied in relation to each spatial data type. Refer to links below for further details.

Transformation method	**To be used for spatial data type: ****
conformal grid (NTv2) *e.g. in ArcGIS (ArcMap, ArcGIS Pro) select Geographic Transformation: 'GDA_1994_To_GDA_2020_NTv2_3_Conformal' **	2D vector
	2D raster + AHD (imagery)
	2D raster (imagery)
	3D raster + AHD retained (point cloud)
7 parameter transformation *e.g. in ArcGIS (ArcMap, ArcGIS Pro) select Geographic Transformation: 'GDA_1994_To_GDA_2020_1'*	3D vector with ellipsoidal heights
	2D raster - height attribute/change ignored (imagery)
	3D raster with ellipsoidal heights (point cloud)
	3D raster AusGeoid converted to ellipsoidal heights (point cloud)

** Note that the 'GDA_1994_To_GDA_2020_NTv2_2_Conformal_and_Distortion' Geographic Transformation option is **not** recommended for use on Queensland data sets due to distortions at the state borders.*

*** For more information on AHD, ellipsoidal heights and GDA2020 refer to:*

- *'GDA2020 Understanding Ellipsoid Heights vs AHD Heights' factsheet*

- *Chapter 6 - GDA2020 Technical Manual*

4.2. Transformation processes

- The factsheets about datum transformation processes can be downloaded from 'DNRME Resources' through the following links:

  vector data

  raster data

- A factsheet about publishing data in GDA2020 process can be downloaded from 'DNRME Resources' here.
- Further datum transformation resources can be accessed on 'GDA2020 in Queensland' page of the DNRME website.
- GDA2020 Technical Manual

4.3. Transformation examples in ESRI ArcGIS desktop

General

*ArcGIS 10.6.1 – **key considerations** when transforming 2D and 3D data*

1. When loading feature classes to SIR environment, make sure to select appropriate keyword on Configuration Keyword under Geodatabase Setting (see section '2.3.1. GDA2020 data keywords')
2. If not already using the Advanced (ArcInfo) Concurrent Use licence run ArcGIS Administrator to change license type. Arc applications must be closed to be able to change the desktop license into Advanced (ArcInfo) Concurrent Use level. (Please confirm if you need to perform this step.)
3. In ArcGIS products transformation methods are listed as:
   a. GDA_1994_To_GDA2020_1 : seven-parameter similarity transformation
   b. GDA_1994_To_GDA2020_NTv2_3_Conformal : Conformal grid
   c. GDA_1994_To_GDA2020_NTv2_2 _Conformal + Distortion: Conformal grid plus distortion ***(note: not to be used for QLD data)***
4. In using the Project Geoprocessing tool to transform to GDA2020 relevant options must be selected:
   a. Output Coordinate System: e.g. GDA2020
   b. Geographic Transformation (optional): e.g. GDA_1994_To_GDA2020_NTv2_3_Conformal
      (This drop-down list parameter is required if the input and output coordinate systems have different datum).
5. To transform map grid (projected) - MGA94 to a different map grid - MGA2020 the following will happen:
   1. Grid to Geographic - MGA94 to GDA94
   2. Datum transformation - GDA94 to GDA2020
   3. Geographic to Grid conversion - GDA2020 to MGA 2020.

   However, in ArcGIS / ArcMap the above 3 step process can be executed in one step. See Example 1.

To transform geographic coordinate system - GDA94 to a different geographic coordinate system - GDA2020 the following will happen:

1. Datum transformation - GDA94 to GDA 2020 (note there is no projection step here). See Example 2.

6. When transforming GDA2020 data to WGS84, ESRI has created a two-step process where GDA2020 data is first transformed to GDA94, and then to WGS84 (Generic). There is a NULL transformation. This process ensures GDA2020 and GDA94 data align on publication. See Example 3.
7. In displaying GDA94 data in GDA2020 map frame, under the Data Frame properties specify the transformation to use before the GDA94 data is projected dynamically ('on-the-fly') to GDA2020. This can also be done after the GDA94 data has been loaded. See Example 4.

Example 1

For example, in order to *transform the 2D file which is in GDA94 datum and projected to MGA Zone 55 coordinate system to GDA2020 MGA Zone 55*, perform the following steps in ArcMap's Project Geoprocessing tool:

1. Select 'Input Dataset or Feature Class' to be transformed e.g. scroll down to select filename
2. 'Input Coordinate System' will be displayed as GDA_1994_MGA_Zone_55
3. 'Output Dataset or Feature Class' location is displayed; change or accept it
4. Select 'Output Coordinate System': Projected Coordinate System → National Grids→ Australia → GDA2020 MGA Zone 55
5. Select 'Geographic Transformation' from the pull down list: GDA_1994_To_GDA2020_NTv2_3_Conformal *
6. Select OK
7. Transformation of datum and projection will be performed.

* Conformal grid (NTv2) - see section 4.1 Transformation methods

Example 2

In order to transform the *3D file which is in GCS GDA94 (geographic coordinate system - data in latitude and longitude) to GDA2020*, perform the following steps in ArcMap's Project Geoprocessing tool:

1. Select 'Input Dataset or Feature Class' to be transformed e.g. scroll down to select filename

2. 'Input Coordinate System' will be displayed as GCS_GDA_1994
2. 'Output Dataset or Feature Class' location is displayed; change or accept it
3. Select 'Output Coordinate System': Geographic Coordinate System → Australia and New Zealand → GDA2020
4. Select geographic transformation from the pull down list: GDA_1994_To_GDA2020_1 **
5. Select OK
6. Transformation of datum will be performed.

* * 7 parameter similarity transformation - see section 4.1 Transformation methods

Example 3

In order to transform the *3D file which is in GCS GDA2020 to WGS84*, perform the following steps in ArcMap's Project Geoprocessing tool:

7. Select 'Input Dataset or Feature Class' to be transformed e.g. scroll down to select filename
8. 'Input Coordinate System' is displayed as GCS_GDA_2020
9. 'Output Dataset or Feature Class' location is displayed; change or accept it
10. Select 'Output Coordinate System': Geographic Coordinate System → World → WGS 1984
11. Select 'Geographic Transformation' from the pull down list: GDA_1994_To_GDA2020_1 + GDA_1994_To_WGS_1984
12. Select OK
13. Transformation of datum will be performed.

Note : The EPSG 8450 code is a NULL transformation between GDA2020 and WGS84 (Generic). EPSG code 1150 is a NULL transformation between GDA94 and WGS84 (Generic). If these codes were to be used to combine GDA94 and GDA2020 data in WGS84 (Generic) before moving to Web-Mercator, data will not align correctly. ESRI have chosen not to implement EPSG code 8450, and instead have created a two-step process where GDA2020 data is first transformed to GDA94, and then to WGS84 (Generic). This process ensures GDA2020 and GDA94 data align on publication. The issue of using NULL transformations to move data to WGS84 (Generic), and then the further projection to Web Mercator is being actively discussed internationally.

For more information on 'GDA94, GDA2020 and WGS84; The projection dilemma' topic see ESRI blog

Example 4

ArcMap can *perform on-the-fly transformation* (note the term projection on-the-fly is also used in ESRI software products). This means ArcMap can display data stored in one projection as if it were in another projection. To transform data 'on the fly' the ESRI transformation parameters must be set in Data Frame Properties.

For example, in displaying imagery WGS84 data in GDA2020 map frame, under the Data Frame properties the transformation to use should be specified. In general, this is done before the WGS84 data is projected dynamically to GDA2020.

1. In Data Frame Properties, under the Coordinate System tab select 'Transformations…'
2. 'Convert from:' displays the current coordinate system e.g. GCS_WGS_1984
3. Click 'Add…' button to select 'Into:' option (this will open the Spatial Reference Properties window)
4. Select 'Output Coordinate System': Geographic Coordinate System → Australia and New Zealand → GDA2020
5. Click OK
6. In 'Using (choices…):' option select 'Transformation Method':

   e.g. GDA_1994_To_WGS_1984 + GDA_1994_To_GDA2020_NTv2_3 Conformal ***

7. Click OK and then OK again – transformation parameters in Data Frame will be set to GDA2020.

*** See section 4.1 Transformation methods

Note: The transformation name can go in the opposite direction. ArcMap applies the transformation in either direction with equal accuracy.