A Dawning Realisation: GDA2020 and the Surveying and Spatial Information Regulation 2017

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ABSTRACT

The Geocentric Datum of Australia 2020 (GDA2020) was enabled for NSW via the Survey Control Information Management System (SCIMS) on 1 July 2019. Amendments to the Surveying and Spatial Information Act 2002 ("the Act") and the Surveying and Spatial Information Regulation 2017 ("the Regulation") came into force on 1 January 2020, legislating GDA2020 to be the official datum for NSW. Survey plans having a date of survey on or after 1 January 2020 that are required by the Regulation to adopt an accurate Map Grid of Australia (MGA) orientation must adopt a GDA2020 orientation. This paper outlines the legislation changes, how they apply to surveys and survey plans under the Regulation, and a practical perspective on the use of SCIMS Online for cadastral purposes. Included are examples of how to use uncertainties and approved schedule changes, discussion of the new general exemption policy 2020-94 and use of the new 'GridCalc (GDA2020) for NSW' spreadsheet.

KEYWORDS: *Regulation, GDA2020, orientation, SCIMS, uncertainties.*

1 INTRODUCTION

The Geocentric Datum of Australia 2020 (GDA2020) was adopted as the national datum on 11 October 2017 (Federal Legislation, 2017). Amendments to the Surveying and Spatial Information Act 2002 ("the Act") (NSW Legislation, 2020a) and the Surveying and Spatial Information Regulation 2017 ("the Regulation") (NSW Legislation, 2020b) came into force on 1 January 2020, legislating GDA2020 to be the official datum for NSW.

For survey plans lodged on public record within NSW, the Regulation requires the datum line of orientation for the majority of those plans to be aligned to the Map Grid of Australia (MGA) and report an MGA position to, at a minimum, Class D standard. In particular, *all* rural surveys and the majority of urban surveys must have an MGA orientation and MGA position.

As the official datum for NSW is now GDA2020, the MGA coordinates adopted by, or reported on, NSW survey plans lodged on public record must be MGA2020 coordinates. Section 1.6 of the GDA2020 technical manual (ICSM, 2020) provides a technical definition of MGA2020 coordinates.

This paper describes some legislative changes, a brief description of the uncertainty values reported by the Survey Control Information Management System (SCIMS), use of SCIMS Online for cadastral purposes, the updated approved coordinate and height schedules, the Exemption Policy 2020-94, the new 'GridCalc (GDA2020) for NSW' spreadsheet and the differences expected for datum lines between GDA94 and GDA2020.

2 LEGISLATIVE CHANGES

Amendments to the Act and the Regulation came into force on 1 January 2020, legislating GDA2020 to be the official datum for NSW. While enabling GDA2020 as the official datum for NSW, the amendments also streamlined the process for any future NSW state datum changes in response to national datum changes.

Definitions for the "Geocentric Datum of Australia" and "Australian Height Datum" in section 3 of the Act were amended so that they referred to the definition for these terms in the Regulation. The Regulation was amended so that the above terms, and their definitions, were inserted into clause 5 of the Regulation. The definition of "Geocentric Datum of Australia" was amended to refer to GDA2020.

3 UNCERTAINTY VALUES REPORTED BY SCIMS

In 2002, the Intergovernmental Committee on Surveying and Mapping (ICSM) adopted Positional Uncertainty (PU) and Local Uncertainty (LU) as methods to classify the accuracy of coordinates while Class remained unchanged (Janssen et al., 2019).

The Standards and Practices for Control Surveys (SP1) version 1.7 (ICSM, 2007) defines PU as "the uncertainty of the coordinates or height of a point, in metres, at the 95% confidence level, with respect to the defined reference frame" and LU as "the average measure, in metres at the 95% confidence level, of the relative uncertainty of the coordinates, or height, of a point(s), with respect to the survey connections to adjacent points in the defined frame."

SCIMS reports the quality of coordinates in the new GDA2020 using Class, Horizontal Positional Uncertainty (HPU), Vertical Positional Uncertainty (VPU), Horizontal Local Uncertainty (HLU), Vertical Local Uncertainty (VLU), AHD-PU and AHD-LU. For more detail regarding PU and LU in SCIMS, the reader is referred to Janssen et al. (2019).

4 USE OF SCIMS ONLINE FOR CADASTRAL PURPOSES

While there are many and various pieces of information contained in a SCIMS report, there is usually only a small subset that comprises the minimum required by cadastral surveyors in NSW for completion of a land survey plan. Typically, the priority of a cadastral surveyor completing a land survey plan is to determine the position of any established survey marks so that the orientation of the datum line required by the Regulation can be determined.

Currently, the determiners of what constitutes an "established survey mark" as defined under clause 5 of the Regulation can be summarised as:

- The mark must be a "survey mark" as defined in clause 27 of the Regulation.
- The mark must be described in SCIMS as having a horizontal position equal to or better than Class D.

As an example, the intersection of two lines painted on a tennis court being an imaging control point (CP) reported as Class D in SCIMS is *not* an established survey mark as the form and style of the mark is *not* a "survey mark" as defined in clause 27 of the Regulation.

Currently, the second determiner above of an "established survey mark" remains the Class as reported in SCIMS. However, it is intended that the future definition will include a HPU range. This is dependant on sufficient marks in the State's Survey Control Network being populated with HPU. Within the Regulation currently in force, HPU is only explicitly stipulated in clause 70(2)(c) regarding the accuracy of coordinates to be shown in the coordinate schedule, though PU is now part of the approved coordinate and height schedules (see section 5 of this paper).

It should be noted that LU is not used as a stipulation in either the Regulation or Surveyor-General's Direction No. 7 (Surveying and Spatial Information Regulation 2017 – Applications) (NSW Spatial Services, 2019). Surveyors must not show LU on survey plans. LU is only intended as a client service for surveyors by providing "a single summary measure of how well the subject mark fits into the existing local network" (Janssen et al., 2019). As an example, HLU might assist surveyors in choosing established survey marks to connect to in a land survey prior to fieldwork, via assessment of their likely compliance under clause 12(7) of the Regulation (connection comparisons exceeding 40 mm + 175 ppm).

5 UPDATED COORDINATE AND HEIGHT SCHEDULES

With the adoption of GDA2020 as the official datum for NSW, the approved coordinate and height schedules have been updated to reflect the removal of Order as a coordinate quality. The only change to the schedules is the replacement of Order with PU (Figures 1 & 2).

COORDINATE SCHEDULE						
MARK	MGA COORDINATES		CLASS	PU	METHOD	STATE
	EASTING	NORTHING				
TS 5112	744 967.495	6 298 524.697	2A	0.02	SCIMS	FOUND
SS 29508	745 309.567	6 299 025.436	C	N/A	SCIMS	FOUND
PM 78165	744 323.423	6 298 970.037	B	N/A	SCIMS	FOUND
SS 205652	744 084.045	6 299 017.814	C	N/A	CAD. TRAV	PLACED
SS 195799	744 061.715	6 298 879.024	C	N/A	CAD.TRAV	FOUND
DATE OF SCIMS COORDINATES: 1-1-2020 MGA ZONE: 55 MGA DATUM: GDA2020						
COMBINED SCALE FACTOR: 1.000223						

Figure 1: New GDA2020 approved coordinate schedule example.

HEIGHT SCHEDULE					
MARK	AHD VALUE	CLASS	PU	HEIGHT DATUM VALIDATION	STATE
PM 3570	680.182	LA	0.01	SCIMS ADOPTED	FOUND
PM 3571	691.290	LA	0.01	FROM SCIMS - DATUM VALIDATION	FOUND
SS 57633	682.201	LD	N/A		FOUND
BM 3	680.128	LD	N/A		PLACED
DATE OF SCIMS AHD VALUES: 1-1-2020 HEIGHT DATUM: AHD71					

Figure 2: New approved height schedule example.

"For established survey marks, the Class and PU as shown in SCIMS is required to be shown; if the PU is reported in SCIMS as null (empty), "N/A" should be shown for PU. For survey marks with MGA coordinates or heights determined by the surveyor (excluding established survey marks), Class is required to be shown and *PU is optional*. If the surveyor does not wish to show PU in this case, "N/A" should be placed in the PU column" (NSW Spatial Services, 2019). Section 3.31.3 of Surveyor-General's Direction No. 7 (NSW Spatial Services, 2019) has further detail regarding the determination of PU.

For further detail and examples regarding the GDA2020 approved schedules required to be shown on a survey plan, the reader is referred to section 3.31 of Surveyor-General's Direction No.7 (NSW Spatial Services, 2019).

6 EXEMPTION POLICY 2020-94

From 1 January 2020, survey plans required to adopt an "accurate MGA orientation" under the Regulation must adopt MGA2020 coordinates unless an exemption applies. To enable a smooth transition between the GDA94 and GDA2020 datums for survey plans, a general exemption policy, "Policy 2020-94 Exemption" has been made available. "A Policy 2020-94 Exemption allows a survey plan with a date of survey between 1 January 2020 and 30 June 2020 (inclusive) to adopt, as orientation of the datum line, the grid bearing derived from the MGA94 coordinates of two survey marks" (NSW Spatial Services, 2019).

Survey plans proposing to apply a "Policy 2020-94 Exemption" *must* adopt an "accurate MGA orientation" under the Regulation and *must* have a date of survey between 1 January 2020 and 30 June 2020 (inclusive). Plans of survey with a date of survey after 30 June 2020 adopting MGA94 coordinates will require a plan-specific exemption. For further detail regarding the "Policy 2020-94 Exemption", the reader is referred to section 3.34.6 of Surveyor-General's Direction No.7 (NSW Spatial Services, 2019).

7 'GridCalc (GDA2020) for NSW' SPREADSHEET

Following on from the 'GridCalc (GDA94) for NSW' spreadsheet (NSW Spatial Services, 2018), a GDA2020 version of the spreadsheet has been developed by the Office of the Surveyor-General (NSW Spatial Services, 2020). The 'GridCalc (GDA2020) for NSW' spreadsheet has a subset of the AUSGeoid2020 model embedded within, allowing rigorous calculation of geodetic elements including grid bearings, a ground distance and Combined Scale Factor (CSF).

Use of the 'GridCalc (GDA2020) for NSW' spreadsheet requires input of MGA2020 coordinates, their projection zone and Australian Height Datum 1971 (AHD71) heights. Use of MGA94 coordinates with the 'GridCalc (GDA2020) for NSW' spreadsheet will result in incorrect AUSGeoid values (N-values) though the impact on the grid bearings, ground distance and CSF will be negligible for the majority of cadastral surveys (compared to the results obtained from the 'GridCalc (GDA94) for NSW' spreadsheet using the same MGA94 coordinates).

It should be noted that the grid bearing, ground distance and CSF for a line computed using MGA94 coordinates from SCIMS might differ from those same elements computed using

MGA2020 coordinates from SCIMS due to small differences in relativity between the coordinates expressed in the different datums in SCIMS (see section 8).

8 DATUM LINE DIFFERENCES GDA94 TO GDA2020

Lines between established survey marks that might, for example, be adopted as datum lines of orientation for survey plans, will show small differences in relativity (grid bearing, ground distance and CSF) when comparing SCIMS MGA94 coordinate pair calculations with SCIMS MGA2020 coordinate pair calculations for the same line. The differences are present due to the differing adjustment and transformation methodologies between the GDA94 and GDA2020 datasets within SCIMS.

The Office of the Surveyor-General has investigated these differences so that cadastral surveyors can be aware of the difference values that might be expected in the transition from GDA94 to GDA2020.

8.1 Methodology

The methodology employed to examine line pair differences between SCIMS MGA94 and SCIMS MGA2020 was as follows:

1. Use only established survey marks to examine line pairs.
2. Divide line distances into three distance ‘bins’:
   (a) 100 m to 1,000 m
   (b) 1,000 m to 5,000 m
   (c) 5,000 m to 15,000 m
3. Determine random pairs of established survey marks for examination, i.e. 5,000 random pairs for each bin comprising:
   (a) 1,000 random pairs from MGA zone 54 for each bin
   (b) 2,000 random pairs from MGA zones 55 and 56 for each bin
4. Retrieve the MGA94 coordinates, MGA2020 coordinates and AHD71 values from SCIMS for each random pair generated.
5. Enter the MGA94 coordinates and AHD71 values into the ‘GridCalc (GDA94) for NSW’ spreadsheet and retrieve the grid bearings, ground distance and CSF for the line.
6. Enter the MGA2020 coordinates and AHD71 values into the ‘GridCalc (GDA2020) for NSW’ spreadsheet and retrieve the grid bearings, ground distance and CSF for the line.
7. Calculate and visualise relevant statistics for the differences found.

The above procedure was automated using the interpreted high-level programming language Python.

8.2 Results

It should be noted that for the purposes of plotting clarity, each of the distributions below shows the majority of each dataset rather than its entirety. Very few outliers were found and are considered anomalies that have been resolved in the GDA2020 state adjustment or are being investigated.

8.2.1 Distances 100 m to 1,000 m

The distributions for the 100 m to 1,000 m line pairs (Figures 3 & 4, Table 1) represent the distance bin in which the majority of datum lines found on survey plans would fall.

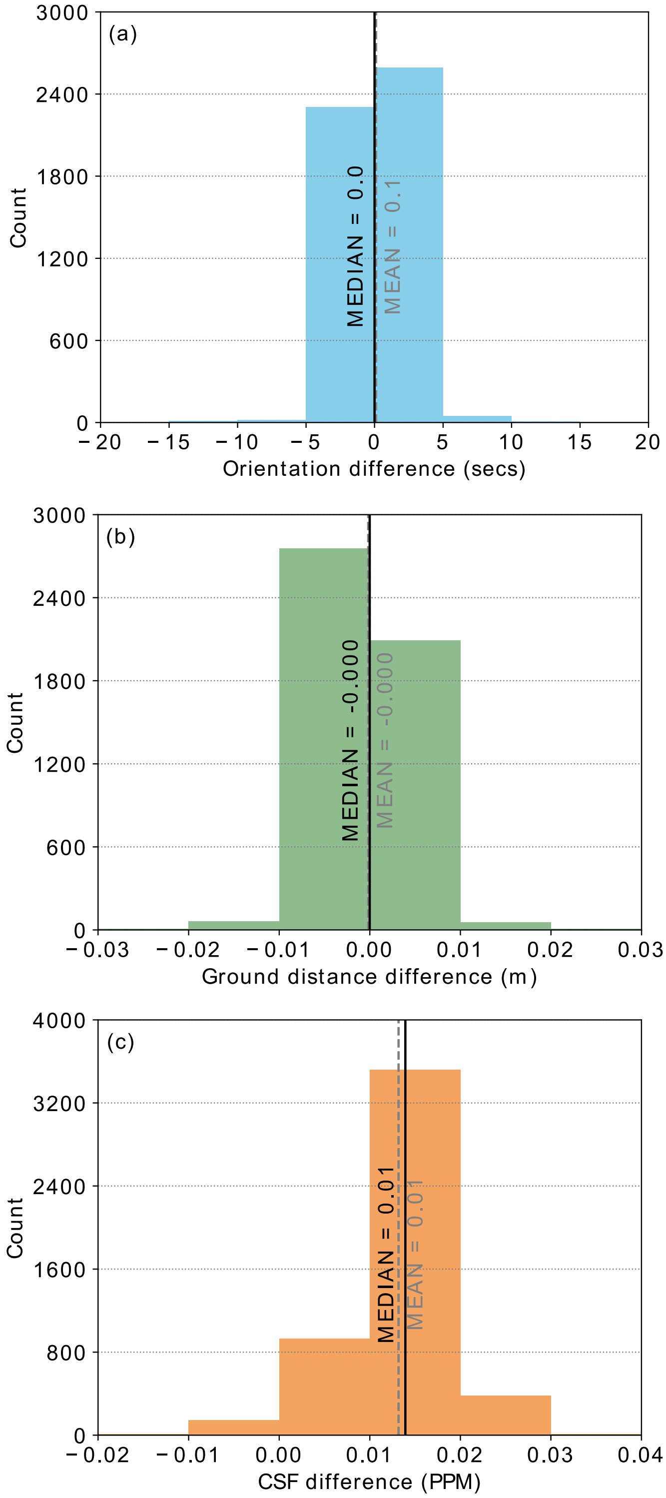

Figure 3: Distribution of (a) orientation difference, (b) ground distance difference and (c) CSF difference values between 5,000 pairs of SCIMS MGA94 and MGA2020 lines of length within 100 m to 1,000 m.

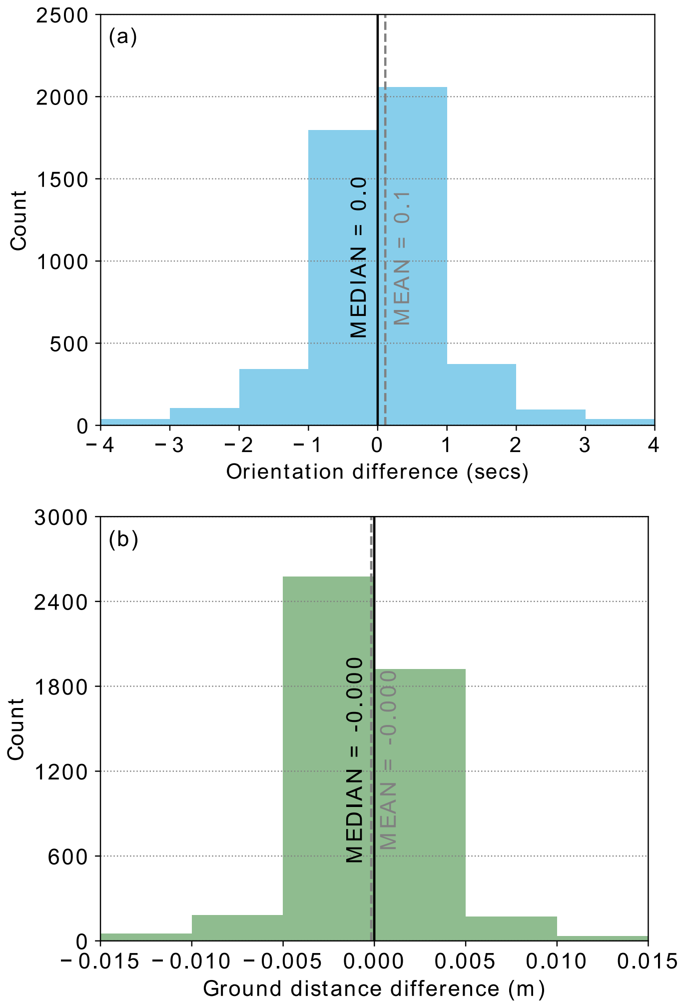

Figure 4: Higher resolution distribution of (a) orientation difference and (b) ground distance difference values between 5,000 pairs of SCIMS MGA94 and MGA2020 lines of length within 100 m to 1,000 m.

Table 1: Statistics for the differences in the 100 m to 1,000 m pair distance bin. IQR is the Interquartile Range.

Quantity	**Mean**	**Median**	**Std. Dev.**	**IQR**
Grid bearing differences (sec)	0.1	0.0	4.8	0.9
Ground distance differences (m)	0.0	0.0	0.008	0.002
CSF differences (PPM)	0.01	0.01	0.01	0.01

It can be seen from Figures 3 & 4 and Table 1 that the orientation differences for the 100 m to 1,000 m distance bin can be considered minor to negligible in a cadastral context, with the majority of differences falling between -1 second of arc and +1 second of arc. Similarly, the ground distances show only minor differences with the majority of differences falling between -0.005 m and +0.005 m. The CSF shows extremely small differences with the majority falling between -0.02 and +0.02 parts per million (PPM), which is negligible in a cadastral context and can be attributed mainly to the effect of the difference between AUSGeoid09 and AUSGeoid2020 values on the height factor component of the CSF.

8.2.2 Distances 1,000 m to 5,000 m

The distributions for the 1,000 m to 5,000 m line pairs (Figures 5 & 6, Table 2) represent the distance bin in which a minority of datum lines found on survey plans would fall.

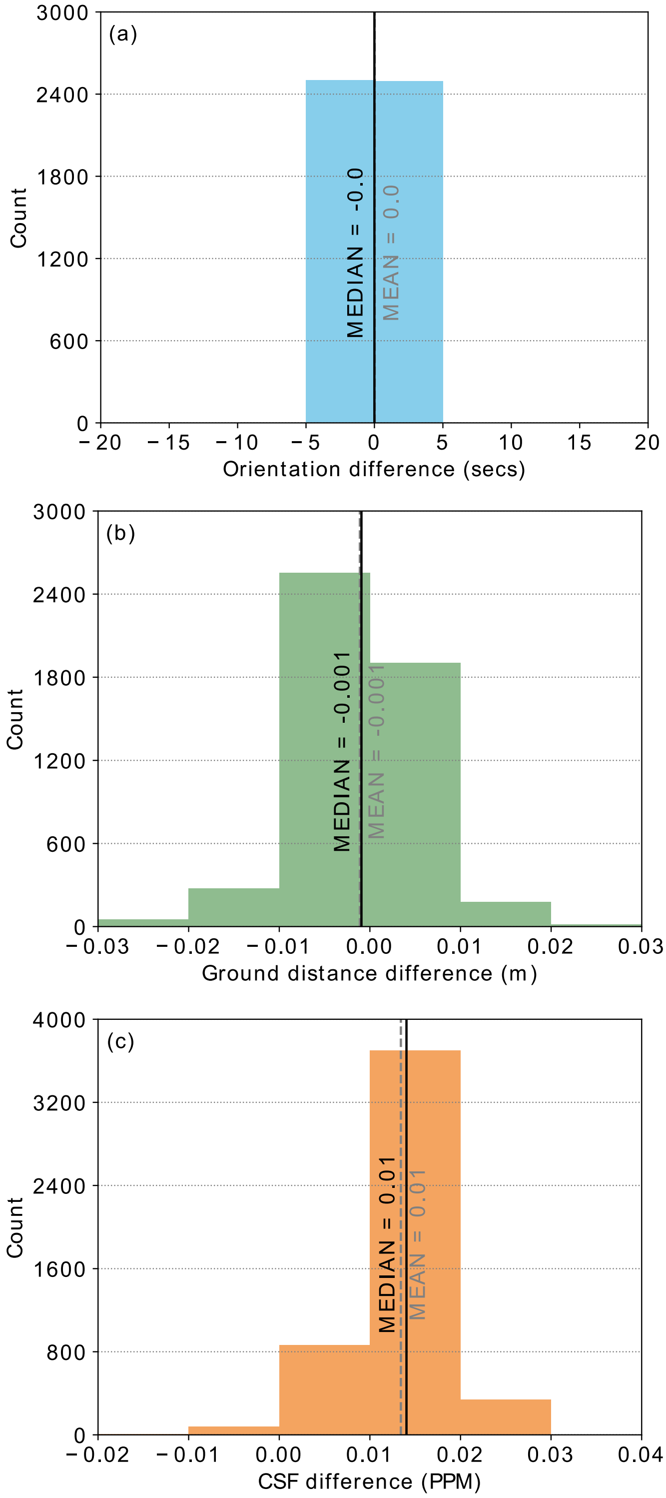

Figure 5: Distribution of (a) orientation difference, (b) ground distance difference and (c) CSF difference values between 5,000 pairs of SCIMS MGA94 and MGA2020 lines of length within 1,000 m to 5,000 m.

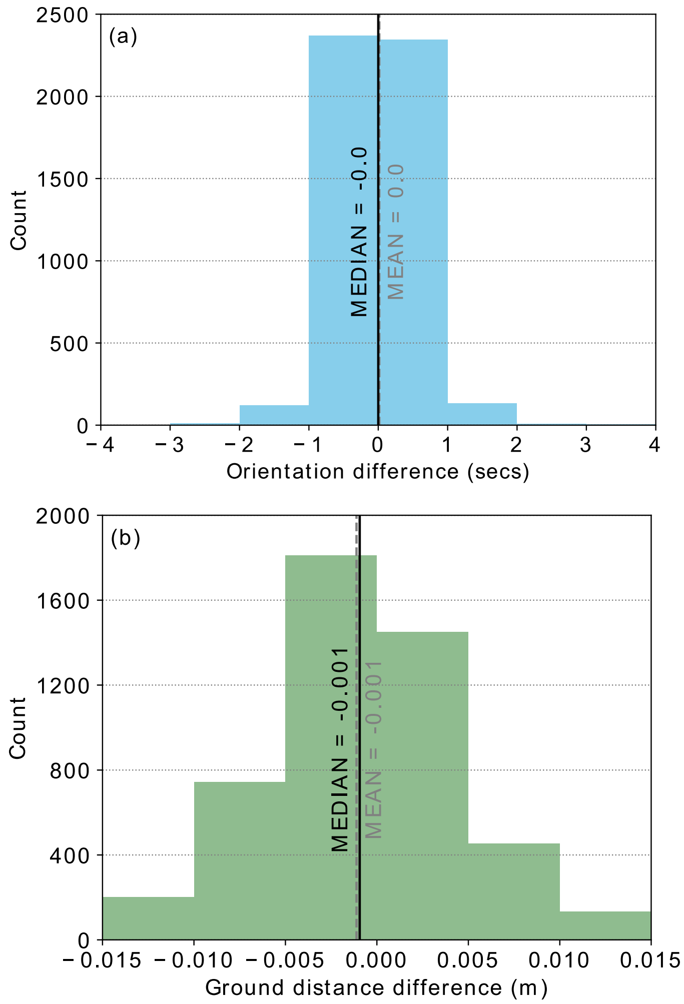

Figure 6: Higher resolution distribution of (a) orientation difference and (b) ground distance difference values between 5,000 pairs of SCIMS MGA94 and MGA2020 lines of length within 1,000 m to 5,000 m.

Table 2: Statistics for the differences in the 1,000 m to 5,000 m pair distance bin. IQR is the Interquartile Range.

Quantity	Mean	Median	Std. Dev.	IQR
Grid bearing differences (sec)	0.0	0.0	0.9	0.5
Ground distance differences (m)	-0.001	-0.001	0.007	0.007
CSF differences (PPM)	0.01	0.01	0.01	0.01

Again, it can be seen from Figures 5 & 6 and Table 2 that the majority of orientation differences for the 1,000 m to 5,000 m distance bin can be considered minor to negligible in a cadastral context. As expected, the orientation difference distribution shows a tighter grouping than the 100 m to 1,000 m bin due to the lesser impact of relative differences on orientation over a longer line. As before, the majority of ground distances show only minor differences with the distribution showing a slightly larger spread, which can be attributed to the longer distances spanning disparate adjustments in GDA94 with greater frequency. The CSF differences are again negligible.

8.2.3 Distances 5,000 m to 15,000 m

The distributions for the 5,000 m to 15,000 m line pairs (Figure 7 and Table 3) represent the distance bin in which very few datum lines found on survey plans would fall.

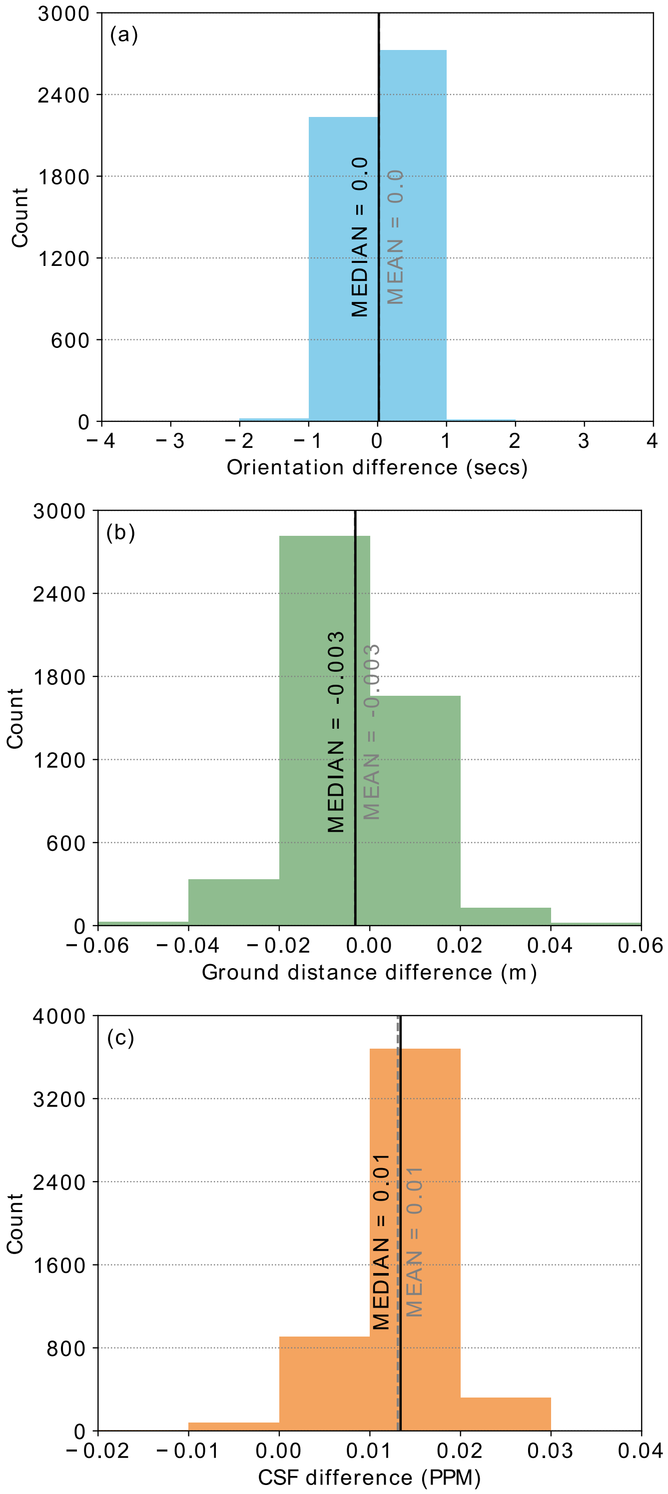

Figure 7: Distribution of (a) orientation difference, (b) ground distance difference and (c) CSF difference values between 5,000 pairs of SCIMS MGA94 and MGA2020 lines of length within 5,000 m to 15,000 m.

Table 3: Statistics for the differences in the 5,000 m to 15,000 m pair distance bin. IQR is the Interquartile Range.

Quantity	**Mean**	**Median**	**Std. Dev.**	**IQR**
Grid bearing differences (sec)	0.0	0.0	0.3	0.2
Ground distance differences (m)	-0.003	-0.003	0.013	0.013
CSF differences (PPM)	0.01	0.01	0.01	0.01

As found for the prior two distance bins, it can be seen from Figure 7 and Table 3 that the majority of orientation differences for the 5,000 m to 15,000 m distance bin can be considered minor to negligible in a cadastral context. As expected, the orientation distribution shows the tightest grouping of the three distance bins. Again, the majority of ground distances show only minor differences with the distribution having the largest spread of the three distance bins due to the frequency with which the longer distances span disparate adjustments in GDA94. The CSF differences are again negligible.

9 CONCLUDING REMARKS

Much effort has been expended to ensure the transition from GDA94 to GDA2020 for cadastral surveyors producing survey plans under the Regulation should be smooth and orderly with only minor alterations to workflow needed. The relevant legislation has been amended to enable GDA2020 and to streamline future datum changes.

Minor changes to approved schedules under the Regulation have been detailed and are available to all surveyors, as is the general "Exemption Policy 2020-94", giving a soft transition from GDA94 to GDA2020. The 'GridCalc (GDA2020) for NSW' spreadsheet is available to allow easy calculation of the grid bearings, ground distance and the Combined Scale Factor for a chosen MGA2020 line. Differences in orientation, ground distance and the CSF between MGA94 and MGA2020 for the vast majority of NSW survey plan datum lines should be minor to negligible. Given the above, cadastral surveyors can begin to adopt GDA2020 as a survey plan orientation with little alteration to their workflows for a smooth transition to a GDA2020 enabled cadastre.

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