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NGS Multi-Year CORS Solution (MYCS)
A Case Study in Oregon

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Introduction

This case study and report was prepared at the request of the NGS Spatial Reference System Division MYCS Team in an effort to investigate the MYCS CORS station coordinates located throughout Oregon. The network adjustment tests performed are an attempt to provide an independent comparison of the MYCS positions of eleven CORS stations (see Table 1) against both the published datasheet positions (NGSIDB) and concurrent (ten day) averaged OPUS-Static solutions.

MYCS: NAD 83(CORS96A)Epoch 2010
vs.
Published Datasheet (NGSIDB): NAD 83(CORS96)Epoch 2002
and
OPUS-S Solution Mean(August 1-10, 2010): NAD 83(CORS96)Epoch 2002

The primary purpose of this study is to evaluate this MYCS coordinate sample for future suitable replacement of the current OPUS-Static derived positions used by the Oregon Real-time GPS Network (ORGN). The Oregon Department of Transportation, Geometronics Unit real time network management team has established best practices that specify that the ORGN coordinate system be aligned with the National Spatial Reference System (NSRS). Testing the MYCS CORS positions to see how well they fit together will give insight into similar future NAD 83(CORS96A)Epoch 2010 positions when the MYCS is implemented through a combination of a new software engine for OPUS called OPUS-Net and a new version release of HTDP. Currently, the ORGN management team plans to re-position the real-time network (RTN) within six months after CORS96A is available to the public. A secondary purpose was to test the MYCS positions on the northwest coast of the U.S. where tectonic plate movement produces significant velocities with respect to the more stable part of the continent east of the Cascade Mountain Range.

Goal

The goal was to test the three sets of solutions comparing each NAD 83 realization to see which network fit together best within itself. These results were not dependent on any other NGS MYCS testing. Every attempt was made to compare each adjustment using the same criteria, processing, and fixed constraints. Originally the plan was to compare the MYCS positions against a subset of the current Oregon Real-time GPS Network (ORGN) positions. This was not possible as only one MYCS CORS station (REDM) was common with the ORGN CORS stations. The MYCS stations provided, represent only those CORS sites within Oregon that have a minimum of three years of data stored on NGS servers thus allowing the MYCS process analysis. Additionally, the results of this study may provide insight into the quality of a future constrained adjustment of the full ORGN network.

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Common Procedures

All baseline processing and adjustment solutions are based on the following data, criteria, and methodology:

1. All antenna measurements were set at 0.000m at the Antenna Reference Point (ARP)
2. Antenna names taken from current log files or as corrected (Table 2.)
3. Absolute antenna models used (NGS)
4. Based on 10 day, 24 hour RINEX files (August 1-10, 2010)
5. Baseline processing saved out before the adjustments were performed
6. Precise ephemerides used (NGS)
7. Performed in third party software (Trimble Geomatics Office v. 1.63) independent of NGS software
8. Achieved 100 percent processed baseline loop closure for 3 leg triangles (Table 3.)
9. All errors reported at the 95% confidence level
10. Points held fixed in all adjustments were consistent and subjectively chosen based on their relative network position and known quality of the CORS station (choosing other stations may yield slightly different results)
11. All final adjustments produced a network reference factor of 1.0 with sufficient degrees of freedom to pass the chi-square test.
12. An unconstrained adjustment was performed to see how well the baseline observations fit within themselves (not shown).
13. Constrained adjustments (beginning on page 5) were performed with 1, 3, and 5 points fixed to understand the full affect when comparing the three different network results.

Table 1. **MYCS coordinates (supplied by NGS Spatial Reference System Division MYCS Team).**

SITE	LATITUDE (N)			LONGITUDE (W)			HT	X	Y	Z	Vx	Vy	Vz
BURN	42	46	46.188550	117	50	36.651830	1181.5006	-2190266.292	-4146573.251	4310356.992	1.99	3.16	-0.06
CABL	42	50	9.943030	124	33	47.986070	38.2843	-2657527.712	-3857585.53	4314193.292	11.93	3.47	10.9
CHZZ	45	29	11.441140	123	58	41.183650	51.1570	-2503335.714	-3714408.607	4525454.799	13.26	1.68	6.91
CORV	44	35	7.913010	123	18	16.516930	107.4991	-2498423.108	-3802822.033	4454737.759	8.44	2.78	4.88
DDSN	43	7	7.633560	123	14	39.212080	953.5800	-2556648.807	-3900394.718	4337795.532	5.03	5.05	5.59
FTS1*	~~46~~	~~12~~	~~17.581460~~	~~123~~	~~57~~	~~21.878600~~	~~-13.6069~~	~~-2469884.406~~	~~-3667816.173~~	~~4581028.203~~	~~13.7~~	~~-1~~	~~7.59~~
MDMT	42	25	6.013880	121	13	17.707890	1711.0742	-2445075.743	-4033869.421	4281176.498	1.6	4.26	3.54
NEWP*	~~44~~	~~35~~	~~6.075350~~	~~124~~	~~3~~	~~42.733130~~	~~22.1936~~	~~-2548453.858~~	~~-3769451.665~~	~~4454637.477~~	~~12.37~~	~~1.39~~	~~7.15~~
ORK1*	~~42~~	~~17~~	~~19.718270~~	~~121~~	~~40~~	~~9.541170~~	~~1258.6986~~	~~-2481437.712~~	~~-4022606.833~~	~~4270236.624~~	~~1.52~~	~~1.86~~	~~5.72~~
ORK2*	~~42~~	~~17~~	~~19.705200~~	~~121~~	~~40~~	~~10.701370~~	~~1258.6674~~	~~-2481460.468~~	~~-4022593.087~~	~~4270236.305~~	~~0.78~~	~~3.55~~	~~4.67~~
ORS1	44	9	51.274000	119	3	31.460480	1438.1199	-2226385.024	-4006811.876	4422203.084	3.06	2.24	1.28
ORS2	44	9	50.882490	119	3	30.350220	1439.0132	-2226367.858	-4006831.781	4422195.037	3.3	2.44	1.11
P367	44	35	6.873050	124	3	41.595930	23.2790	-2548423.828	-3769452.036	4454655.776	12.2	2.53	6.52
P376	44	56	28.315860	123	6	8.099260	181.2334	-2469806.123	-3788349.772	4482853.368	8.52	2.65	4.81
REDM	44	15	35.146710	121	8	52.314910	920.3443	-2366948.81	-3916334.906	4429451.078	4.47	2.99	1.73

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*FTS1, NEWP, ORK1 and ORK2 were decommissioned in 2007-8. They were not used in this analysis.

These MYCS positions are derived from the reprocessing of the full 16 year time series and a rigorous stacking of weekly estimates in a fully consistent, global framework. For more information on the MYCS see: http://beta.ngs.noaa.gov/myear/

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Table 2. **Antenna model names used in processing**

Site	Antenna (Log file)	Correction/Addition
BURN	TRM29659.00 DOME	UNAV CLEAR DOME
CABL	TRM29659.00 SCIT	
CHZZ	TRM59800.00 NONE	SCIT RAY DOME
CORV	ASH700936E C NONE	
DDSN	TRM29659.00 UNAV	
MDMT	ASH701945B M SCIS	
ORS1	ASH701945E M SCIT	
ORS2	ASH701945E M SCIT	
P367	TRM29659.00 SCIT	
P376	TRM29659.00 SCIT	
REDM	TRM29659.00 NONE	

Baseline Processing

All baselines were processed, loop closures completed and then the project was saved and copied before further network adjustment in each of three datum realizations identified in the introduction. Baselines that did not meet the loop closure requirement (0.030m horiz. and 0.050m vert.) were disabled. For the purposes of this investigation, performing the loop closure analysis provided informative statistics on the baseline vector interrelationships as shown in table 3 below.

Table 3. **Loop Closure Report**

Report includes active solutions only.
Report applies to whole database.

Legs in loop: 3
Number of Loops: 4291
Number Passed: 4291
Number Failed: 0

	Length	ΔHoriz	ΔVert	PPM
Pass/Fail Criteria		0.030m	0.050m	
Best		0.000m	0.000m	0.001
Worst		0.030m	0.048m	0.116
Average Loop	497493.57155m	0.006m	0.005m	0.025
Standard Deviation	92082.28524m	0.006m	0.012m	0.017

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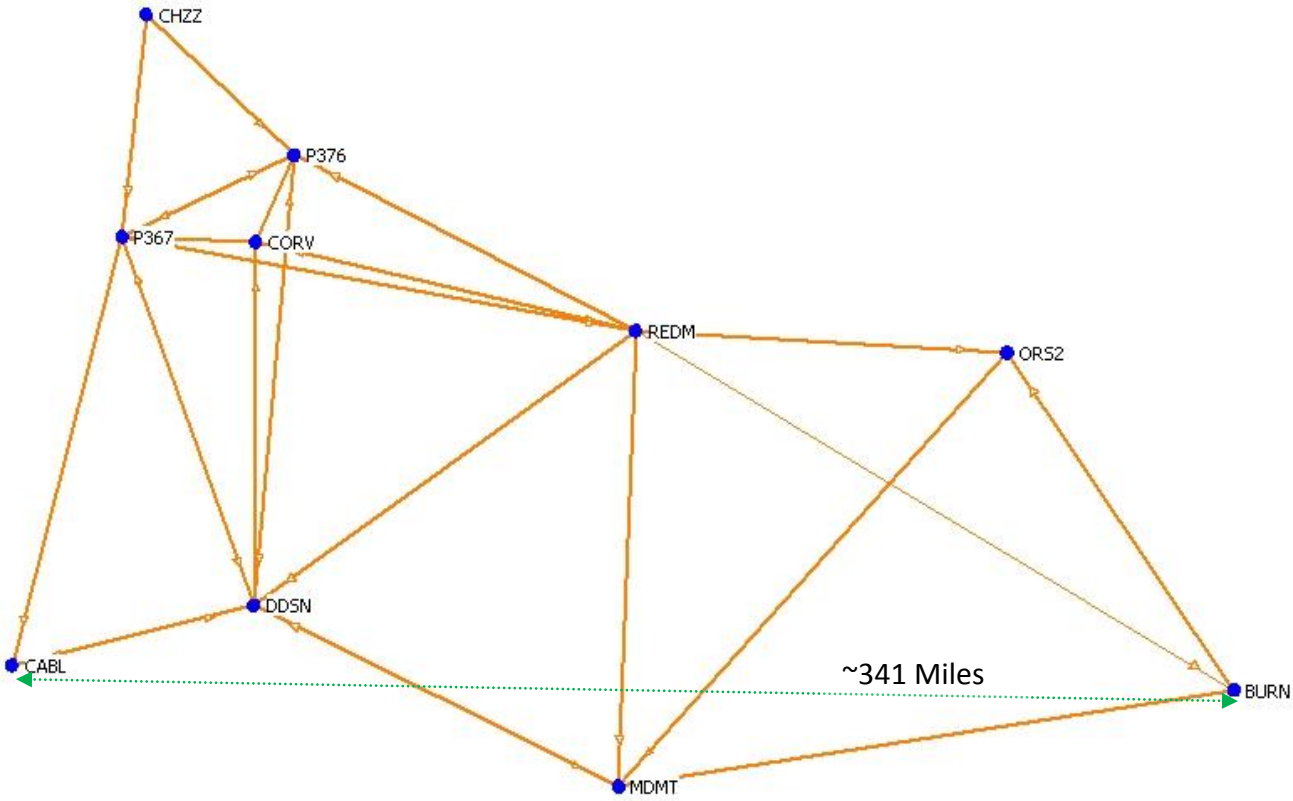
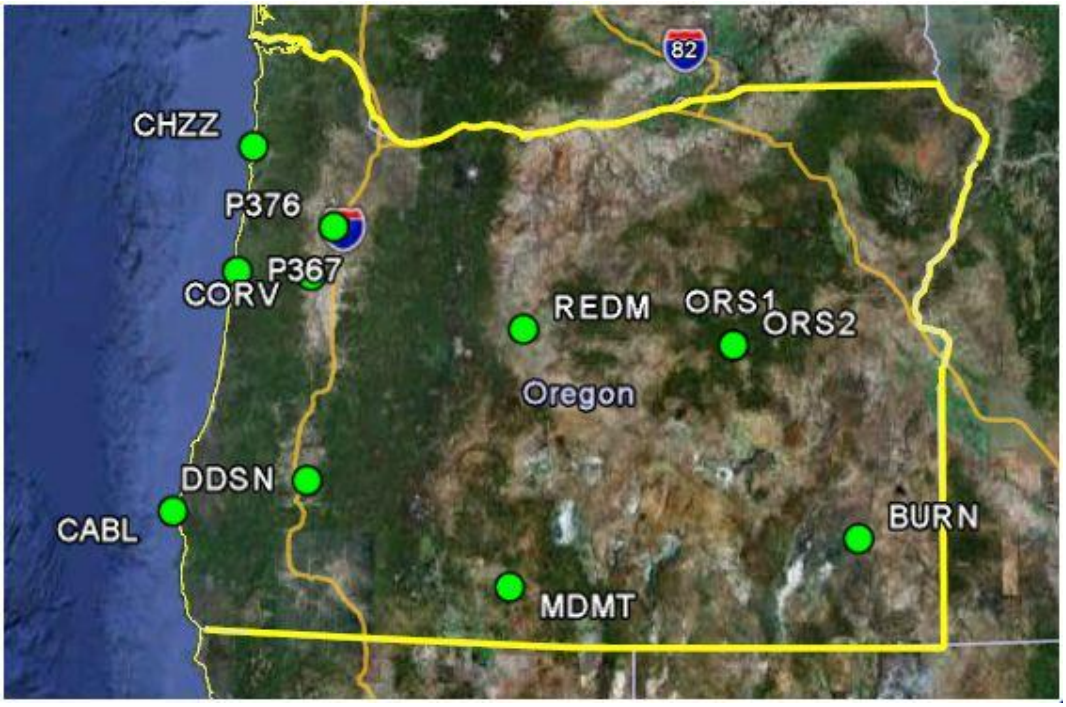


Figure 1. **Oregon CORS baseline network (above); Google Earth snapshot of CORS sites (below)**



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Adjustment Results

Table 4. **MYCS: NAD 83(CORS96A)Epoch 2010 - *Minimally Constrained Adjustment (1 Point)***

Adjusted Geodetic Coordinates

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
BURN	42°46'46.18853"N	0.002m	117°50'36.65215"W	0.002m	1181.450m	0.007m	
MDMT	42°25'06.01413"N	0.002m	121°13'17.70794"W	0.002m	1711.002m	0.006m	
ORS1	44°09'51.27400"N	0.002m	119°03'31.46049"W	0.002m	1438.070m	0.006m	
ORS2	44°09'50.88250"N	0.002m	119°03'30.35024"W	0.002m	1438.967m	0.006m	
P367	44°35'06.87346"N	0.002m	124°03'41.59558"W	0.002m	23.233m	0.006m	
CABL	42°50'09.94369"N	0.002m	124°33'47.98576"W	0.002m	38.226m	0.007m	
CHZZ	45°29'11.44127"N	0.003m	123°58'41.18330"W	0.003m	51.093m	0.012m	
P376	44°56'28.31623"N	0.002m	123°06'08.09922"W	0.002m	181.196m	0.006m	
DDSN	43°07'07.63385"N	0.002m	123°14'39.21205"W	0.001m	953.525m	0.006m	
REDM	44°15'35.14671"N	0.000m	121°08'52.31491"W	0.000m	920.344m	0.000m	Lat Long h
CORV	44°35'07.91324"N	0.002m	123°18'16.51670"W	0.002m	107.466m	0.007m	

Table 5. **MYCS: NAD 83(CORS96A)Epoch 2010 - *Constrained Adjustment (3 Point)***

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
BURN	42°46'46.18855"N	0.000m	117°50'36.65183"W	0.000m	1181.501m	0.000m	Lat Long h
MDMT	42°25'06.01401"N	0.002m	121°13'17.70762"W	0.002m	1711.153m	0.021m	
ORS1	44°09'51.27415"N	0.002m	119°03'31.46036"W	0.002m	1438.032m	0.011m	
ORS2	44°09'50.88266"N	0.002m	119°03'30.35011"W	0.002m	1438.929m	0.011m	
P367	44°35'06.87305"N	0.000m	124°03'41.59593"W	0.000m	23.279m	0.000m	Lat Long h
CABL	42°50'09.94318"N	0.002m	124°33'47.98579"W	0.002m	38.423m	0.024m	
CHZZ	45°29'11.44096"N	0.003m	123°58'41.18380"W	0.003m	51.064m	0.018m	
P376	44°56'28.31600"N	0.001m	123°06'08.09953"W	0.001m	181.190m	0.008m	
DDSN	43°07'07.63349"N	0.001m	123°14'39.21204"W	0.001m	953.669m	0.017m	
REDM	44°15'35.14671"N	0.000m	121°08'52.31491"W	0.000m	920.344m	0.000m	Lat Long h
CORV	44°35'07.91299"N	0.002m	123°18'16.51696"W	0.002m	107.493m	0.007m	

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Table 6. **MYCS: NAD 83(CORS96A)Epoch 2010 - *Constrained Adjustment (5 Point)***

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
BURN	42°46'46.18855"N	0.000m	117°50'36.65183"W	0.000m	1181.501m	0.000m	Lat Long h
MDMT	42°25'06.01388"N	0.000m	121°13'17.70789"W	0.000m	1711.074m	0.000m	Lat Long h
ORS1	44°09'51.27410"N	0.002m	119°03'31.46032"W	0.002m	1438.077m	0.010m	
ORS2	44°09'50.88261"N	0.002m	119°03'30.35007"W	0.002m	1438.974m	0.010m	
P367	44°35'06.87317"N	0.002m	124°03'41.59600"W	0.002m	23.248m	0.009m	
CABL	42°50'09.94303"N	0.000m	124°33'47.98607"W	0.000m	38.284m	0.000m	Lat Long h
CHZZ	45°29'11.44114"N	0.000m	123°58'41.18365"W	0.000m	51.157m	0.000m	Lat Long h
P376	44°56'28.31608"N	0.002m	123°06'08.09955"W	0.002m	181.202m	0.010m	
DDSN	43°07'07.63345"N	0.001m	123°14'39.21223"W	0.001m	953.574m	0.007m	
REDM	44°15'35.14671"N	0.000m	121°08'52.31491"W	0.000m	920.344m	0.000m	Lat Long h
CORV	44°35'07.91305"N	0.002m	123°18'16.51703"W	0.002m	107.477m	0.012m	

Table 7. **MYCS: NAD 83(CORS96A)Epoch 2010 - *Control coordinates minus adjusted coordinates***

Values shown are control coord minus adjusted coord.

Point Name	ΔNorthing	ΔEasting	ΔElevation	ΔHeight
BURN	N/A	N/A	N/A	N/A
MDMT	N/A	N/A	N/A	N/A
ORS1	-0.003m	-0.004m	N/A	0.042m
ORS2	-0.004m	-0.003m	N/A	0.039m
P367	-0.004m	0.001m	N/A	0.031m
CABL	N/A	N/A	N/A	N/A
CHZZ	N/A	N/A	N/A	N/A
P376	-0.007m	0.006m	N/A	0.031m
DDSN	0.003m	0.003m	N/A	0.006m
REDM	N/A	N/A	N/A	N/A
CORV	-0.001m	0.002m	N/A	0.021m

Table 8. **MYCS: NAD 83(CORS96A)Epoch 2010 - *Adjustment transformation details***

GPS Observations

GPS Transformation Group: <GPS Default>

Deflection in Longitude	: -0°00'00.0056"	**(1.96σ)**	: 0°00'00.0067"
Deflection in Latitude	: 0°00'00.0471"	**(1.96σ)**	: 0°00'00.0086"
Azimuth Rotation	: 0°00'00.0048"	**(1.96σ)**	: 0°00'00.0010"
Network Scale	: 0.99999997	**(1.96σ)**	: 0.00000000

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Table 9. **MYCS: NAD 83(CORS96A)Epoch 2010 Summary (Average Error)**

	N error	E error	h error
1 Point Constrained*	0.0021m	0.0020m	**0.0069m**
3 Points Constrained	0.0019m	0.0019m	0.0146m
5 Points Constrained	**0.0018m**	**0.0018m**	0.0097m

* A free network adjustment in which only enough constraints to define the coordinate system are employed. Used to measure internal consistency in observations.
Summary results showing average error NEh for unconstrained stations
Smallest error results shown in red

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Table 10. **Published NGSIDB: NAD 83(CORS96)Epoch 2002 - *Minimally Constrained Adjustment (1 Point)***

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
BURN	42°46'46.18695"N	0.002m	117°50'36.65357"W	0.002m	1181.472m	0.006m	
MDMT	42°25'06.01255"N	0.002m	121°13'17.70927"W	0.002m	1711.024m	0.006m	
ORS1	44°09'51.27242"N	0.002m	119°03'31.46187"W	0.002m	1438.092m	0.005m	
ORS2	44°09'50.88093"N	0.002m	119°03'30.35162"W	0.002m	1438.989m	0.005m	
P367	44°35'06.87188"N	0.002m	124°03'41.59683"W	0.002m	23.255m	0.005m	
CABL	42°50'09.94211"N	0.002m	124°33'47.98700"W	0.002m	38.249m	0.006m	
CHZZ	45°29'11.43969"N	0.003m	123°58'41.18456"W	0.003m	51.116m	0.010m	
P376	44°56'28.31465"N	0.002m	123°06'08.10050"W	0.002m	181.218m	0.005m	
DDSN	43°07'07.63227"N	0.002m	123°14'39.21332"W	0.001m	953.548m	0.005m	
REDM	44°15'35.14513"N	0.000m	121°08'52.31624"W	0.000m	920.367m	0.000m	Lat Long h
CORV	44°35'07.91166"N	0.002m	123°18'16.51798"W	0.002m	107.489m	0.006m	

Table 11. **Published NGSIDB: NAD 83(CORS96)Epoch 2002 - *Constrained Adjustment (3 Point)***

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
BURN	42°46'46.18761"N	0.000m	117°50'36.65227"W	0.000m	1181.520m	0.000m	Lat Long h
MDMT	42°25'06.01186"N	0.004m	121°13'17.70808"W	0.003m	1711.080m	0.049m	
ORS1	44°09'51.27314"N	0.003m	119°03'31.46149"W	0.003m	1438.095m	0.026m	
ORS2	44°09'50.88164"N	0.003m	119°03'30.35125"W	0.003m	1438.992m	0.026m	
P367	44°35'06.87019"N	0.000m	124°03'41.59831"W	0.000m	23.278m	0.000m	Lat Long h
CABL	42°50'09.93984"N	0.003m	124°33'47.98711"W	0.003m	38.312m	0.056m	
CHZZ	45°29'11.43836"N	0.006m	123°58'41.18665"W	0.005m	51.113m	0.044m	
P376	44°56'28.31360"N	0.002m	123°06'08.10189"W	0.002m	181.224m	0.019m	
DDSN	43°07'07.63071"N	0.002m	123°14'39.21330"W	0.002m	953.598m	0.040m	
REDM	44°15'35.14513"N	0.000m	121°08'52.31624"W	0.000m	920.367m	0.000m	Lat Long h
CORV	44°35'07.91050"N	0.003m	123°18'16.51910"W	0.003m	107.502m	0.019m	

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Table 12. **Published NGSIDB: NAD 83(CORS96)Epoch 2002 - *Constrained Adjustment (5 Point)***

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
BURN	42°46'46.18761"N	0.000m	117°50'36.65227"W	0.000m	1181.520m	0.000m	Lat Long h
MDMT	42°25'06.01243"N	0.000m	121°13'17.70770"W	0.000m	1711.051m	0.000m	Lat Long h
ORS1	44°09'51.27334"N	0.007m	119°03'31.46102"W	0.005m	1438.096m	0.046m	
ORS2	44°09'50.88182"N	0.007m	119°03'30.35080"W	0.005m	1438.993m	0.046m	
P367	44°35'06.87040"N	0.005m	124°03'41.59933"W	0.004m	23.249m	0.041m	
CABL	42°50'09.93918"N	0.000m	124°33'47.98916"W	0.000m	38.293m	0.000m	Lat Long h
CHZZ	45°29'11.43812"N	0.000m	123°58'41.18748"W	0.000m	51.170m	0.000m	Lat Long h
P376	44°56'28.31376"N	0.006m	123°06'08.10257"W	0.004m	181.212m	0.045m	
DDSN	43°07'07.63049"N	0.005m	123°14'39.21435"W	0.003m	953.572m	0.033m	
REDM	44°15'35.14513"N	0.000m	121°08'52.31624"W	0.000m	920.367m	0.000m	Lat Long h
CORV	44°35'07.91065"N	0.007m	123°18'16.51986"W	0.005m	107.485m	0.052m	

Table 13. **Published NGSIDB: NAD 83(CORS96)Epoch 2002 - *Control coordinates minus adjusted coordinates***

Values shown are control coord minus adjusted coord.

Point Name	ΔNorthing	ΔEasting	ΔElevation	ΔHeight
BURN	N/A	N/A	N/A	N/A
MDMT	N/A	N/A	N/A	N/A
ORS1	-0.011m	-0.010m	N/A	0.031m
ORS2	-0.007m	-0.012m	N/A	0.030m
P367	-0.008m	0.022m	N/A	0.029m
CABL	N/A	N/A	N/A	N/A
CHZZ	N/A	N/A	N/A	N/A
P376	-0.003m	0.045m	N/A	0.014m
DDSN	0.015m	0.025m	N/A	0.009m
REDM	N/A	N/A	N/A	N/A
CORV	0.000m	0.014m	N/A	0.010m

Table 14. **Published NGSIDB: NAD 83(CORS96)Epoch 2002 -** *Adjustment transformation details*

GPS Observations

GPS Transformation Group: <GPS Default>

Deflection in Longitude	: 0°00'00.0019"	**(1.96σ)**	: 0°00'00.0319"
Deflection in Latitude	: 0°00'00.0090"	**(1.96σ)**	: 0°00'00.0361"
Azimuth Rotation	: 0°00'00.0220"	**(1.96σ)**	: 0°00'00.0031"
Network Scale	: 0.99999989	**(1.96σ)**	: 0.00000002

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Table 15. **Published NGSIDB CORS: NAD 83(CORS96)Epoch 2002 Summary (Average Error)**

	N error	E error	h error
1 Point Constrained*	**0.0021m**	**0.0020m**	**0.0059m**
3 Points Constrained	0.0033m	0.0030m	0.0349m
5 Points Constrained	0.0062m	0.0043m	0.0438m

* A free network adjustment in which only enough constraints to define the coordinate system are employed. Used to measure internal consistency in observations.
Summary results showing average error NEh for unconstrained stations
Smallest error results shown in red

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Table 16. **OPUS-S Mean (August 1-10, 2010): NAD 83(CORS96)Epoch 2002 – *Minimally Constrained Adjustment (1 Point)***

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
BURN	42°46'46.18716"N	0.002m	117°50'36.65422"W	0.002m	1181.462m	0.006m	
MDMT	42°25'06.01276"N	0.002m	121°13'17.70993"W	0.002m	1711.013m	0.006m	
ORS1	44°09'51.27263"N	0.002m	119°03'31.46252"W	0.002m	1438.082m	0.005m	
ORS2	44°09'50.88114"N	0.002m	119°03'30.35228"W	0.002m	1438.979m	0.005m	
P367	44°35'06.87209"N	0.002m	124°03'41.59750"W	0.002m	23.244m	0.005m	
CABL	42°50'09.94232"N	0.002m	124°33'47.98767"W	0.002m	38.238m	0.006m	
CHZZ	45°29'11.43990"N	0.003m	123°58'41.18523"W	0.003m	51.105m	0.010m	
P376	44°56'28.31487"N	0.002m	123°06'08.10116"W	0.002m	181.208m	0.005m	
DDSN	43°07'07.63248"N	0.002m	123°14'39.21398"W	0.001m	953.537m	0.005m	
REDM	44°15'35.14534"N	0.000m	121°08'52.31690"W	0.000m	920.356m	0.000m	Lat Long h
CORV	44°35'07.91187"N	0.002m	123°18'16.51864"W	0.002m	107.478m	0.006m	

Table 17. **OPUS-S Mean (August 1-10, 2010): NAD 83(CORS96)Epoch 2002 – *Constrained Adjustment (3 Point)***

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
BURN	42°46'46.18786"N	0.000m	117°50'36.65218"W	0.000m	1181.511m	0.000m	Lat Long h
MDMT	42°25'06.01175"N	0.004m	121°13'17.70832"W	0.003m	1711.083m	0.056m	
ORS1	44°09'51.27353"N	0.004m	119°03'31.46185"W	0.003m	1438.080m	0.030m	
ORS2	44°09'50.88204"N	0.004m	119°03'30.35161"W	0.003m	1438.977m	0.030m	
P367	44°35'06.86993"N	0.000m	124°03'41.59943"W	0.000m	23.283m	0.000m	Lat Long h
CABL	42°50'09.93931"N	0.004m	124°33'47.98788"W	0.003m	38.327m	0.065m	
CHZZ	45°29'11.43827"N	0.007m	123°58'41.18798"W	0.005m	51.111m	0.052m	
P376	44°56'28.31355"N	0.003m	123°06'08.10296"W	0.002m	181.222m	0.022m	
DDSN	43°07'07.63040"N	0.003m	123°14'39.21397"W	0.002m	953.607m	0.046m	
REDM	44°15'35.14534"N	0.000m	121°08'52.31690"W	0.000m	920.356m	0.000m	Lat Long h
CORV	44°35'07.91039"N	0.004m	123°18'16.52012"W	0.003m	107.502m	0.022m	

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Table 18. **OPUS-S Mean (August 1-10, 2010): NAD 83(CORS96)Epoch 2002 – *Constrained Adjustment (5 Point)***

Errors are reported using 1.96σ.

Point Name	Latitude	N error	Longitude	E error	Height	h error	Fix
BURN	42°46'46.18786"N	0.000m	117°50'36.65218"W	0.000m	1181.511m	0.000m	Lat Long h
MDMT	42°25'06.01188"N	0.000m	121°13'17.70715"W	0.000m	1711.077m	0.000m	Lat Long h
ORS1	44°09'51.27361"N	0.006m	119°03'31.46154"W	0.004m	1438.087m	0.038m	
ORS2	44°09'50.88211"N	0.006m	119°03'30.35133"W	0.005m	1438.984m	0.039m	
P367	44°35'06.87001"N	0.005m	124°03'41.59942"W	0.004m	23.241m	0.035m	
CABL	42°50'09.93890"N	0.000m	124°33'47.98842"W	0.000m	38.284m	0.000m	Lat Long h
CHZZ	45°29'11.43781"N	0.000m	123°58'41.18707"W	0.000m	51.122m	0.000m	Lat Long h
P376	44°56'28.31353"N	0.005m	123°06'08.10288"W	0.004m	181.194m	0.037m	
DDSN	43°07'07.63030"N	0.004m	123°14'39.21393"W	0.003m	953.567m	0.028m	
REDM	44°15'35.14534"N	0.000m	121°08'52.31690"W	0.000m	920.356m	0.000m	Lat Long h
CORV	44°35'07.91039"N	0.006m	123°18'16.52012"W	0.005m	107.475m	0.043m	

Table 19. **OPUS-S Mean (August 1-10, 2010): NAD 83(CORS96)Epoch 2002** – ***Control coordinates minus adjusted coordinates***

Values shown are control coord minus adjusted coord.

Point Name	ΔNorthing	ΔEasting	ΔElevation	ΔHeight
BURN	N/A	N/A	N/A	N/A
MDMT	N/A	N/A	N/A	N/A
ORS1	-0.016m	0.019m	N/A	0.038m
ORS2	-0.015m	0.020m	N/A	0.038m
P367	-0.002m	0.000m	N/A	0.042m
CABL	N/A	N/A	N/A	N/A
CHZZ	N/A	N/A	N/A	N/A
P376	0.005m	0.015m	N/A	0.078m
DDSN	0.021m	0.018m	N/A	0.017m
REDM	N/A	N/A	N/A	N/A
CORV	0.014m	0.019m	N/A	0.023m

Table 20. **OPUS-S Mean (August 1-10, 2010): NAD 83(CORS96)Epoch 2002** – ***Adjustment transformation details***

GPS Observations

GPS Transformation Group: <GPS Default>

Deflection in Longitude	: -0°00'00.0203"	**(1.96σ)**	: 0°00'00.0245"
Deflection in Latitude	: 0°00'00.0472"	**(1.96σ)**	: 0°00'00.0316"
Azimuth Rotation	: 0°00'00.0451"	**(1.96σ)**	: 0°00'00.0027"
Network Scale	: 0.99999988	**(1.96σ)**	: 0.00000001

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Table 21. **OPUS-S Solutions Mean (August 1-10, 2010): NAD 83(CORS96)Epoch2002 Summary (Average Error)**

	N error	E error	h error
1 Point Constrained*	**0.0021m**	**0.0020m**	**0.0059m**
3 Points Constrained	0.0041m	0.0030m	0.0404m
5 Points Constrained	0.0053m	0.0042m	0.0366m

* A free network adjustment in which only enough constraints to define the coordinate system are employed. Used to measure internal consistency in observations.
Summary results showing average error NEh for unconstrained stations
Smallest error results shown in red

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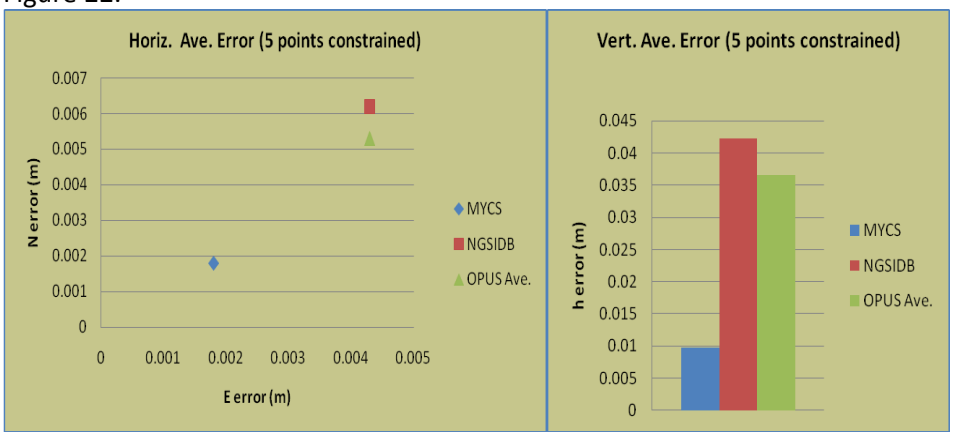
Conclusions

The results showed that the average of all of the summary adjustment north and east errors were at the +/-0.003m level and height error average were at the +/-0.020m level. This would appear adequate for a typical RTN control network adjustment result.

The 1 point minimally constrained adjustments for all three adjustment series matched exactly in north and east error and varied by 0.001m in the MYCS solution which may have been a rounding issue. Given that all contained the exact same baseline file and the only variable was the 1 point fixed position, you would expect this to be the case.

For the MYCS (CORS96A) solution the horizontal adjustment error decreased as more points were constrained which implies that those fixed positions fit more closely with the baselines observed (in this case) and thereby producing smaller residuals. Whereas, in the other two adjustments it appears that the horizontal component of the baselines observed fit each other slightly better with less fixed constraints. Another characteristic of the MYCS adjustment (5 points fixed) solution is the consistent millimeter level delta north and east values for the results of the control coordinates minus the adjusted coordinates as shown in Table 7. The overall network adjustment scale result (0.99999997) was superior to the other two adjustments as shown in Table 8. A comparison of the horizontal and vertical average error (with 5 points constrained) for each of the coordinate systems is shown in Figure 22.

Figure 22.



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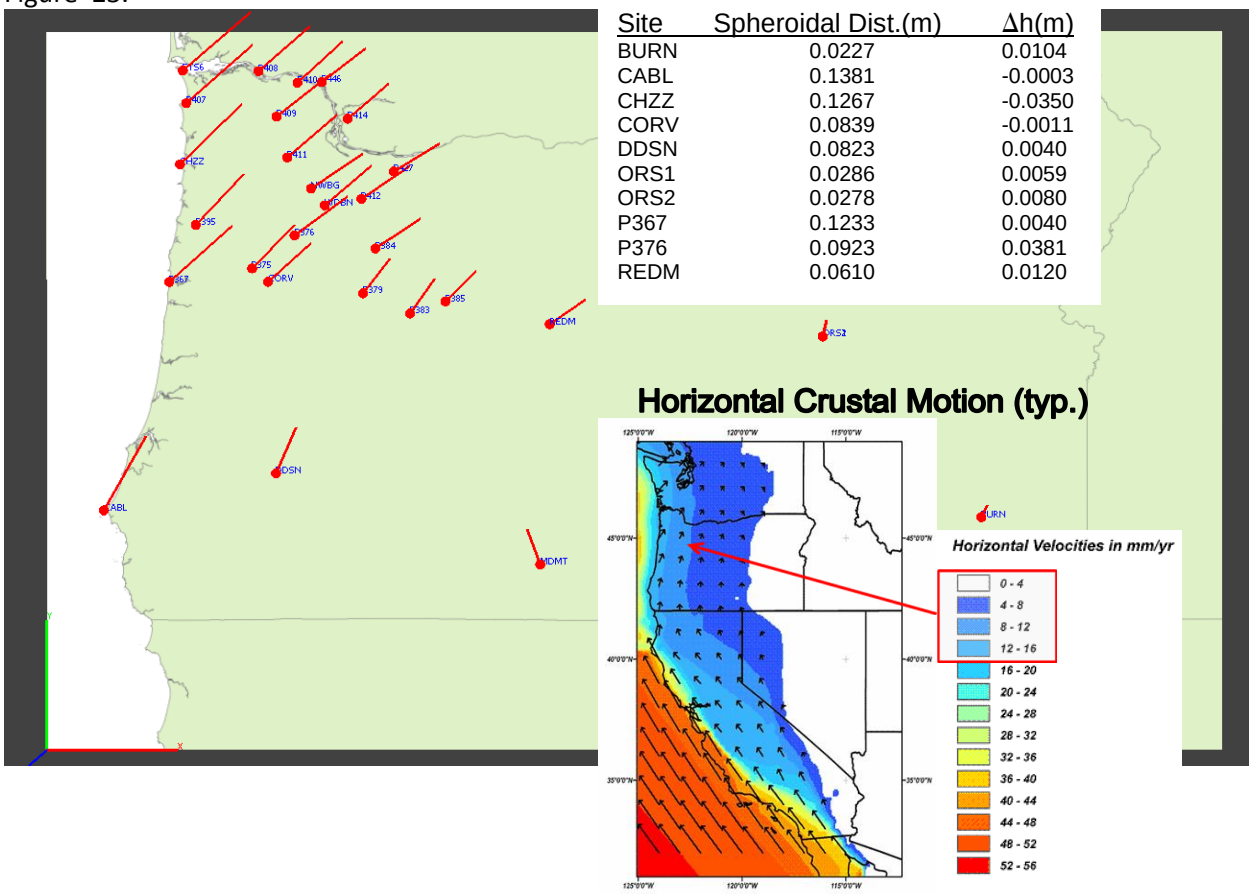
Shown on Figure 23 below are the relative shifts in position (CORS96 - CORS96a) for a subset (inset table) of CORS stations used in this study. The eight year difference in epoch [NAD 83(CORS96)Epoch2002 and NAD 83(CORS96a)Epoch 2010] reflects crustal motion movement that has occurred for the sites shown.

Figure 23.



Site	Spheroidal Dist.(m)	Δh(m)
BURN	0.0227	0.0104
CABL	0.1381	-0.0003
CHZZ	0.1267	-0.0350
CORV	0.0839	-0.0011
DDSN	0.0823	0.0040
ORS1	0.0286	0.0059
ORS2	0.0278	0.0080
P367	0.1233	0.0040
P376	0.0923	0.0381
REDM	0.0610	0.0120

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Antenna QA Notes

This study reinforced the importance of checking antenna names and models. The antenna names embedded within corresponding RINEX files do not always appear to match the antenna name noted in the operators station log file. While the log files should rule, this observer discovered multiple antenna errors within the log files of particular CORS. A thank you goes out to Ken Austin, UNAVCO/PBO Northwest Region Manager for back checking the PANGA and PBO stations used in this study.

It should also be noted that when importing CORS RINEX files into any baseline processing and adjustment software, the Antenna Reference Point (ARP) position should be reviewed and possibly edited so that the measure up vertical height is correct by the classic definition of the ARP (normally 0.000m is at the bottom of the antenna). Many downloaded RINEX files (including PBO) report an 'eccentric up' offset as the measured up that gets automatically inserted when importing into software thereby effectively changing the location of the ARP. This also happens within the OPUS suite of programs with certain CORS station files that contain this 'eccentric up' offset. While this may not result in vertical errors within processing and adjustment software the ARP for a particular CORS will not be located at the bottom of the antenna. The real purpose of this 'eccentric up' offset measure up distance (of up to +/-0.10m in height) is to actually reference a line scribed on the antenna mount that is used to reposition the exact location height of the antenna when it is removed and replaced.