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SHORT ARC OPTICAL SURVEY TECHNIQUES

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GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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SHORT ARC OPTICAL SURVEY TECHNIQUES

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Contract NAS5-10618

December 1971

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SHORT ARC OPTICAL SURVEY TECHNIQUES

by

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ABSTRACT

The effect of the gravity parameter, μ, the choice of fixed origin station, the local survey of the fixed origin station, and the choice of initial datum on the results of short arc satellite survey adjustments are investigated using GEOS-1 MOTS optical observations from 13 stations. It is concluded that each of these parameters has an effect on derived network scale on the order of 2×10^{-6} for the nominal variations used in this study. Consequently, best available values should be used. A particular solution using what we thought to be the best available values for these parameters is recommended.

SHORT ARC OPTICAL SURVEY TECHNIQUES

1. INTRODUCTION

The purpose of this report is to present the results of studies to determine the effect of various parameters on the short arc recovery of survey for 13 GEOS-1 MOTS optical stations using real data. The parameters investigated are

(1) The error in the gravity parameter, μ,
(2) The choice of fixed origin station,
(3) The error in the assumed position of the fixed origin station,
(4) The choice of datum to which the initial station positions are referred.

This report documents and further details the results of geodetic studies for which preliminary results were given in References 1, 2, 3, and 4.

Survey solutions are obtained for different values of each of the investigated parameters to illustrate the sensitivity of the solution to changes in these parameters. A best set of parameters is chosen and the resulting survey solution is compared with the earlier results given by Brown (Reference 1), where a different set of parameters and a somewhat larger network were used.

The goal of this work is to develop the techniques for short arc survey adjustment using MOTS camera GEOS satellite tracking data, and if possible, to reduce the uncertainty in the conventional surveys for these stations. The uncertainty in the relative positions of the MOTS stations represents a significant portion of the error budgets of the optical reference short arcs generated for use in the GEOS Observation Systems Intercomparison Investigation.

2. THE OPTICAL TRACKING NETWORK

The network includes 13 NASA MOTS camera stations as depicted in Figure 1. In all our short arc solutions, the position of one MOTS camera, usually the centrally located camera at Columbia, Missouri, was held fixed. All other camera positions were allowed to freely adjust along with the six short arc orbital elements of each of the 38 GEOS-1 passes observed. The ground tracks of these selected passes and their relationship to the tracking stations are illustrated in Figure 2. As many as seven different well-spaced, 7-flash sequences were observed on some passes, but the typical number was four or five. In general, each camera was exercised to the maximum practical extent, so that as many as four separate 7-flash sequences were sometimes obtained from a single camera on a single pass.

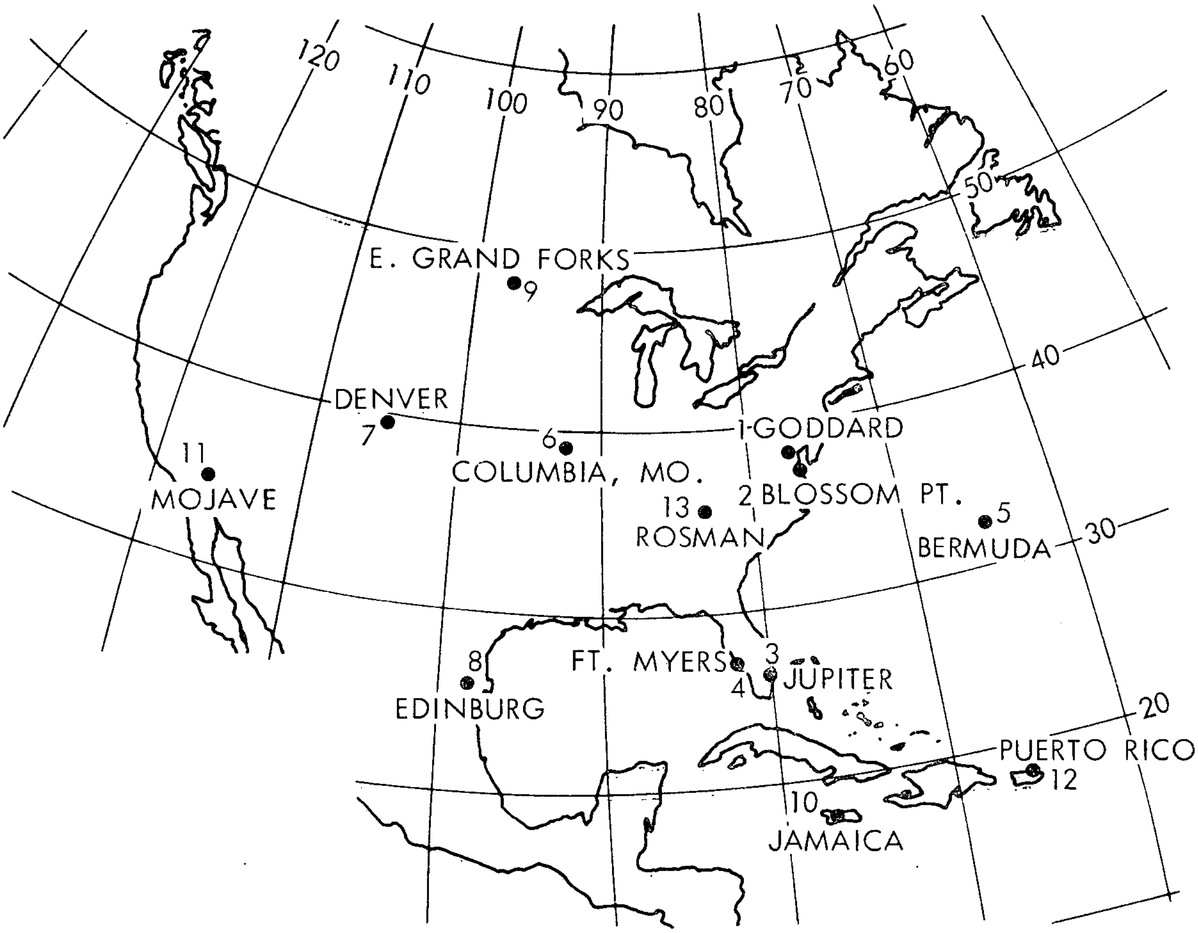

Figure 1. Optical Tracking Network Established for GEOS Investigations

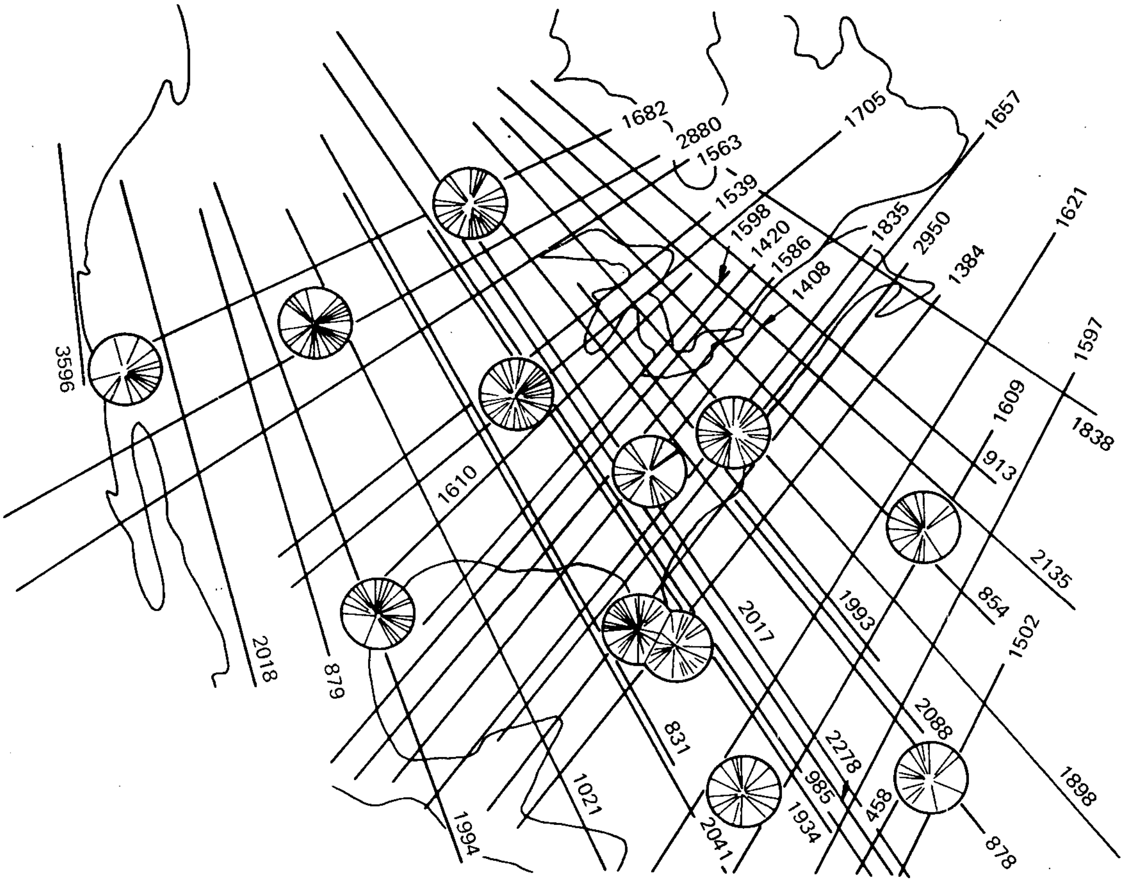

Figure 2. Ground Traces Relative to Tracking Network of Set of 38 Passes Carried in Short Arc Reduction

3. DATA REDUCTION

The GEOS-1 MOTS camera observations were obtained on cards from the NSSDC at Goddard. The given UTC flash observation times were transformed to UT1 and 0.5 milliseconds were added to account for flash buildup time. The given right ascensions and declinations were corrected to allow for polar motion relative to the adopted IPMS mean pole of 1900-1905.

Simultaneous multipass short arc survey adjustments were done with the Geodetic Data Adjustment Program (GDAP). This program was described by Lynn in Reference 6. Briefly, it is an orbit integration and generalized least squares parameter recovery program. The orbit integrations in GDAP are performed by means of power series expansions developed by Hartwell (Reference 7). GDAP is capable of recovering an unlimited number of orbits simultaneously with up to 64 error model or survey parameters. In these solutions, the recovered parameters were the East, North, and Up (ΔE, ΔN, ΔV) topocentric corrections to the initial estimates of the coordinates of the 12 adjusted stations, a total of $3 \times 12 = 36$ parameters. Two or three iterations of the solution of the normal equations are usually sufficient to minimize the sum of squares of the weighted observation residuals and to achieve convergence to the final estimates of the survey adjustments.

As mentioned by Brown (Reference 1), the errors in the adopted geopotential coefficients can be almost totally absorbed by the recovered orbital elements, so that short arc trajectory errors due to geopotential errors can be held to about one meter. Thus, the GDAP geopotential model, which includes only the zonal harmonics, J_2 through J_7, is probably sufficient for these reductions. The zonal harmonic coefficients used are given below. They were taken from the NWL 5E-6 solutions (Reference 8) where they are associated with a gravity constant, μ, of $3.986\ 0542 \times 10^{14}\ m^3/sec^2$.

Denormalized Zonal Harmonic Coefficients ($\times 10^{-6}$)

J2	J3	J4	J5	J6	J7
1082.640	-2.546	-1.649	-0.210	0.640	-0.333

Survey solutions were obtained to determine the effect of variations in the parameters investigated, as indicated in Table 1 below.

Tables 2, 3, and 4 list the initial survey coordinates in geodetic latitude, longitude, and geodetic height (φ, λ, h), and in earth fixed geocentric cartesian coordinates (X, Y, Z) for the NAD-27, the SAO C-5, and the Mercury datums.

Table 1

Parameter Variations for Each Solution

Parameter Investigated	Solution	Gravity Parameter, μ ($\times 10^{14}$ m^3/sec^2)	Origin	Datum
Effect of error in μ	1	3.986032	Columbia	SAO-C5
	2	3.986013	Columbia	SAO-C5
	3	3.985994	Columbia	SAO-C5
	4	3.985956	Columbia	SAO-C5
Effect of Origin Location	4	3.985956	Columbia	SAO-C5
	5	3.985956	Rosman	SAO-C5
	6	3.985956	Mojave	SAO-C5
Effect of error in Origin	7	3.986032	Columbia(X_0,Y_0,Z_0)	Mercury
	8	3.986032	Columbia (X_0-50m)	Mercury
	9	3.986032	Columbia (Y_0-50m)	Mercury
	10	3.986032	Columbia (Y_0+50m)	Mercury
	11	3.986032	Columbia (Z_0-50m)	Mercury
Effect of initial Datum*	2	3.986013	Columbia	SAO-C5
	12	3.986013	Columbia	Mercury
	13	3.986013	Columbia	NAD-27

Initial Datum Origin Shifts With Respect to NAD Origin (meters) (Reference 9)

*Initial Datum	A (meters)	F	ΔX	ΔY	ΔZ
SAO-C5	6378165.0	298.25	-31	144	181
Mercury	6378166.0	298.30	3	111	225
NAD-27	6378206.4	294.9787	0	0	0

These initial coordinates are taken from References 9 and 10. The initial chords with respect to Columbia are also given for each datum.

The Mercury datum ellipsoid and origin (not the individual site surveys) were derived from the NAD-27 datum ellipsoid and origin using all available data including observations on Sputnik-1 and Vanguard (Reference 9). Thus, the Mercury datum coordinates contain both an origin translation and small systematic individual station translations with respect to the NAD-27 datum coordinates. The size of the latter individual station translations is indicated by the slight differences in chord length from Columbia between the two datums.

The SAO C-5 datum ellipsoid and origin were derived from SAO Baker Nunn camera observations on many satellites. In addition, the SAO camera site surveys were individually adjusted. The MOTS camera C-5 datum surveys were then obtained by a weighted interpolation of the SAO camera survey adjustments (Reference 10). Therefore, the SAO C-5 datum coordinates also contain both an origin translation and small systematic individual station translations with respect to the NAD-27 datum coordinates. Again, the size of the individual station translations is indicated by the slight differences in chords between the two datums. The chord differences between the SAO C-5 and the NAD-27 datums are generally several times larger than those between the Mercury and NAD-27 datums.

4. RESULTS

The results of the 13 solutions outlined in Table 1 are given in Tables 5 through 17. For each solution the topocentric survey adjustments East, North, and Up (ΔE, ΔN, ΔV) are given relative to the initial positions given in Tables 2, 3, or 4. Also given in Tables 5 through 17 are the accuracy estimates of the adjustments based on an estimated accuracy of 1 arc second for the camera observations and a priori estimates of 100 meters for the site coordinates for the 12 adjusted stations.

In each solution, the whole network, including the previously fixed origin station, is then shifted by the mean ΔE, ΔN, ΔV adjustment for the network to provide a reasonable correction for the effects of an error in the origin station initial position. The resulting ΔE, ΔN, ΔV corrections are called the adjusted corrections. These adjusted corrections are also given in geocentric cartesian coordinates ΔX, ΔY, ΔZ.

The chord changes, ΔC, are calculated as the difference between the adjusted chords and initial chords. The adjusted chord is the distance between the adjusted station and adjusted origin positions. Also given are the proportional scale changes, S, due to these chord changes ($S = \frac{\Delta C}{C}$).

Figures 5 through 17 illustrate the East ($\Delta E - \Delta\bar{E}$) and North ($\Delta N - \Delta\bar{N}$) vector components of the adjusted corrections given in Tables 5 - 17. The numbers in parentheses on these figures are the station height adjustments ($\Delta V - \Delta\bar{V}$).

The results of the 13 solutions are summarized below according to their effect on the parameters investigated, as indicated in Table 1.

As a matter of interest, in some of the early SAO C-5 initial datum solutions, the initial height for Bermuda was incorrectly entered without a minus sign as +28.4 meters rather than -28.4 meters. These solutions recovered -55 to -68 meters, of which $2 \times 28.4 = 56.8$ meters can be attributed to this input error, demonstrating the ability of the short arc techniques to successfully recover such errors. In Solutions 1 through 6, -56.8 meters were removed from the recovered Bermuda heights to avoid an erroneous effect on the chord calculations.

(1) Effect of Error in μ

The first four solutions (Tables and Figures 5 - 8) investigating the effect of an error in μ are summarized below:

Solution	μ ($\times 10^{14} m^3/sec^2$)	$\frac{\Delta\mu}{\mu_2}$ ($\times 10^{-6}$)	$\overline{\Delta C}$ (meters)	$\overline{S}$ ($\times 10^{-6}$)	$\delta\overline{S}$ ($\times 10^{-6}$)	$3\delta\overline{S}$
1	3.986032	+4.77	14.3	8.3	2.6	7.8
2	3.986013	0	9.7	5.7	0	0
3	3.985994	-4.77	7.0	4.1	-1.6	-4.8
4	3.985956	-14.30	-2.8	-1.3	-7.0	-21.0

As is well known (Reference 11), a unit proportional change in μ should produce a 3-unit proportional change in scale. This comes from Kepler's Law:

$$n^2 a^3 = \mu$$

$$\text{so } \frac{1}{3}\frac{d\mu}{\mu} = \frac{da}{a} = \delta S \qquad (1)$$

where it is assumed the change in scale of the orbits leads to a change in scale of the derived station positions.

The first four solutions utilized different values of μ. The proportional changes in μ relative to the JPL μ of solution 2 are given as $\frac{\Delta\mu}{\mu_2}$. The average chord adjustments and average proportional scale adjustments, obtained in each solution (Tables 5 - 8) are given under the headings $\overline{\Delta C}$ and $\overline{S}$ where $\overline{\Delta C} = \frac{1}{12}\Sigma\Delta C_i$ and $\overline{S} = \frac{1}{12}\Sigma S_i$. The changes in S relative to the solution 2 adjustment are listed under $\delta\overline{S}$. These values are then multiplied by the factor 3 in order to compare directly with the values of $\frac{\Delta\mu}{\mu_2}$. The results are plotted in Figure 3, and according

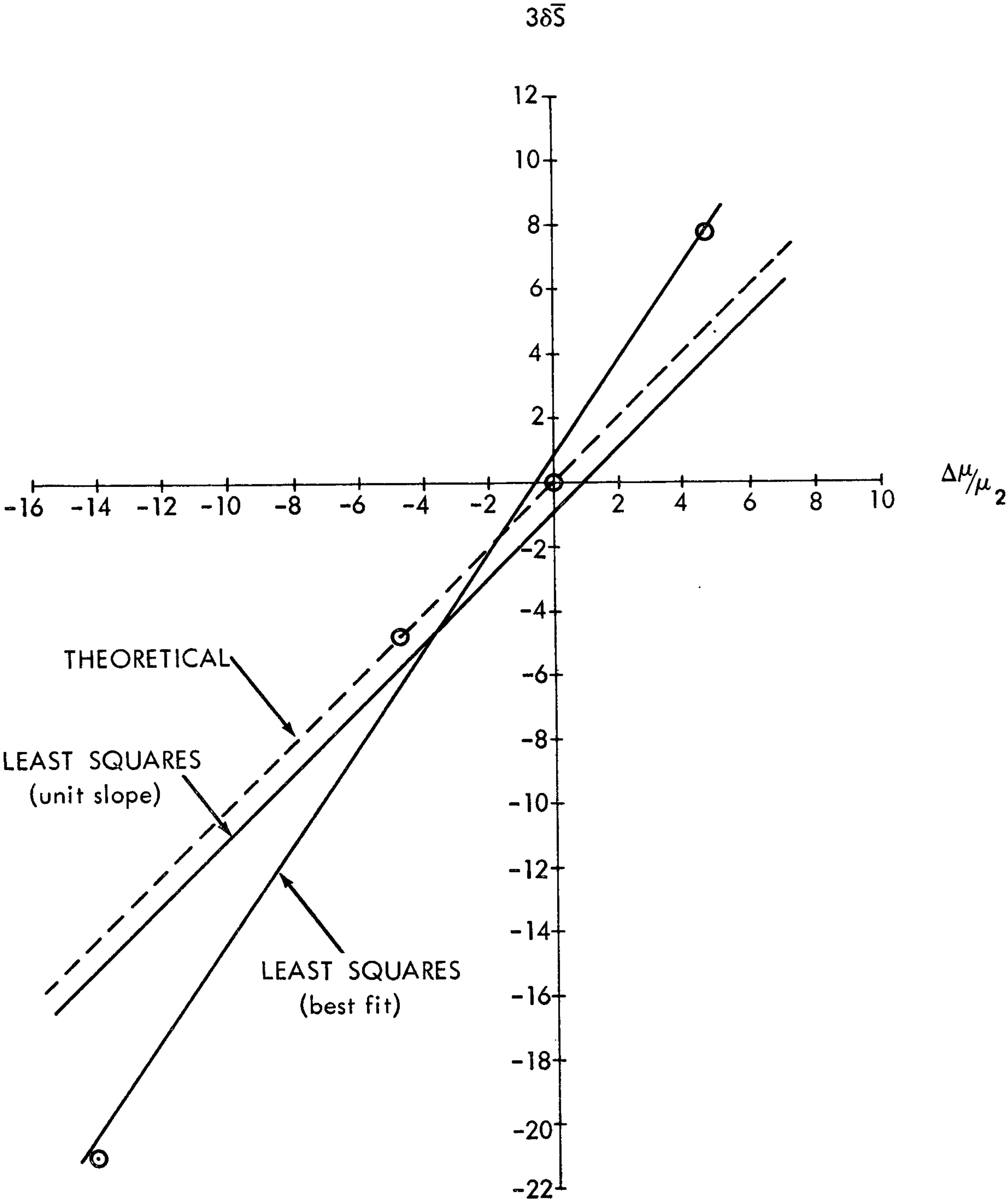

Figure 3. Effect of Error in μ.

ing to equation (1) should lie on a straight line of unit slope. The least squares fitted straight line of unit slope was calculated and is shown in Figure 3. This represents the theoretical behavior of equation (1), allowing for possible error in the reference solution (Solution 2). The largest residual with respect to this line represents an anomalous change in scale of only 1.9×10^{-6} beyond the theoretically expected change from equation (1).

If the slope of the line is also allowed to adjust in the least squares fit, we obtain a slope of 1.5, as shown in Figure 3, and the largest remaining residual with respect to this new line represents a difference in scale of only 0.5×10^{-6}. This best fitting line of slope 1.5 is equivalent to a line of unit slope in a plot of $2\delta\bar{S}$ rather than $3\delta\bar{S}$ versus $\frac{\Delta\mu}{\mu_2}$. The better fit of the steeper slope may reflect a departure from the region of linearity where equation (1) applies. In any case, these solutions verify that significant scale changes arise due to changes in μ. Thus, dynamic constraints do affect these short arc solutions, and it is important to choose the best available value for μ. We have assumed the JPL value of $\mu = 3.986013 \times 10^{14}$ m^3/sec^2 to be the best available value.

(2) Effect of Fixed Origin Choice

Solutions 4, 5, and 6 (Tables and Figures 8 - 10) investigated the effect the choice of the fixed origin station has on the adjustment of the other stations. Origin stations were chosen so that one was near the network center, one east of this center, and one near the western limit of the network.

The results of the three solutions are summarized below:

Solution	Origin	$\overline{\Delta C}$ (meters)	$\overline{S}$ ($\times 10^{-6}$)	$\delta\overline{S}$ ($\times 10^{-6}$)
4	Columbia	-2.8	-1.3	0
5	Rosman	-7.7	-4.0	-2.7
6	Mojave	1.2	0.9	2.2

As before, the average chord change is given as $\overline{\Delta C}$, the average scale change is $\overline{S}$, the relative scale change with respect to solution 4 is $\delta\overline{S}$. As can be seen, choosing the origin towards the eastern or western edge of the network does result in small scale changes of a few parts per million relative to the solution with origin near the center of the network. The magnitude of these scale changes due to change in origin are about equivalent to the estimated accuracy (Reference 1) in the solutions for scale. From considerations of symmetry and geometrical strength, it is probably better to utilize the central station as the fixed origin station.

(3) Effect of Error in Fixed Origin

Solutions 7 through 11 (Tables and Figures 11 - 15) were made to determine the effect of an error in the position of the origin station on the other site adjustments.

Solution 7 assumed the published survey for the Columbia station on the Mercury datum. Solution 8 was made with Columbia's X-component of its cartesian coordinates perturbed by -50 meters. This transforms into a primarily westward movement of the station site. Solutions 9 and 10 were made with the Y-component perturbed by -50 meters first and then by +50 meters. A decrease in the Y- component transforms into primarily an increase in station height. In solution 11, the Z-component was perturbed by -50 meters, which transforms into a predominantly southward shift and some decrease in station height.

These solutions are summarized as follows:

		Tables 11 - 15 Summaries			Tables 11A - 15A Summaries		
Solution	Columbia Origin	$\overline{\Delta C}$ (meters)	$\bar{S}$ ($\times 10^{-6}$)	$\delta\bar{S}$ ($\times 10^{-6}$)	$\overline{\Delta C}$ (meters)	$\bar{S}$ ($\times 10^{-6}$)	$\delta\bar{S}$ ($\times 10^{-6}$)
7	X_0, Y_0, Z_0	6.3	3.7	0	5.1	2.8	0
8	X_0-50m, Y_0, Z_0	6.3	3.6	-0.1	6.3	3.4	0.6
9	X_0,Y -50m,Z_0	-19.8	-8.3	-12.0	-5.6	-3.1	-5.9
10	X_0,Y_0+50m,Z_0	28.7	16.2	12.5	15.8	8.8	6.0
11	X_0,Y_0,Z_0-50m	13.0	7.4	3.7	10.9	6.2	3.4

The column labeled $\delta\bar{S}$ is the change in scale for the various solutions relative to solution 7. As can be seen, a 50-meter shift in the X-direction (West) of the origin station position causes only a -0.1×10^{-6} change in scale relative to the unshifted position (solution 7). This type of shift can be absorbed by the orbital elements and by a lateral shift of the whole network and still maintain the observation directions in right ascension and declination. On the other hand, a 50-meter shift of Columbia in the ±Y-directions, corresponding primarily to ∓height shifts, leads to a $\pm 12 \times 10^{-6}$ change in scale relative to solution 7. As noted, a decrease in Y of the origin station, corresponding to an increase in height, causes a corresponding decrease in scale or a shrinkage of the network and vice-versa. The 50-meter shift in the Z-direction is predominantly south, but also significantly reduces the height component leading to a scale expansion of 3.7×10^{-6}.

This situation is illustrated in Figure 4, where the observation directions to the satellite, S, are shown from the origin station, O, and from the observation

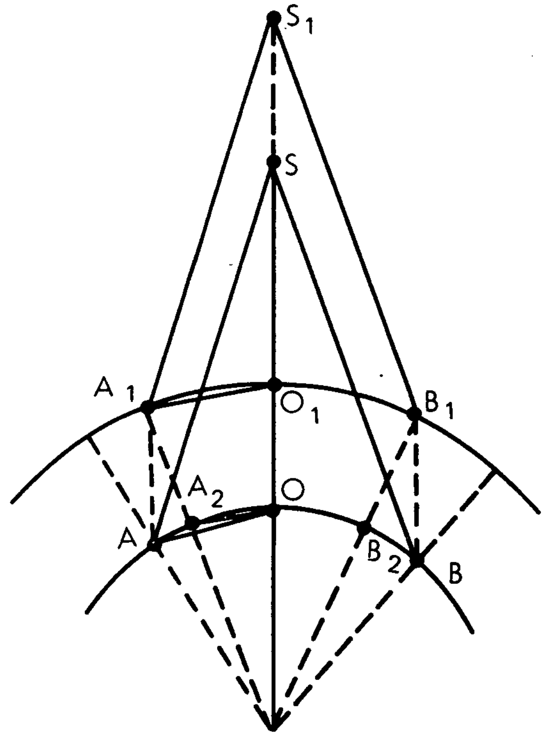

Figure 4. Change in Scale Due to Adjustment Method.

stations A and B. Let it be assumed that the total set of observation directions from all stations in the net has the geometrical strength to maintain the configuration of adjusted station positions relative to the origin station invariant under translations of the origin station. If this assumption is valid, a translation of the origin station should not change network scale. Then, it follows that an increase in height of the origin station from O to O_1, moves the derived satellite position and station positions by the same translation from S to S_1, A to A_1 and from B to B_1 with no change in scale. However, removing the mean biases in local topocentric shifts ($\overline{\Delta E}$, $\overline{\Delta N}$, $\overline{\Delta V}$) from the network station position corrections to obtain the adjusted corrections, as described earlier, tends to translate O_1 back to O, A_1 to A_2, and B_1 to B_2. This results, as shown in Figure 4, in a net decrease in scale, which is about the right magnitude to explain our results. Thus, if the above assumption is correct, the recovered scale changes are due to our shortcut technique of adjusting the derived corrections by ΔE, ΔN, ΔV. We should have converted each station local topocentric shift ΔE, ΔN, ΔV, to ΔX, ΔY, ΔZ in a common cartesian system and used these to obtain mean biases $\overline{\Delta X}$, $\overline{\Delta Y}$, $\overline{\Delta Z}$ with which to adjust the corrections.

The latter technique was applied to our solutions 7 - 11. The results are detailed in Tables 11A - 15A and summarized above. These solutions in general contain about half the changes in scale due to ΔY origin station shifts as were previously obtained. However, some scale change still does occur and therefore the assumption of scale invariance under origin station translations is not entirely valid.

The conclusion drawn from these studies is that an error in origin station initial height relative to the initial surveys of the observation stations leads to scale changes on the order of -1.5×10^{-6} per +10 meter error in origin station height, assuming the station corrections are adjusted by ΔX, ΔY, ΔZ, rather than by $\Delta \overline{E}$, $\Delta \overline{N}$, $\Delta \overline{V}$.

height,

$$\text{(i.e.,} \quad \frac{\delta \overline{S}}{\Delta H_o} = \frac{\delta \overline{S}}{-\Delta Y_o \cos \phi_o} = \frac{6 \times 10^{-6}}{-50 \cos 39°} = -0.15 \times 10^{-6} \text{ per meter).}$$

The scale changes due to origin station height errors are approximately doubled by adjusting the corrections by $\overline{\Delta E}$, $\overline{\Delta N}$, $\overline{\Delta V}$ rather than by $\overline{\Delta X}$, $\overline{\Delta Y}$, $\overline{\Delta Z}$. This indicates that for regular solutions, such as 2, 12, and 13, where the origin station average height adjustments $\overline{\Delta Y}$, are only 3 to 4 meters, the unwanted effect on network scale due to our method of adjustment is only about -0.5×10^{-6}.

It is also of interest to note the ability of the solutions to recover the 50 meter ΔX, ΔY, ΔZ errors injected into the origin station positions. The results are summarized below where the corrections are normalized relative to solution 7 in order to remove the contributions of the data from those of the origin shifts. It can be seen that this recovery is good to 1.7 meters or better.

		Avg. Network Corrections (meters)			Adjusted Avg. Network Corrections Relative to Solution 7 (meters)		
Solution	Columbia Origin	$\overline{\Delta X}$	$\overline{\Delta Y}$	$\overline{\Delta Z}$	ΔX	ΔY	ΔZ
7	X_0, Y_0, Z_0	4.2	6.9	2.2	0	0	0
8	X_0 - 50m	-44.6	7.2	2.8	-48.8	0.3	0.6
9	Y_0 - 50m	0.0	-41.5	7.6	-4.1	-48.4	5.4
10	Y_0 50m	6.0	55.4	1.0	1.9	48.5	-32
11	Z_0 - 50m	6.2	6.3	-48.3	2.0	-0.6	-50.5

(4) Effect of Choice of Initial Datum

The last effect investigated was the choice of datum to which the initial station positions are referred. A major effect in using the different initial datums is the translation of all the initial station positions (not just the origin station) by the amounts ΔX, ΔY, ΔZ, given in Table 1 and repeated below. This is equivalent to translating the Earth's Center of Mass by these values. The results are given in solutions 2, 12, and 13, which are summarized below:

Solution	Initial Datum	Initial Datum Origin Shifts From NAD (meters)			Results of Solutions		
		ΔX	ΔY	ΔZ	$\overline{\Delta C}$ (meters)	$\overline{S}$ ($\times 10^{-6}$)	$\delta\overline{S}$ ($\times 10^{-6}$)
2	SAO-C5	-31	144	181	9.7	5.7	+2.4
12	Mercury	3	111	225	2.8	1.6	-1.7
13	NAD-27	0	0	0	4.9	3.3	0

The change in scale of 4.1×10^{-6} obtained between solution 12 with the Mercury datum and solution 2 with the SAO-C5 datum is supported by a similar change of 4.6×10^{-6} observed between solutions 7 (Mercury datum) and 1 (SAO-C5 datum) while using a different value of μ.

The scale changes observed between solutions 2, 12, and 13, due primarily to the given center-of-mass translations, are about the same net magnitude as might be expected from the same translations of the fixed origin station, as described in the previous section. About 1/3 of the observed average change in scale is due to the small systematic differences in the Cartesian coordinates for the initial station positions.

The SAO-C5 dynamically improved origin station initial position relative to the Earth Center of Mass is taken to be the best starting value for these short arc solutions.

5. CONCLUSIONS

1. The short arc solutions are affected in scale by the value chosen for μ, more or less as anticipated by equation (1). The decrease in μ from the Mercury value in solution 1 to the JPL value in solution 2, a proportional change of -4.77×10^{-6}, causes a change in network scale of -2.6×10^{-6}. Therefore, the best available value for μ should be used.

2. The solutions are also affected by 2 to 3×10^{-6} in scale by choosing the reference or origin station near the extremes of the network rather than near the more favorable central location.

3. An error in height of the central origin station relative to the other station initial surveys causes a scale change of about -1.5 x 10

per +10 meter height error. Therefore, the best available origin station local survey should be used.

4. An error in origin station position relative to the Earth Center-of-Mass causes about the same scale change as the error relative to the local survey. Therefore, the best available Earth Center of Mass System should be used.

5. In summary, solution 2 utilizes the best available value for μ, a centrally located origin station, the best available local survey for the origin station, and a dynamically improved value for the origin station position relative to the Earth's Center of Mass, and is therefore the best solution in this study. It is recognized that more recent and probably better dynamic solutions for the Earth's Center of Mass have become available since this study was initiated.

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Table 2

Initial NAD27 Surveys

Station	Geodetic Coordinates			Earth-Centered Cartesian Coordinates (meters)			Chord to Columbia (meters)
	Geodetic Latitude ϕ	Longitude λ	Geodetic Height h(m)	x	y	z	c
GSFMA	39°01'15.01"	283°10'19.93"	54.5	1130742.4	-4831487.5	3993952.5	1329018.2
BPOMA	38°25'49.63"	282°54'48.23"	5.5	1118061.1	-4876471.2	3942792.9	1313095.4
JU4MA	27°01'13.17"	279°53'12.49"	25.7	976297.2	-5601548.7	2880071.8	1726828.4
FTMMA	26°32'51.89"	278°08'03.93"	19.6	807883.1	-5652136.1	2833327.0	1670046.3
BERMA	32°21'48.83"	295°20'32.56"	21.0	2308226.6	-4873758.0	3394383.5	2569587.0
COLMA	38°53'36.07"	267°47'42.12"	271.7	-191260.6	-4967427.4	3983083.7	0
DENMA	39°38'48.03"	255°23'41.19"	1796.1	-1240449.7	-4760379.7	4048804.7	1071441.0
EDIMA	26°22'45.44"	261°40'09.03"	67.1	-828464.2	-5657605.0	2816640.1	1497652.9
GFOMA	48°01'21.40"	262°59'21.56"	253.9	-521678.9	-4242197.4	4718542.7	1084451.4
JAMMA	18°04'31.98"	283°11'26.52"	485.9	1384188.0	-5905826.7	1966367.6	2725761.3
MOJMA	35°19'48.09"	243°06'02.73"	905.4	-2357213.7	-4646474.4	3668133.7	2212138.5
PURMA	18°15'26.22"	294°00'22.17"	58.7	2465090.2	-5535082.2	1985346.2	3371852.0
ROSMA	35°12'06.93"	277°07'41.01"	914.0	647539.4	-5178081.8	3656533.4	924443.5

Table 3

Initial SAO C-5 Surveys

Station	Geodetic Coordinates			Earth-Centered Cartesian Coordinates (meters)			Chord to Columbia (meters)
	Geodetic Latitude ϕ	Longitude λ	Geodetic Height h(m)	x	y	z	c
GSFMA	39°01'14.787"	283°10'20.392"	-1.3	1130720.4	-4831344.4	3994125.3	1329021.2
BPOMA	38°25'49.448"	282°54'48.658"	-50.4	1118038.9	-4876327.9	3942965.7	1313098.2
JU4MA	27°01'14.398"	279°53'12.492"	-38.1	976270.8	-5601396.6	2880250.6	1726820.6
FTMMA	26°32'53.081"	278°08'03.806"	-42.5	807858.3	-5651986.8	2833504.1	1670041.2
BERMA	32°21'48.944"	295°20'34.189"	-28.4	2308206.9	-4873616.9	3394555.1	2569592.5
COLMA	38°53'35.819"	267°47'40.856"	218.2	-191285.6	-4967284.5	3983257.1	0
DENMA	39°38'47.544"	255°23'38.529"	1751.6	-1240478.0	-4760236.9	4048979.3	1071444.2
EDIMA	26°22'46.352"	261°40'07.347"	15.8	-828490.4	-5657462.3	2816813.7	1497653.3
GFOMA	48°01'20.811"	262°59'19.553"	200.3	-521703.3	-4242055.4	4718715.1	1084449.9
JAMMA	18°04'34.202"	283°11'27.039"	424.0	-1384170.5	-5905686.0	1966540.3	2725767.0
MOJMA	35°19'47.579"	243°05'59.186"	874.9	-2357241.9	-4646332.0	3668307.5	2212141.5
PURMA	18°15'28.307"	294°00'23.633"	5.9	2465075.9	-5534944.5	1985518.7	3371861.8
ROSMA	35°12'07.031"	277°07'40.811"	857.3	647516.2	-5177937.2	3656707.2	924444.6

Table 4

Initial MERCURY Surveys

Station	Geodetic Coordinates			Earth-Centered Cartesian Coordinates (meters)			Chord to Columbia (meters)
	Geodetic Latitude ϕ	Longitude λ	Geodetic Height h(m)	x	y	z	c
GSFMA	39°01'15.239"	283°10'21.107"	53.0	1130744.7	-4831372.7	3994174.5	1329017.7
BPOMA	38°25'49.910"	282°54'49.370"	6.0	1118063.5	-4876358.2	3943016.2	1313094.7
JU4MA	27°01'14.970"	279°53'13.290"	14.0	976299.1	-5601430.8	2880293.3	1726827.0
FTMMA	26°32'53.780"	278°08'04.600"	9.0	807885.2	-5652020.0	2833549.7	1670044.9
BERMA	32°21'49.660"	295°20'34.480"	30.0	2308229.8	-4873647.5	3394608.9	2569586.7
COLMA	38°53'36.380"	267°47'42.070"	270.0	-191257.5	-4967314.7	3983307.3	0
DENMA	39°38'48.210"	255°23'40.140"	1800.0	-1240446.9	-4760296.6	4049030.3	1071435.6
EDIMA	26°22'47.370"	261°40'08.560"	60.0	-828460.9	-5657492.8	2816864.7	1497652.3
GFOMA	48°01'21.180"	262°59'21.050"	250.0	-521675.5	-4242083.2	4718764.3	1084450.9
JAMMA	18°04'35.412"	283°11'27.488"	446.0	1384185.6	-5905692.7	1966584.9	2725755.5
MOJMA	35°19'48.560"	243°06'00.850"	922.0	-2357213.8	-4646369.6	3668363.4	2212139.6
PURMA	18°15'29.538"	294°00'23.804"	50.0	2465093.0	-5534970.4	1985570.9	3371851.2
ROSMA	35°12'07.580"	277°07'41.670"	912.0	647542.1	-5177968.8	3656756.8	924443.1

Table 5

Solution 1

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta \bar{E}$	$\Delta N - \Delta \bar{N}$	$\Delta V - \Delta \bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	6.7	19.1	-3.2	3.3	2.1	3.1	-0.4	19.3	4.0	-3.1	11.8	15.0	5.5	4.2
BPOMA	13.4	-4.5	1.6	4.5	3.6	4.7	6.4	-4.3	4.8	7.7	-4.8	-0.4	14.6	11.1
JU4MA	11.6	-17.3	-7.1	3.1	3.2	3.1	4.6	-17.1	-3.9	5.2	-3.4	-17.0	21.1	12.2
FTMMA	11.3	-8.5	0.4	2.5	2.9	2.4	4.3	-8.2	3.6	5.2	-6.2	-5.7	14.6	8.7
BERMA	42.5	7.8	-3.1	5.3	3.2	3.7	35.5	8.1	0.1	30.2	19.1	6.9	36.0	14.0
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	-7.0	0.3	3.2	-7.1	-2.1	2.3	0.0	0.0
DENMA	-2.3	6.7	3.9	3.1	1.9	2.6	-9.3	6.9	7.1	-9.2	1.3	9.8	3.2	3.0
EDIMA	-5.8	-4.4	4.9	2.5	3.2	2.7	-12.8	-4.1	8.1	-14.0	-7.1	0.0	7.0	4.7
GFOMA	-6.5	16.8	5.1	2.1	2.6	2.4	-13.5	17.0	8.3	-12.5	8.7	17.5	19.2	17.7
JAMMA	14.5	-7.7	-17.1	3.7	4.7	3.8	7.4	-7.4	-13.9	4.8	12.3	-11.4	12.0	4.4
MOJMA	-17.0	-1.3	7.6	5.2	2.4	3.1	-24.0	-1.0	10.8	-25.7	2.5	5.4	18.4	8.3
PURMA	15.3	-11.0	-26.4	4.5	4.6	4.4	8.3	-10.8	-23.2	0.0	20.4	-17.5	13.6	4.0
ROSMA	7.5	1.0	-4.5	2.8	2.1	3.0	0.5	1.2	-1.3	0.2	1.8	0.3	6.4	7.0
AVERAGE	7.0	-0.3	-3.2	3.3	2.8	3.0	0.0	0.0	0.0	-1.4	4.8	0.4	14.3	8.3

Table 6

Solution 2

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	3.0	19.2	-3.6	3.3	2.1	3.1	-3.3	17.3	0.4	-5.6	9.5	13.7	2.4	1.8
BPOMA	9.8	-4.1	1.2	4.5	3.6	4.7	3.5	-6.1	5.2	5.2	-6.8	-1.5	11.5	8.8
JU4MA	8.7	-13.5	-7.8	3.1	3.2	3.1	2.4	-15.4	-3.8	3.0	-3.2	-15.4	16.5	9.6
FTMMA	8.8	-4.5	-0.3	2.5	2.9	2.4	2.5	-6.4	3.7	3.3	-5.8	-4.1	10.0	6.0
BERMA	35.9	10.7	-4.5	5.3	3.2	3.7	29.6	8.7	-0.5	24.6	17.3	7.1	29.7	11.5
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	-6.3	-1.9	4.0	-6.4	-4.1	1.0	0	0
DENMA	0.8	6.6	3.6	3.1	1.9	2.6	-5.5	4.7	7.6	-6.0	-1.4	8.5	0.5	0.5
EDIMA	-4.3	-0.4	4.4	2.5	3.2	2.8	-10.6	-2.4	8.4	-11.7	-7.0	1.6	3.2	2.0
GFOMA	-5.3	13.9	4.8	2.1	2.6	2.4	-11.6	12.0	8.8	-11.1	4.4	14.5	16.3	15.0
JAMMA	10.8	-1.2	-18.9	3.7	4.7	3.8	4.5	-3.2	-14.9	1.4	13.8	-7.6	4.7	1.7
MOJMA	-11.1	0.6	6.5	5.2	2.4	3.1	-17.4	-1.4	10.9	-19.9	-0.8	5.2	13.0	5.9
PURMA	9.4	-4.3	-29.2	4.5	4.6	4.4	3.1	-6.3	-25.2	-6.1	21.3	-13.8	4.8	1.4
ROSMA	5.3	2.3	-4.7	2.8	2.1	3.0	-1.0	0.3	-0.7	-1.1	0.6	-0.2	4.1	4.5
AVERAGE	6.3	1.9	-4.0	3.3	2.8	3.0	0.0	0.0	0.0	-2.5	2.9	0.7	9.7	5.7

Table 7

Solution 3

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change (x 10^{-6})
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	2.0	18.1	-5.3	3.6	2.3	3.3	-2.4	15.6	-1.8	-5.0	10.4	11.0	1.3	0.9
BPOMA	5.1	-6.8	6.1	4.9	4.0	5.4	0.7	-9.3	9.6	3.7	-12.8	-1.3	7.7	5.9
JU4MA	7.6	-11.5	-7.2	3.3	3.5	3.3	3.2	-14.0	-3.7	3.7	-2.5	-14.2	14.2	8.2
FTMMA	6.9	-2.7	-1.2	2.7	3.1	2.6	2.5	-5.2	2.3	3.1	-4.0	-3.6	7.2	4.3
BERMA	32.1	10.5	-3.5	5.7	3.5	4.1	27.7	8.0	0.0	23.2	15.7	6.7	26.4	10.3
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	-4.4	-2.5	3.5	-4.6	-4.1	0.3	0	0
DENMA	1.5	5.9	2.3	3.3	2.0	2.8	-3.0	3.4	5.8	-3.4	-1.5	6.3	-0.3	-0.3
EDIMA	-3.3	0.1	4.4	2.6	3.4	3.0	-7.7	-2.4	7.9	-8.8	-7.0	1.3	2.2	1.5
GFOMA	-4.7	11.6	4.1	2.3	2.7	2.5	-9.1	9.1	7.6	-8.9	2.8	11.7	13.7	12.6
JAMMA	9.1	2.5	-20.5	3.9	5.1	4.1	4.7	0.0	-17.0	0.9	16.8	05.2	0.0	0.0
MOJMA	-6.4	3.0	7.0	5.6	2.5	3.4	-10.8	0.5	10.5	-13.4	-2.5	6.5	8.0	3.6
PURMA	4.1	-1.5	-20.6	4.8	4.9	4.7	0.3	-4.0	-17.1	-5.8	13.8	-9.1	1.6	0.5
ROSMA	3.3	3.3	-7.5	3.0	2.3	3.2	-1.2	0.8	-4.0	-1.6	3.5	-1.7	1.5	1.6
AVERAGE	4.4	2.5	-3.5	3.5	3.0	3.3	0.0	0.0	0.0	-1.3	2.2	0.7	7.0	4.1

Table 8

Solution 4

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	-5.7	18.6	-6.2	3.6	2.3	3.3	-7.0	11.6	-0.1	-8.5	5.6	8.9	-5.2	-3.9
BPOMA	-2.4	-5.9	5.2	4.9	4.0	5.4	-3.7	-13.0	-0.3	0.2	-17.3	-3.1	1.4	1.1
JU4MA	1.5	-3.6	-8.6	3.3	3.5	3.3	0.2	-10.6	-2.5	0.7	-2.5	-10.6	4.9	2.8
FTMMA	1.7	5.5	-2.6	2.7	3.1	2.6	0.4	-1.6	3.5	0.7	-2.4	3.0	-4.6	-2.7
BERMA	18.7	16.5	-6.7	5.7	3.5	4.1	17.4	9.4	-0.6	13.4	12.4	7.6	13.3	5.2
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	-1.3	-7.1	6.1	-1.7	-9.1	-1.7	0	0
DENMA	7.8	5.9	1.7	3.3	2.0	2.8	6.5	-1.2	7.8	4.6	-8.2	4.0	-5.6	-5.3
EDIMA	-0.1	8.2	3.3	2.6	3.4	3.0	-1.4	1.1	9.4	-2.6	-7.6	5.2	-5.6	-3.7
GFOMA	-2.2	5.7	3.5	2.3	2.7	2.5	-3.5	-1.3	9.6	-4.4	-6.9	6.2	7.6	7.0
JAMMA	1.6	15.9	-24.1	3.9	5.1	4.1	0.2	8.8	-18.0	-4.3	19.3	2.8	-14.7	-5.4
MOJMA	5.9	6.8	4.6	5.6	2.5	3.4	4.6	-0.2	10.7	0.0	-10.0	6.0	-2.8	-1.3
PURMA	-8.3	12.4	-35.1	4.8	4.9	4.7	-9.6	5.3	-29.0	-20.7	22.8	-4.1	-18.9	-5.6
ROSMA	-1.5	6.0	-7.8	3.0	2.3	3.2	-2.8	-1.1	-1.7	-2.9	0.4	-1.9	-3.2	-3.4
AVERAGE	1.3	7.1	-6.1	3.5	3.0	3.3	0.0	0.0	0.0	-2.0	-0.3	1.7	-2.8	-1.3

Table 9

Solution 5

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	-5.5	11.9	1.3	3.0	2.6	3.5	-9.5	9.1	-0.7	-10.6	3.9	6.6	-9.7	-7.3
BPOMA	-2.0	-12.3	12.9	4.6	4.2	5.7	-6.0	-15.1	10.9	-1.8	-18.8	-5.1	-3.0	-2.3
JU4MA	2.7	-6.7	0.0	3.0	3.1	3.5	-1.3	-9.5	-2.0	-0.8	-2.6	-9.4	0.2	0.1
FTMMA	3.3	2.5	6.0	2.5	2.7	2.8	-0.6	-0.3	4.0	-0.1	-3.7	1.6	-6.3	-3.8
BERMA	15.5	12.0	1.3	5.1	3.4	4.3	11.5	9.2	-0.7	8.0	9.9	7.4	5.5	2.1
COLMA	4.9	-5.9	7.2	3.2	2.2	3.1	1.0	-8.8	5.2	0.6	-9.6	-3.5	0	0
DENMA	15.7	0.5	7.6	5.0	2.5	3.5	11.8	-2.4	5.6	10.0	-8.6	1.7	-8.7	-8.1
EDIMA	6.3	5.9	10.9	4.1	3.4	3.5	2.3	3.0	8.9	1.3	-6.9	6.7	-9.5	-6.3
GFOMA	3.7	-2.2	9.1	3.7	3.5	3.3	-0.2	-5.1	7.1	-1.2	-8.5	1.9	5.0	4.6
JAMMA	1.7	15.5	-15.1	3.4	4.6	4.1	-2.3	12.7	-17.1	-6.8	19.1	6.7	-21.7	-8.0
MOJMA	16.5	3.6	9.3	7.1	2.9	4.0	12.6	0.8	7.3	8.7	-10.5	4.8	-9.3	-4.2
PURMA	-11.4	12.1	-26.4	4.0	4.4	4.4	-15.4	9.2	-28.4	-26.2	21.0	-0.1	-28.2	-8.4
ROSMA	0.0	0.0	0.0	0.0	0.0	0.0	-3.9	-2.8	-2.0	-4.0	-0.5	-3.4	-6.3	-6.8
AVERAGE	3.9	2.8	2.0	3.7	3.0	3.5	0.0	0.0	0.0	-1.7	-1.2	1.2	-7.7	-4.0

Table 10

Solution 6

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change (x 10^{-6})
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	-3.5	14.3	-11.9	6.7	2.7	4.6	-5.3	13.4	-0.6	-7.2	7.4	10.0	-3.3	-2.5
BPOMA	-0.3	-10.4	-0.4	7.4	4.3	6.3	-2.0	-11.3	10.9	1.6	-15.6	-2.1	3.4	2.6
JU4MA	3.2	-11.3	-13.2	6.4	3.8	4.5	1.4	-12.1	-1.9	2.0	-3.5	-11.6	8.6	5.0
FTMMA	3.0	-2.3	-7.1	6.0	3.4	4.0	1.2	-3.1	4.2	1.9	-4.9	-0.9	1.8	1.1
BERMA	23.0	9.8	-11.3	8.2	4.2	5.6	21.2	9.0	0.0	17.1	13.4	7.6	17.8	6.9
COLMA	-0.3	-4.1	-5.9	4.9	2.1	3.6	-2.0	-5.0	5.4	-2.3	-7.3	-0.5	0.0	0.0
DENMA	4.8	1.3	-4.1	3.5	2.1	3.2	3.0	0.5	7.2	1.6	-5.8	4.9	-3.2	-3.0
EDIMA	-2.0	0.1	-1.2	4.1	3.2	3.7	-3.7	-0.7	10.1	-5.0	-8.7	3.9	-1.6	-1.1
GFOMA	-3.6	4.2	-2.9	4.3	3.0	3.5	-5.4	3.4	8.4	-5.7	-2.4	8.5	10.4	9.6
JAMMA	3.7	6.0	-26.8	6.8	5.1	5.4	1.9	5.2	-15.5	-1.9	16.4	0.2	-8.5	-3.1
MOJMA	0.0	0.0	0.0	0.0	0.0	0.0	-1.8	-0.8	11.3	-6.0	-7.8	5.9	2.6	1.2
PURMA	-4.8	2.7	-37.1	7.3	5.2	6.4	-6.5	1.8	-25.8	-16.2	20.2	-6.3	-12.2	-3.6
ROSMA	-0.3	0.5	-13.5	6.1	2.8	4.4	-2.1	-0.3	-2.2	-2.3	1.4	-1.5	-1.6	-1.8
AVERAGE	1.8	0.8	-11.3	5.5	3.2	4.2	0.0	0.0	0.0	1.7	0.2	0.2	1.2	0.9

Table 11

Solution 7

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	3.1	17.2	-2.9	3.6	2.3	3.3	-2.1	13.6	-0.5	-3.6	8.4	10.3	2.5	1.9
BPOMA	6.4	-7.7	6.3	4.9	4.0	5.4	1.2	-11.2	8.7	4.7	-13.0	-3.4	9.0	6.8
JU4MA	6.6	-0.9	-7.8	3.3	3.5	3.3	1.4	-4.4	-5.5	1.4	3.2	-6.4	4.9	2.9
FTMMA	7.1	4.9	-2.3	2.7	3.1	2.6	1.9	1.3	0.1	2.3	0.9	1.2	0.6	0.4
BERMA	32.9	8.1	-4.8	5.7	3.5	4.1	27.7	4.6	-2.5	23.6	16.2	2.6	27.5	10.7
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	-5.2	-3.5	2.3	-4.8	-3.9	-1.3	0.0	0.0
DENMA	-0.6	6.3	0.6	3.3	2.0	2.8	-5.8	-2.8	2.9	-6.6	-2.4	-0.3	6.8	6.4
EDIMA	-4.0	1.3	3.6	2.6	3.4	3.0	-9.2	-2.3	5.1	-9.5	-5.0	0.6	1.0	0.7
GFOMA	-3.8	8.4	6.6	2.3	2.7	2.5	-9.0	4.9	8.9	-8.7	-1.3	9.9	10.5	9.7
JAMMA	14.2	2.9	4.6	3.9	5.1	4.1	9.0	-0.6	6.9	10.8	-4.4	1.6	7.2	2.6
MOJMA	-7.0	2.8	-2.4	5.6	2.5	3.4	-12.2	-0.7	-0.1	-10.6	5.0	-0.6	6.8	3.1
PURMA	8.4	-2.7	-23.8	4.8	4.9	4.7	3.2	-6.2	-21.4	-4.1	18.3	-12.6	3.6	1.1
ROSMA	4.3	5.2	-8.2	3.0	3.3	3.2	-0.9	1.6	-5.8	-1.1	5.6	-2.0	1.5	1.6
AVERAGE	5.2	3.5	-2.3	3.5	3.1	3.3	0.0	0.0	0.0	-0.5	2.4	0.3	6.3	3.7

Table 12

Solution 8

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change (x 10^{-6})
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	-44.2	25.2	-11.2	3.6	2.3	3.3	-6.0	19.9	-5.8	-9.7	15.2	11.8	5.1	3.9
BPOMA	-41.0	0.5	-2.2	4.9	4.0	5.4	-8.9	-4.8	3.3	-7.4	-7.4	-1.7	5.2	3.9
JU4MA	-42.0	3.2	-15.1	3.3	3.5	3.3	-3.8	-2.0	-9.7	-5.1	6.9	-6.2	3.3	1.9
FTMMA	-41.8	8.3	-8.2	2.7	3.1	2.6	-3.7	3.0	-2.8	-4.2	3.2	1.5	-0.7	-0.4
BERMA	-9.9	19.8	-22.4	5.7	3.5	4.1	28.3	14.6	-16.9	16.1	32.0	3.2	28.6	11.1
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	38.1	-5.3	5.5	37.8	-9.0	-0.7	0.0	0.0
DENMA	-48.9	-1.0	10.9	3.3	2.0	2.8	-10.7	-6.3	16.4	-14.6	-13.4	5.7	6.8	6.4
EDIMA	-53.6	-1.3	10.2	2.6	3.4	3.0	-15.5	-6.6	15.7	-17.8	-14.6	1.1	4.4	2.9
GFOMA	-52.8	4.9	11.5	2.3	2.7	2.5	-14.7	-0.3	16.9	-16.0	-9.7	12.4	8.6	7.9
JAMMA	-32.6	5.8	-5.9	3.9	5.1	4.1	5.5	0.5	-0.5	5.2	1.8	0.3	6.6	2.4
MOJMA	51.1	-9.1	16.9	5.6	2.5	3.4	-13.0	-14.4	22.3	-23.5	-17.8	1.2	9.6	4.3
PURMA	-33.1	2.6	-43.0	4.8	4.9	4.7	5.0	-2.7	-37.5	-9.6	33.8	-14.3	3.8	1.1
ROSMA	-44.9	9.6	-12.5	3.0	2.3	3.2	-6.7	4.4	-7.1	-7.7	7.4	-0.5	0.9	1.0
AVERAGE	-38.1	5.3	-5.5	3.5	3.1	3.3	0.0	0.0	0.0	-4.3	2.2	1.1	6.3	3.6

Table 13

Solution 9

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	-16.2	-11.8	34.7	3.6	2.3	3.3	-14.3	1.9	1.1	-14.0	-3.0	2.1	-15.7	-11.8
BPOMA	-12.3	-35.5	44.1	4.9	4.1	5.4	-10.4	-21.8	10.6	-5.3	-23.6	-10.5	-8.8	-6.7
JU4MA	-8.5	-13.6	35.2	3.3	3.5	3.3	-6.6	0.1	1.6	-6.3	-2.5	0.8	-17.5	-10.1
FTMMA	-5.6	-7.3	41.2	2.7	3.1	2.6	-3.7	6.4	7.6	-3.1	-4.4	9.1	-20.6	-12.4
BERMA	-2.1	-8.5	30.6	5.6	3.5	4.1	-0.2	5.2	-3.0	-2.4	4.7	2.8	-7.3	-2.9
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	1.9	13.7	-33.6	3.2	34.6	-10.4	0.0	0.0
DENMA	18.2	-23.4	37.6	3.3	2.0	2.8	20.0	-9.7	4.1	17.0	-14.1	-4.9	-8.0	-7.5
EDIMA	6.5	-10.8	47.3	2.6	3.4	3.0	8.4	2.9	13.7	6.7	-12.1	8.7	-17.0	-11.3
GFOMA	4.7	-32.7	39.6	2.3	2.7	2.5	6.6	-19.0	6.0	4.3	-18.8	-8.2	-2.1	-1.9
JAMMA	-5.1	3.7	47.3	3.9	5.1	4.1	-3.2	17.3	13.7	-1.4	-8.2	20.7	-27.1	-9.9
MOJMA	27.4	-17.9	32.0	5.6	2.5	3.4	29.3	-4.2	-1.6	25.6	-14.3	-4.4	-22.7	-10.2
PURMA	-24.6	-0.5	14.1	4.8	4.9	4.7	-22.7	13.2	-19.5	-30.0	11.4	6.5	-39.7	-11.8
ROSMA	-6.8	-19.6	32.7	3.0	2.3	3.2	-4.9	-5.9	-0.8	-4.5	-3.3	-5.3	-10.8	-11.7
AVERAGE	-1.9	-13.7	33.6	3.5	3.0	3.3	0.0	0.0	0.0	-0.8	-4.1	0.5	-19.8	-8.3

Table 14

Solution 10

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change (x 10^{-6})
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	20.2	48.2	-39.5	3.6	2.3	3.3	9.1	23.7	1.0	5.6	15.9	19.1	21.9	16.4
BPOMA	22.9	22.2	-30.5	4.9	4.0	5.4	11.7	-2.3	10.0	13.5	-6.4	4.4	27.9	21.3
JU4MA	19.5	14.1	-50.3	3.3	3.5	3.3	8.3	-10.4	-9.7	7.5	5.3	-13.6	28.1	16.2
FTMMA	17.4	19.3	-45.1	2.7	3.1	2.6	6.3	-5.2	-4.6	6.0	2.7	-6.7	22.6	13.5
BERMA	65.8	27.2	-40.0	5.7	3.5	4.1	54.6	2.8	0.6	48.9	24.3	2.6	64.1	24.9
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	-11.1	-24.5	40.5	-12.9	-46.4	6.4	0.0	0.0
DENMA	-21.4	37.4	-34.6	3.3	2.0	2.8	-32.5	12.9	5.9	-30.5	11.7	13.7	22.3	20.9
EDIMA	-16.6	15.3	-38.9	2.6	3.4	3.0	-27.8	-9.1	1.6	-28.3	-1.4	-7.5	19.4	13.0
GFOMA	-14.4	50.6	-24.5	2.3	2.7	2.5	-25.5	26.1	16.0	-24.3	11.8	29.3	23.2	21.4
JAMMA	31.2	4.6	-38.0	3.9	5.1	4.1	20.0	-19.9	2.5	21.4	-3.7	-18.1	42.6	15.6
MOJMA	-43.0	24.9	-34.8	5.6	2.5	3.4	-54.2	0.5	5.7	-50.3	20.6	3.7	37.5	16.9
PURMA	39.2	-2.3	-61.9	4.8	4.9	4.7	28.1	-26.7	-21.4	20.8	22.3	-32.1	48.5	14.4
ROSMA	13.0	31.9	-48.1	3.0	2.3	3.2	1.9	7.5	-7.5	0.5	10.6	1.8	14.5	15.7
AVERAGE	11.1	24.5	-40.5	3.5	3.0	3.3	0.0	0.0	0.0	-1.7	5.2	0.2	28.7	16.2

Table 15

Solution 11

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	7.1	-21.1	-32.9	3.6	2.3	3.3	0.5	15.4	-8.0	-3.2	15.6	6.9	4.8	3.6
BPOMA	10.5	-46.0	-23.2	4.9	4.0	5.4	3.8	-9.6	1.7	5.3	-6.2	-6.5	11.4	8.7
JU4MA	9.8	-48.7	-28.8	3.3	3.5	3.3	3.1	-12.2	-4.0	3.4	-1.5	-12.7	13.7	7.9
FTMMA	9.9	-43.2	-22.8	2.7	3.1	2.6	3.2	-6.7	2.1	3.7	-4.3	-5.1	9.8	5.8
BERMA	40.5	-36.3	-28.8	5.7	3.5	4.1	33.8	0.1	-3.9	29.2	17.5	-2.0	34.8	13.6
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	-6.7	36.4	24.8	-6.5	3.8	43.9	0.0	0.0
DENMA	-4.7	-31.1	-30.6	3.3	2.0	2.8	-11.4	5.3	-5.8	-9.0	10.4	0.4	9.1	8.5
EDIMA	-5.8	-46.8	-17.1	2.6	3.4	3.0	-12.4	-10.4	7.8	-14.0	-9.6	-5.8	9.9	6.6
GFOMA	-5.5	-19.9	-29.9	2.3	2.7	2.5	-12.2	16.5	-5.1	-10.2	17.1	7.3	18.3	16.9
JAMMA	17.9	-49.6	-8.1	3.9	5.1	4.1	11.3	-13.1	16.7	15.5	-16.8	-7.3	21.8	8.0
MOJMA	-14.7	-39.3	-29.2	5.6	2.5	3.4	-21.4	-2.9	-4.4	-18.2	11.4	-4.9	12.3	5.5
PURMA	14.6	-55.2	-35.6	4.8	4.9	4.7	8.0	-18.8	-10.7	5.5	7.2	-21.2	18.8	5.6
ROSMA	7.1	-36.5	-36.0	3.0	2.3	3.2	0.4	0.0	-11.1	-0.7	9.1	-6.4	4.8	5.2
AVERAGE	6.7	-36.4	-24.8	3.5	3.0	3.3	0.0	0.0	0.0	0.1	4.1	-1.0	13.0	7.4

Table 16

Solution 12

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	$\sigma_{\Delta E}$	$\sigma_{\Delta N}$	$\sigma_{\Delta V}$	$\Delta E - \Delta \bar{E}$	$\Delta N - \Delta \bar{N}$	$\Delta V - \Delta \bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	-0.5	17.43	-3.3	3.6	2.3	3.3	-4.2	12.4	-0.3	-6.0	6.9	9.5	-0.7	-0.6
BPOMA	2.9	-7.2	5.9	4.9	4.0	5.4	-0.9	-12.2	9.0	2.4	-14.4	-4.0	5.7	4.3
JU4MA	3.7	1.6	-8.4	3.3	3.5	3.3	0.0	-3.4	-5.3	-0.5	3.2	-5.4	1.4	0.8
FTMMA	4.6	7.4	-2.8	2.7	3.1	2.6	0.9	2.4	0.3	0.7	1.0	2.3	-2.6	-1.5
BERMA	26.6	10.3	-6.3	5.7	3.5	4.1	22.9	5.3	-3.2	19.0	15.2	2.8	21.9	8.5
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	-3.7	-5.0	3.0	-3.9	-5.3	-2.0	0.0	0.0
DENMA	2.4	6.4	0.3	3.3	2.0	2.8	-1.3	1.4	3.3	-1.7	-1.3	3.2	4.1	3.9
EDIMA	-2.5	3.8	3.2	2.6	3.4	3.0	-6.2	-1.2	6.2	-7.0	-5.1	1.7	-1.6	-1.1
GFOMA	-2.6	6.4	6.3	2.3	2.7	2.5	-6.3	1.4	9.4	-6.9	-4.4	7.9	8.1	7.4
JAMMA	10.5	6.8	3.3	3.9	5.1	4.1	6.8	1.8	6.4	7.9	-3.8	3.7	2.2	0.8
MOJMA	-1.2	4.3	-3.5	5.6	2.5	3.4	-4.9	-0.6	-0.5	-4.4	2.3	-0.8	1.4	0.6
PURMA	2.4	1.6	-25.9	4.8	4.9	4.7	-1.3	-3.4	-22.9	-9.6	18.3	-10.4	-3.3	-1.0
ROSMA	2.0	6.1	-8.3	3.0	2.3	3.2	-1.7	1.1	-5.3	-2.3	4.7	-2.2	-0.7	-0.8
AVERAGE	3.7	5.0	-3.0	3.5	3.0	3.3	0.0	0.0	0.0	-1.1	1.3	0.5	2.8	1.6

Table 17

Solution 13

Stations	Topocentric Coordinate Corrections (meters)			Standard Deviation (meters)			Adjusted Corrections (meters)			Adjusted Correction in Earth-Centered Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	$''\Delta E$	$''\Delta N$	$''\Delta V$	$\Delta E - \Delta\bar{E}$	$\Delta N - \Delta\bar{N}$	$\Delta V - \Delta\bar{V}$	ΔX	ΔY	ΔZ	ΔC	S
GSFMA	1.8	17.7	-4.3	3.6	2.3	3.3	-2.4	10.8	-1.2	-4.1	7.0	-7.7	1.9	1.4
BPOMA	6.2	-4.6	7.0	4.9	4.0	5.4	2.0	-11.5	10.2	5.3	-14.3	-2.7	9.1	7.0
JU4MA	5.1	1.7	-11.3	3.3	3.5	3.3	0.9	-5.2	-8.2	0.0	5.0	-8.3	2.0	1.1
FTMMA	6.2	8.0	-2.9	2.7	3.1	2.6	2.1	1.1	0.3	2.0	0.6	1.1	-2.2	-1.3
BERMA	33.0	10.1	-0.4	5.7	3.5	4.1	28.8	3.2	2.7	26.3	11.8	4.2	28.8	11.2
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	-4.2	-6.9	3.1	-4.4	-6.6	-3.4	0.0	0.0
DENMA	-2.4	7.6	1.4	3.3	2.0	2.8	-6.5	0.7	4.5	-7.1	-1.3	3.4	3.8	3.6
EDIMA	-2.9	4.6	6.5	2.6	3.4	3.0	-7.0	-2.3	9.6	-8.3	-8.5	2.3	-1.9	-1.3
GFOMA	-4.6	15.5	0.5	2.3	2.7	2.5	-8.8	8.6	3.6	-8.2	5.0	8.5	17.0	15.7
JAMMA	12.0	12.9	-16.4	3.9	5.1	4.1	7.8	6.0	-13.3	4.3	15.9	1.6	-6.4	-2.3
MOJMA	-10.9	3.0	7.9	5.6	2.5	3.4	-15.0	-3.9	11.0	-18.5	-3.2	3.2	13.4	6.0
PURMA	5.1	8.2	-21.0	4.8	4.9	4.7	0.9	1.4	-17.9	-6.2	16.3	-4.3	-4.8	-1.4
ROSMA	5.4	4.6	-7.6	3.0	2.3	3.2	1.3	-2.3	-4.5	1.0	2.5	-4.4	3.2	3.4
AVERAGE	4.2	6.9	-3.1	3.5	3.0	3.3	0.0	0.0	0.0	-1.4	2.3	0.7	4.9	3.3

Table 11A

Solution 7, Without Adjusted Corrections

Stations	Topocentric Coordinate Corrections (meters)			Topocentric Corrections Transformed to Common Cartesian Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	ΔX	ΔY	ΔZ	C	S
COLMA	0.0	0.0	0.0	0	0	0	0	0
GSFMA	3.1	17.2	-2.9	0.1	13.4	11.6	1.6	1.2
BPOMA	6.4	-7.7	6.3	8.4	-8.1	-2.2	7.9	6.0
JU4MA	6.6	-0.9	-7.8	5.4	7.6	-4.4	3.7	2.1
FTMMA	7.1	4.9	-2.3	6.5	5.2	3.4	-0.6	-0.4
BERMA	32.9	8.1	-4.8	26.1	21.6	4.3	25.2	9.8
DENMA	-0.6	6.3	0.6	0.3	3.5	5.3	0.7	0.6
EDIMA	-4.0	1.3	3.6	-4.4	-2.0	2.8	0.6	0.4
GFOMA	-3.8	8.4	6.6	-3.5	2.3	10.5	9.7	9.0
JAMMA	14.2	2.9	4.6	14.6	-0.1	4.2	5.4	2.0
MOJMA	-7.0	2.8	-2.4	-4.6	6.3	0.9	5.3	2.4
PURMA	8.4	-2.7	-23.8	-1.2	23.3	-10.0	1.1	0.3
ROSMA	4.3	5.2	-8.2	3.0	10.1	-0.5	0.6	0.6
AVERAGE	5.2	3.5	-2.3	4.2	6.9	2.2	5.1	2.8

Table 12A

Solution 8, Without Adjusted Corrections

Stations	Topocentric Coordinate Corrections (meters)			Topocentric Corrections Transformed to Common Cartesian Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	ΔX	ΔY	ΔZ	C	S
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	0	0
GSFMA	-44.2	25.2	-11.2	-48.6	13.9	12.6	3.1	2.3
BPOMA	-41.0	0.5	-2.2	-40.4	-7.2	-1.0	9.3	7.1
JU4MA	-42.0	3.2	-15.1	-43.9	7.5	-4.0	4.9	2.8
FTMMA	-41.8	8.3	-8.2	-42.9	5.0	3.8	0.6	0.3
BERMA	-9.9	19.8	-22.4	-21.6	22.4	4.8	27.8	10.8
DENMA	-48.9	-1.0	10.9	-49.6	3.6	6.2	0.4	0.3
EDIMA	-53.6	-1.3	10.2	-54.5	-1.8	3.4	1.0	0.7
GFOMA	-52.8	4.9	11.5	-52.9	2.5	11.8	9.6	8.9
JAMMA	-32.6	5.8	-5.9	-33.4	-0.2	3.7	7.9	2.9
MOJMA	-51.1	-9.1	16.9	-54.2	6.2	2.4	4.6	2.1
PURMA	-33.1	2.6	-43.0	-47.2	24.6	-11.0	5.5	1.6
ROSMA	-44.9	9.6	-12.5	-46.5	10.0	0.7	1.2	1.4
AVERAGE	-38.1	5.3	-5.5	-44.6	7.2	2.8	6.3	3.4

Table 13A

Solution 9, Without Adjusted Corrections

Stations	Topocentric Coordinate Corrections (meters)			Topocentric Corrections Transformed to Common Cartesian Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	ΔX	ΔY	ΔZ	C	S
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	0	0
GSFMA	-16.2	-11.8	34.7	-7.9	-37.1	12.7	-6.1	-4.6
BPOMA	-12.3	-35.5	44.1	0.7	-57.9	-0.4	0.5	0.4
JU4MA	-8.5	-13.6	35.2	-1.9	-38.4	3.8	-6.9	-4.0
FTMMA	-5.6	-7.3	41.2	0.2	-40.5	11.9	-10.9	-6.5
BERMA	-2.1	-8.5	30.6	11.1	-28.4	9.2	10.1	3.9
DENMA	18.2	-23.4	37.6	6.5	-47.1	6.0	-5.9	-5.5
EDIMA	6.5	-10.8	47.3	-0.4	-47.6	11.3	-8.8	-5.9
GFOMA	4.7	-32.7	39.6	-1.5	-50.9	7.5	3.9	3.6
JAMMA	-5.1	3.7	47.3	5.0	-43.8	18.2	-11.5	-4.2
MOJMA	27.4	-17.9	32.0	7.9	-44.9	3.9	-7.7	-3.5
PURMA	-24.6	-0.5	14.1	-17.0	-22.4	4.0	-19.4	-5.8
ROSMA	-6.8	-19.6	32.7	-2.0	-38.5	2.8	-4.7	-5.0
AVERAGE	-1.9	-13.7	33.6	0.1	-41.5	7.6	-5.6	-3.1

Table 14A

Solution 10, Without Adjusted Corrections

Stations	Topocentric Coordinate Corrections (meters)			Topocentric Corrections Transformed to Common Cartesian Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	ΔX	ΔY	ΔZ	C	S
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GSFMA	20.2	48.2	-39.5	5.8	64.0	12.6	9.5	7.2
BPOMA	22.9	22.2	-30.5	13.9	41.8	-1.6	15.6	11.9
JU4MA	19.5	14.1	-50.3	10.4	53.8	-10.3	14.4	8.3
FTMMA	17.4	19.3	-45.1	10.3	50.9	-2.9	9.8	5.9
BERMA	65.8	27.2	-40.0	38.8	71.8	1.6	40.5	15.8
DENMA	-21.4	37.4	-34.6	-8.0	54.2	6.8	6.8	6.4
EDIMA	-16.6	15.3	-38.9	-10.4	43.6	-3.6	10.0	6.7
GFOMA	-14.4	50.6	-24.5	-7.7	55.4	15.6	15.2	14.0
JAMMA	31.2	4.6	-38.0	21.8	43.7	-7.4	22.2	8.2
MOJMA	-43.0	24.9	-34.8	-19.0	57.6	0.2	17.6	8.0
PURMA	39.2	-2.3	-61.9	12.1	69.0	-21.6	21.4	6.3
ROSMA	13.0	31.9	-48.1	5.7	58.8	-1.6	6.1	6.6
AVERAGE	11.1	24.5	-40.5	6.1	55.4	-1.0	15.8	8.8

Table 15A

Solution 11, Without Adjusted Corrections

Stations	Topocentric Coordinate Corrections (meters)			Topocentric Corrections Transformed to Common Cartesian Coordinates (meters)			Chord Change (meters)	Proportional Scale Change ($\times 10^{-6}$)
	ΔE	ΔN	ΔV	ΔX	ΔY	ΔZ	C	S
COLMA	0.0	0.0	0.0	0.0	0.0	0.0	0	0
GSFMA	7.1	-21.1	-32.9	4.1	13.6	-37.1	5.9	4.4
BPOMA	10.5	-46.0	-23.2	12.6	-7.9	-50.5	12.4	9.4
JU4MA	9.8	-48.7	-28.8	9.1	5.2	-56.5	9.3	5.4
FTMMA	9.9	-43.2	-22.8	9.7	2.5	-48.8	4.8	2.9
BERMA	40.5	-36.3	-28.8	34.5	21.7	-46.0	33.9	13.2
DENMA	-4.7	-31.1	-30.6	-3.6	4.7	-43.4	4.5	4.2
EDIMA	-5.8	-46.8	-17.1	-6.5	-4.5	-49.5	5.1	3.4
GFOMA	-5.5	-19.9	-29.9	-4.8	5.9	-35.5	14.5	13.3
JAMMA	17.9	-49.6	-8.1	19.2	-3.4	-49.6	12.9	4.7
MOJMA	-14.7	-39.3	-29.2	-12.6	7.6	-48.9	13.2	6.0
PURMA	14.6	-55.2	-35.6	6.6	21.0	-63.5	10.5	3.1
ROSMA	7.1	-36.5	-36.0	6.0	9.2	-50.5	4.1	4.5
AVERAGE	6.7	-36.4	-24.8	6.2	6.3	-48.3	10.9	6.2

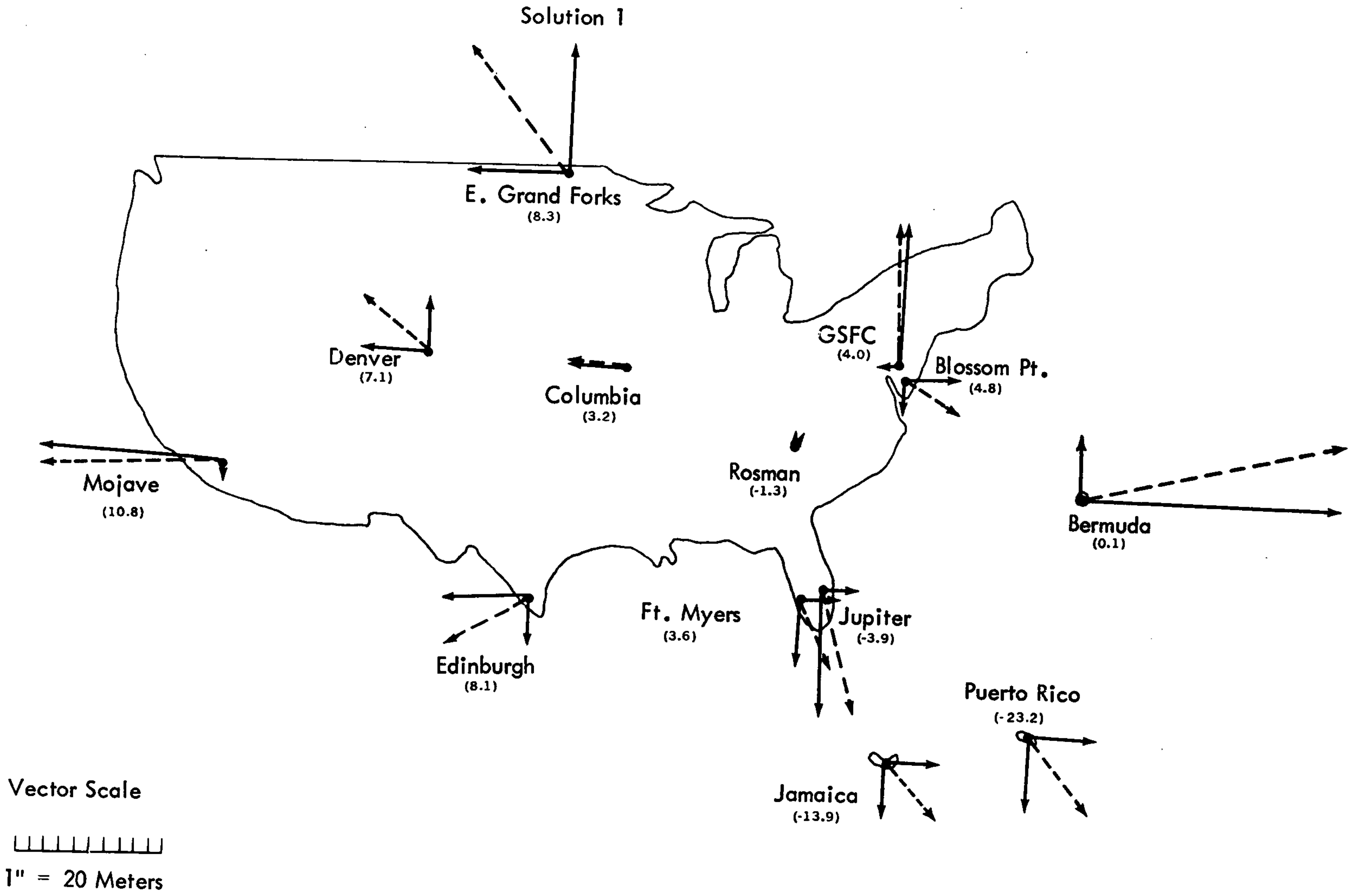

Figure 5. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 1

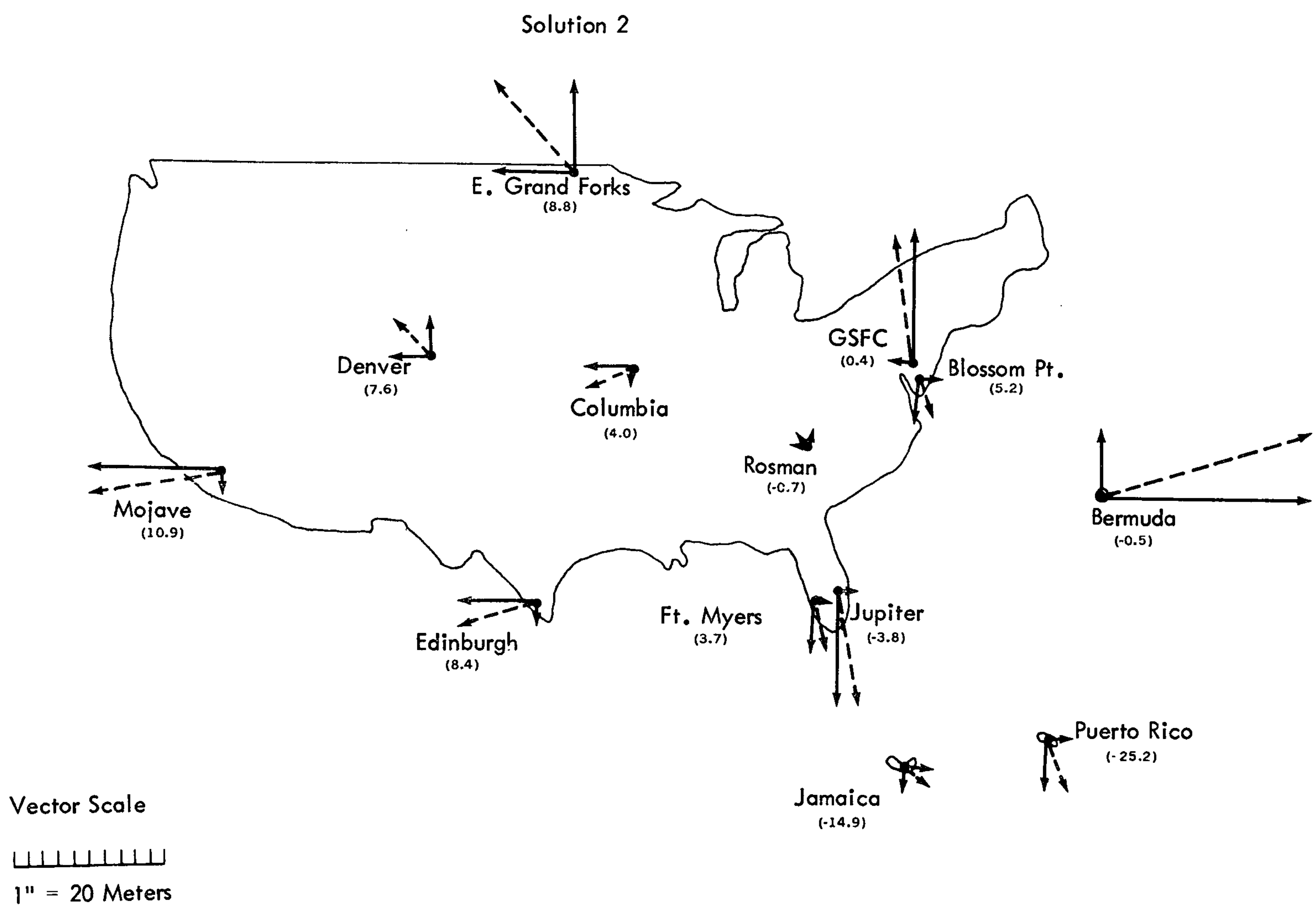

Figure 6. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 2

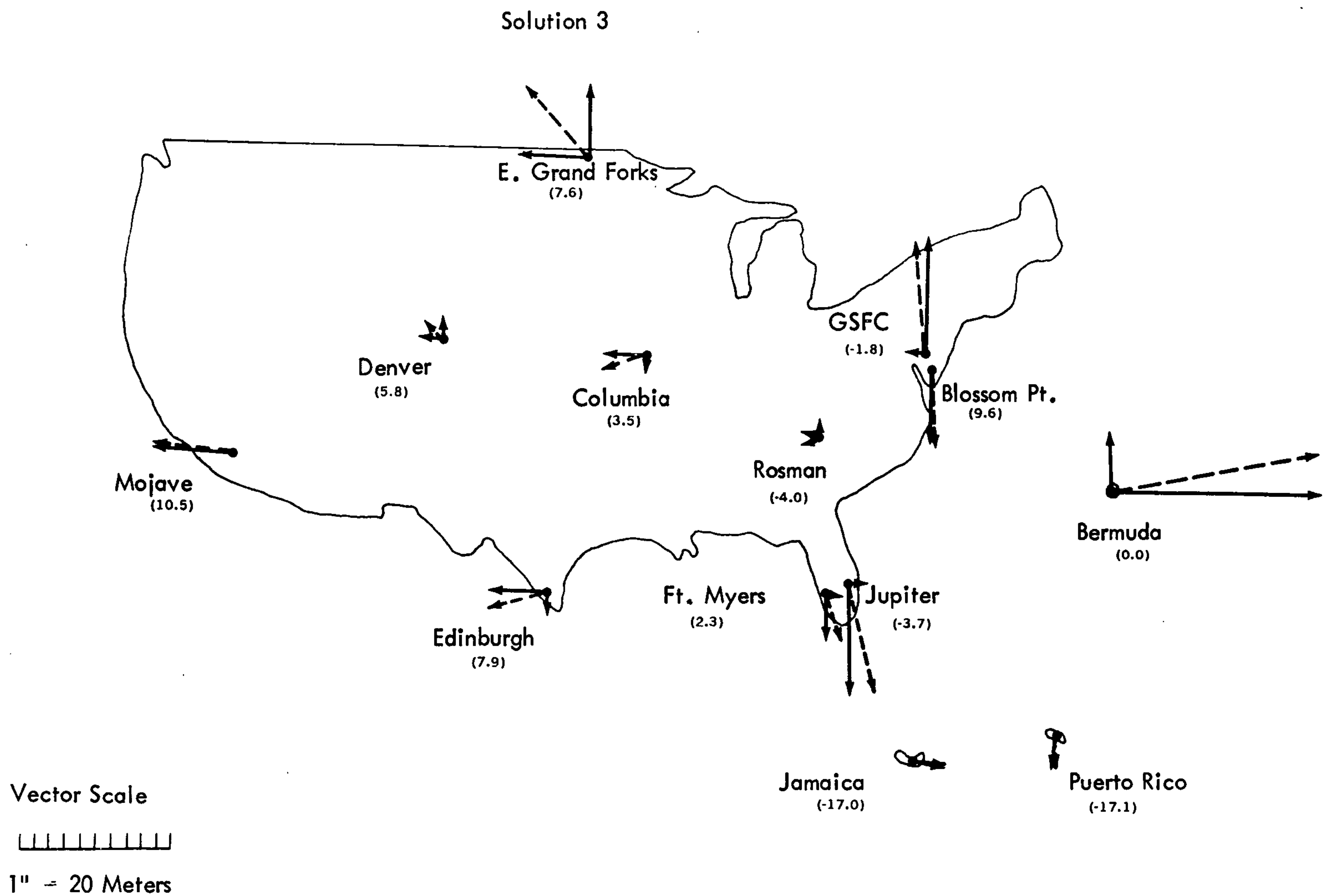

Figure 7. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 3

Solution 4

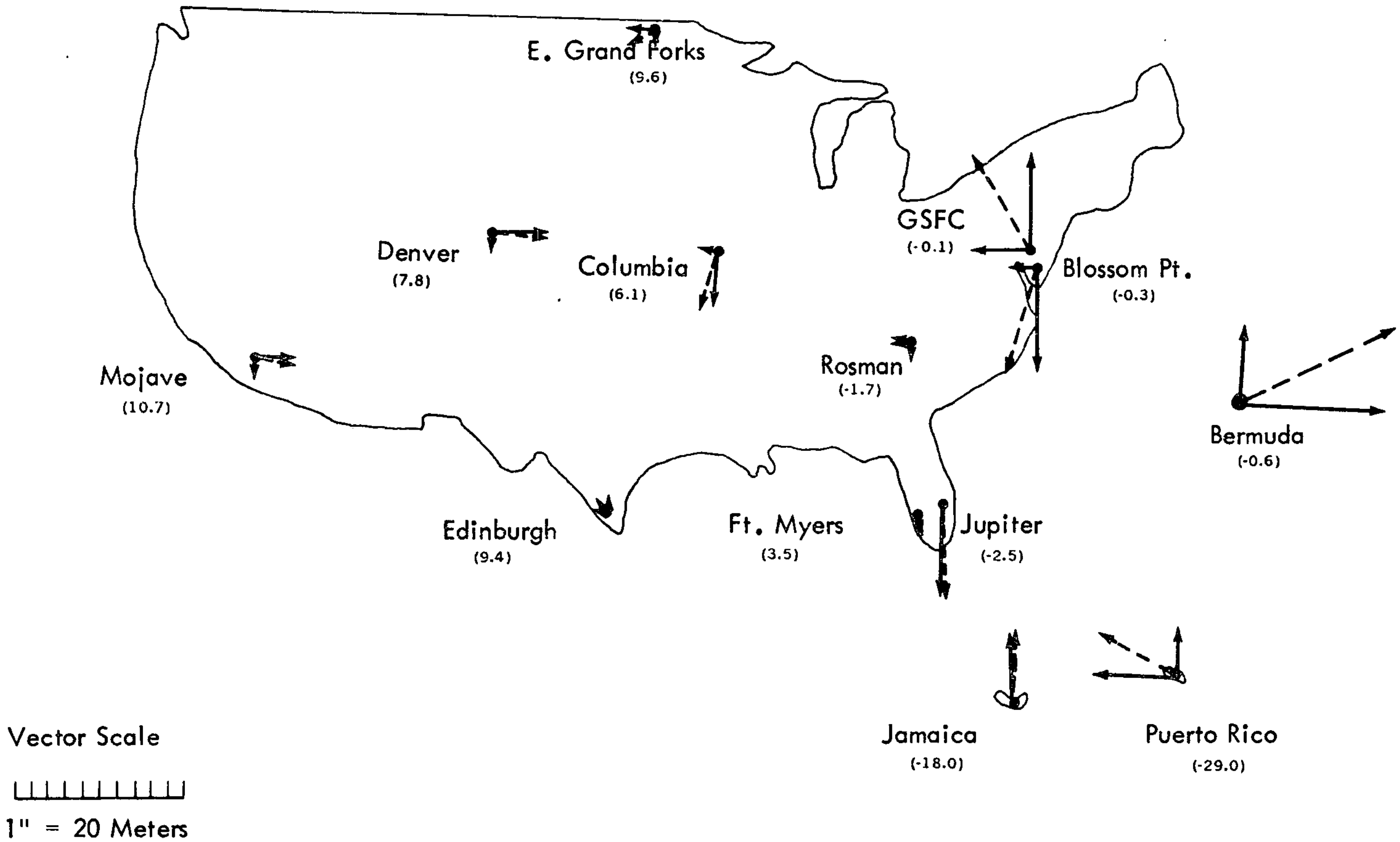

Figure 8. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 4

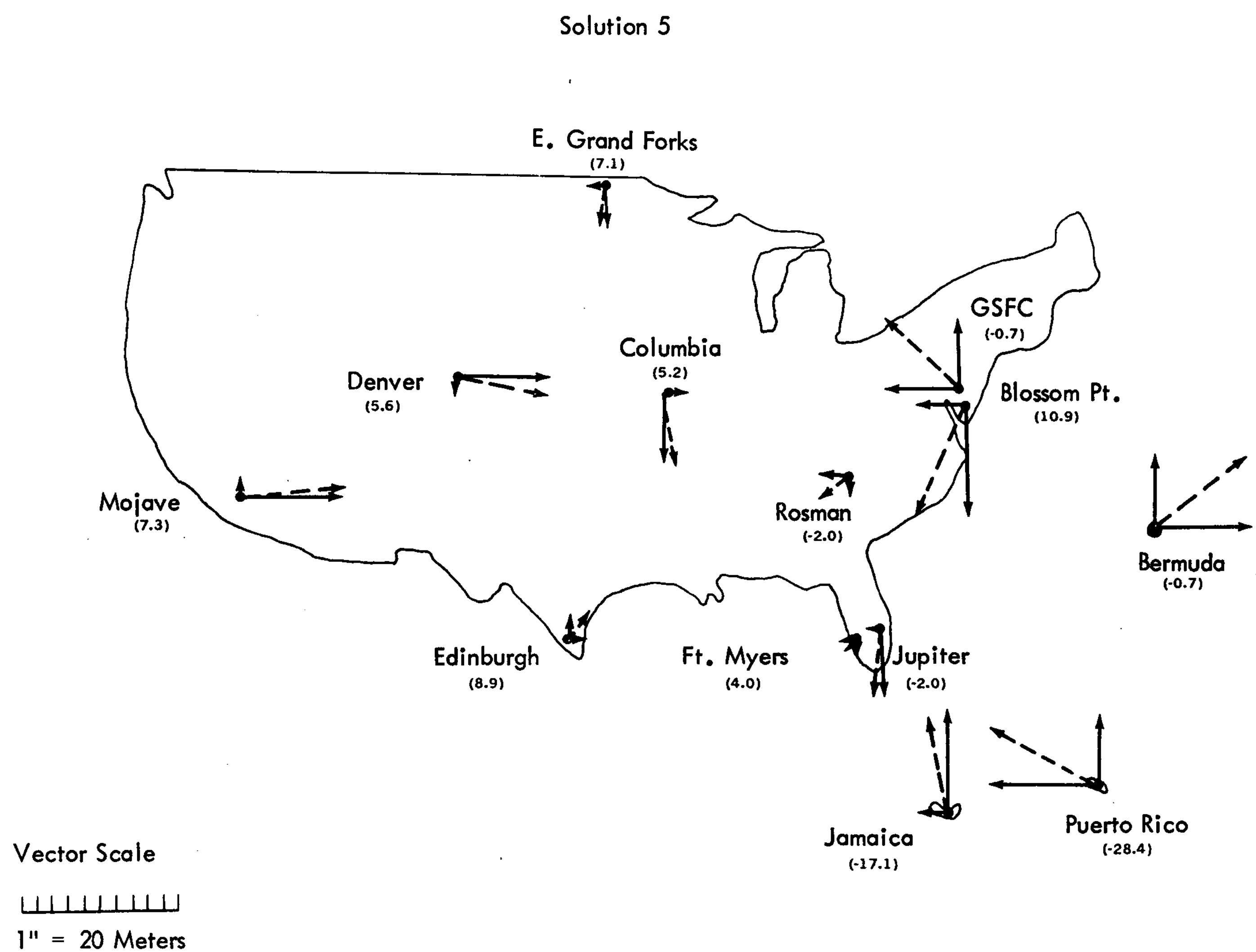

Figure 9. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 5

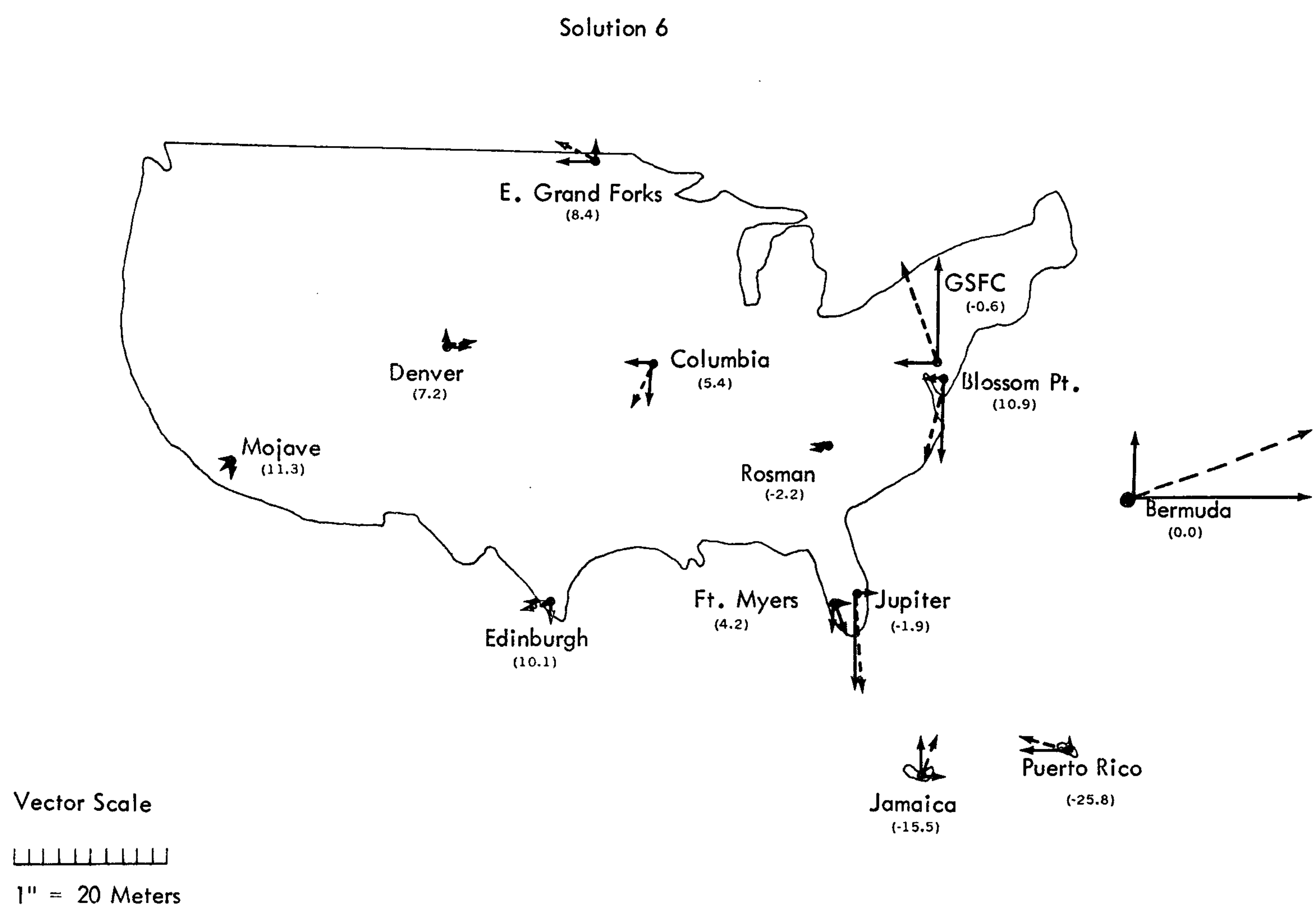

Figure 10. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 6

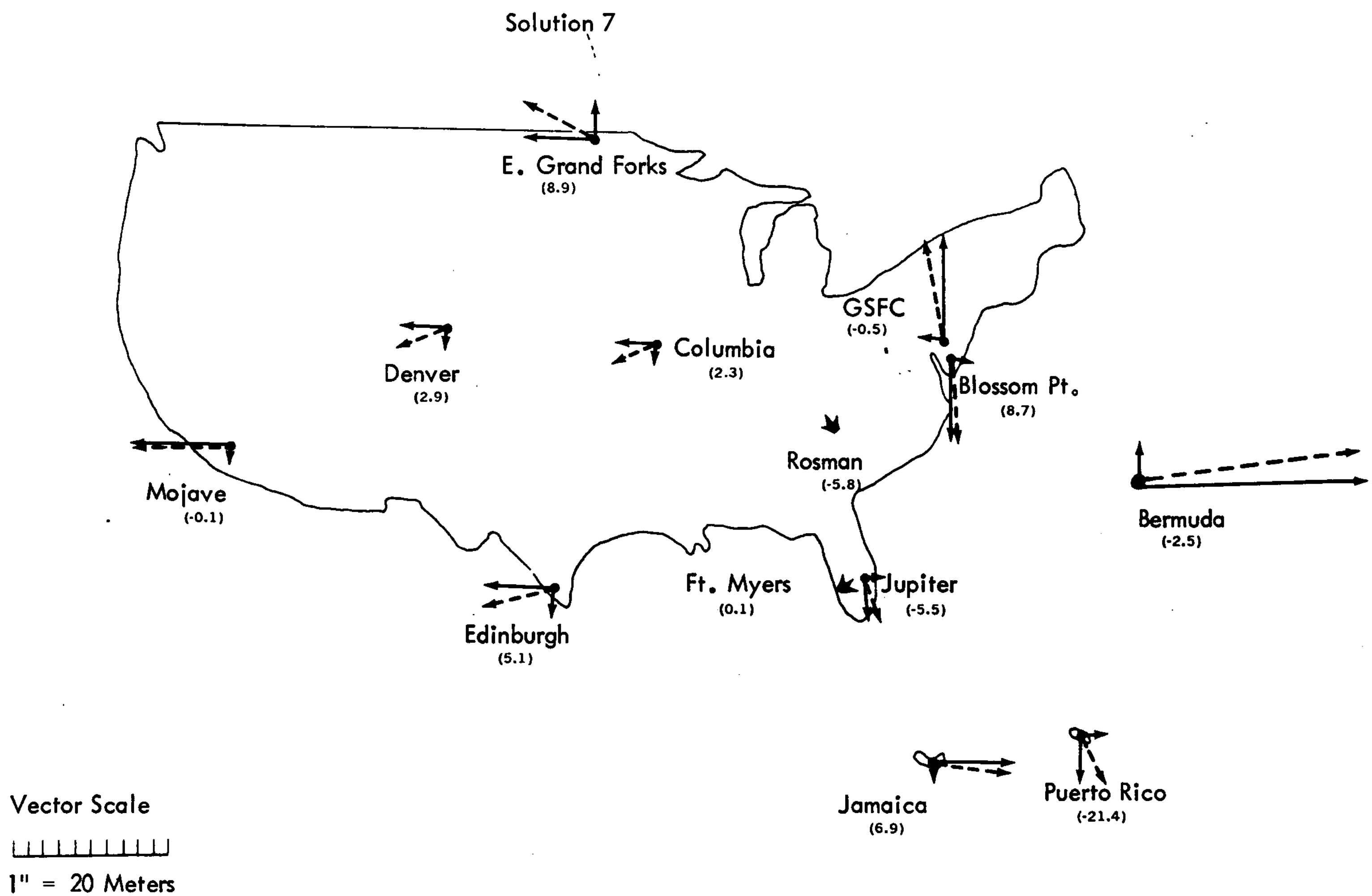

Figure 11. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 7

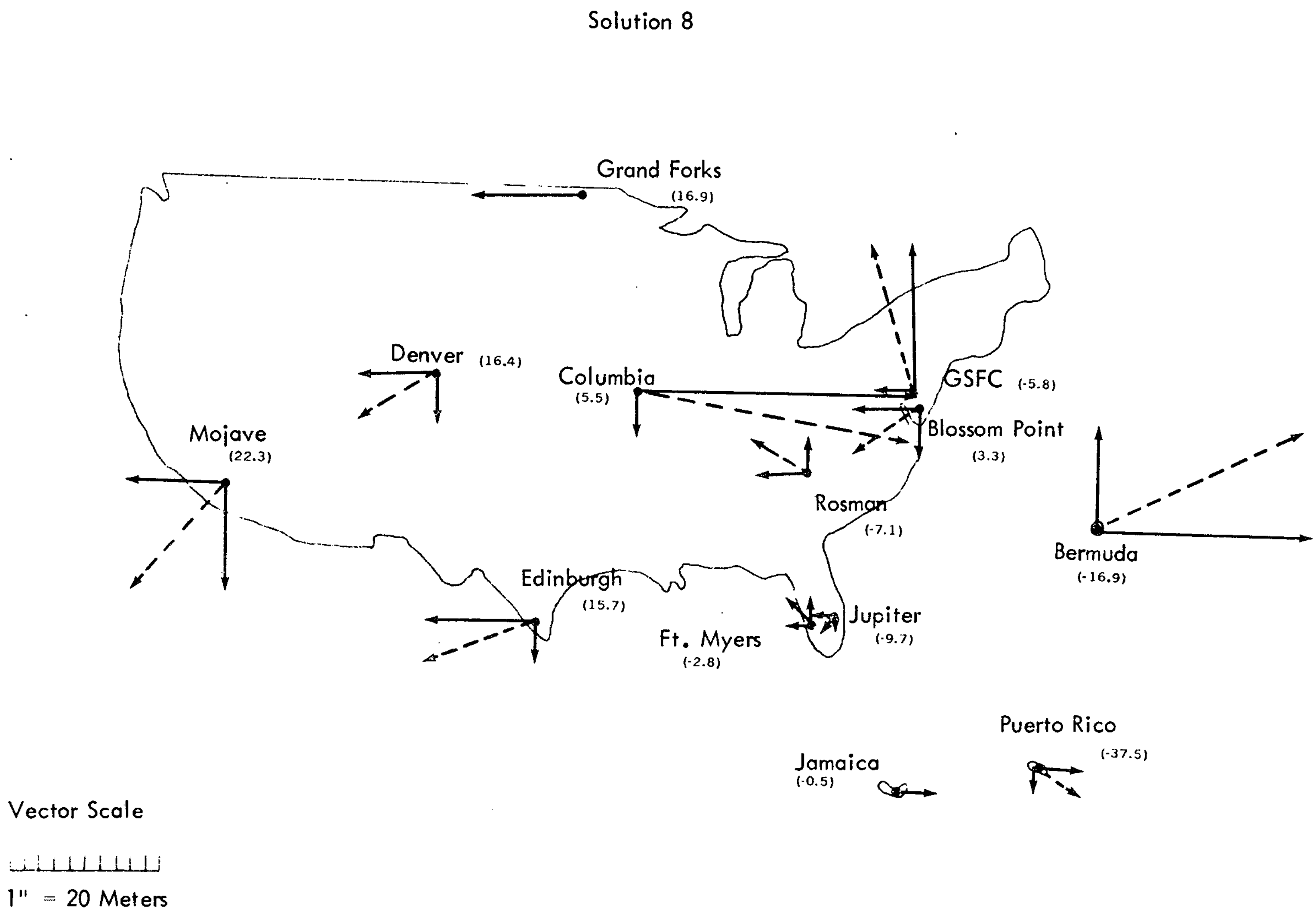

Figure 12. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 8

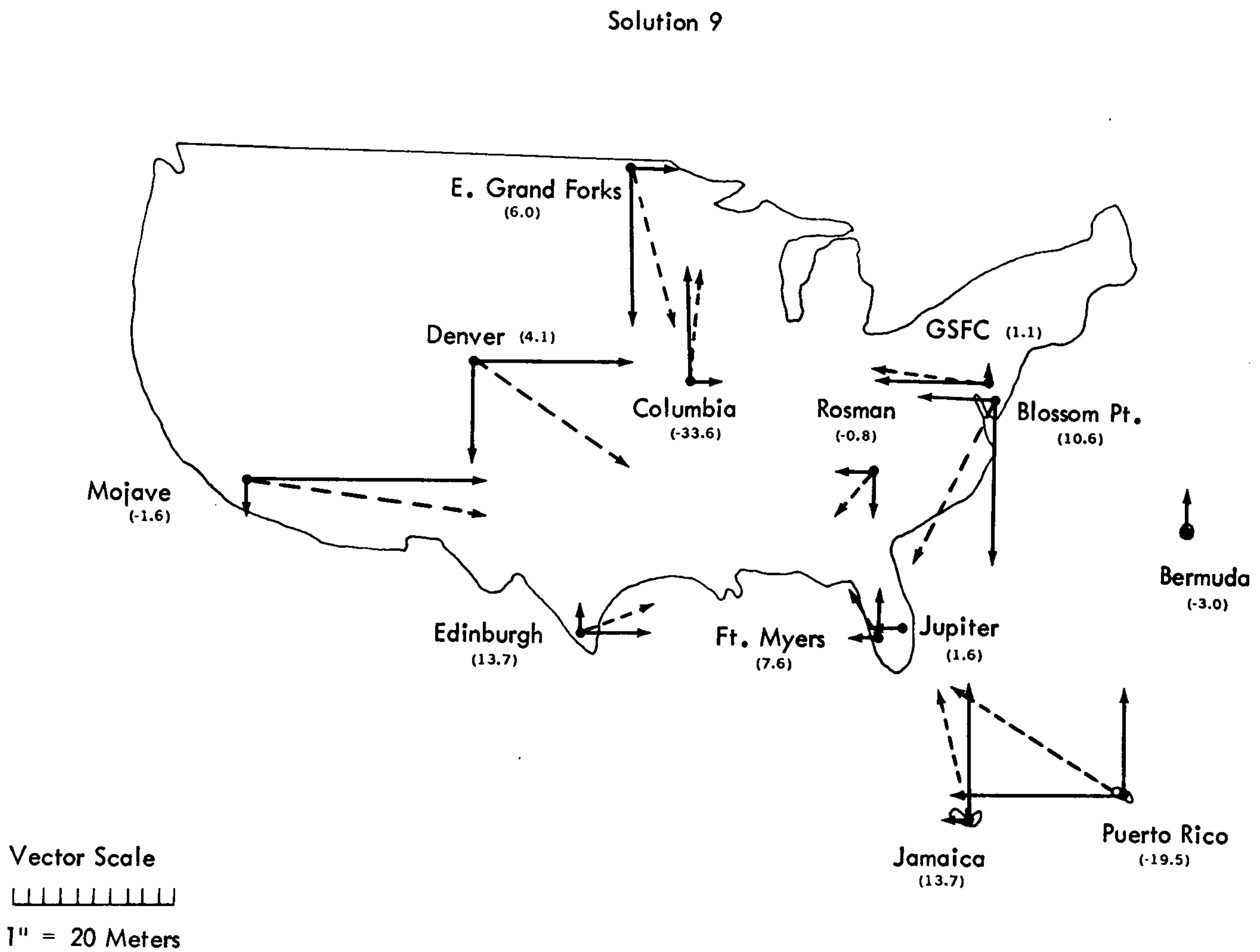

Figure 13. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 9

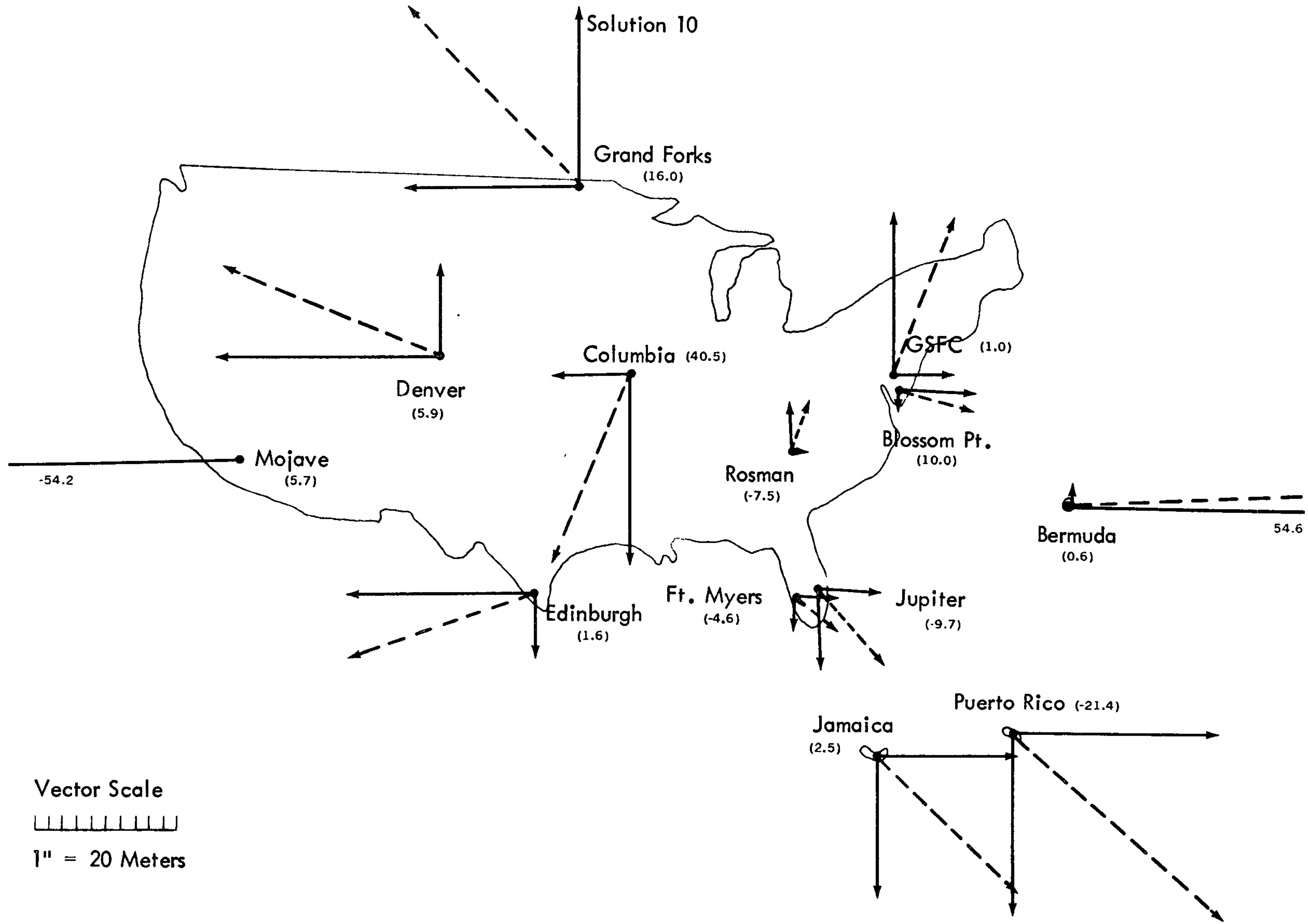

Figure 14. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 10

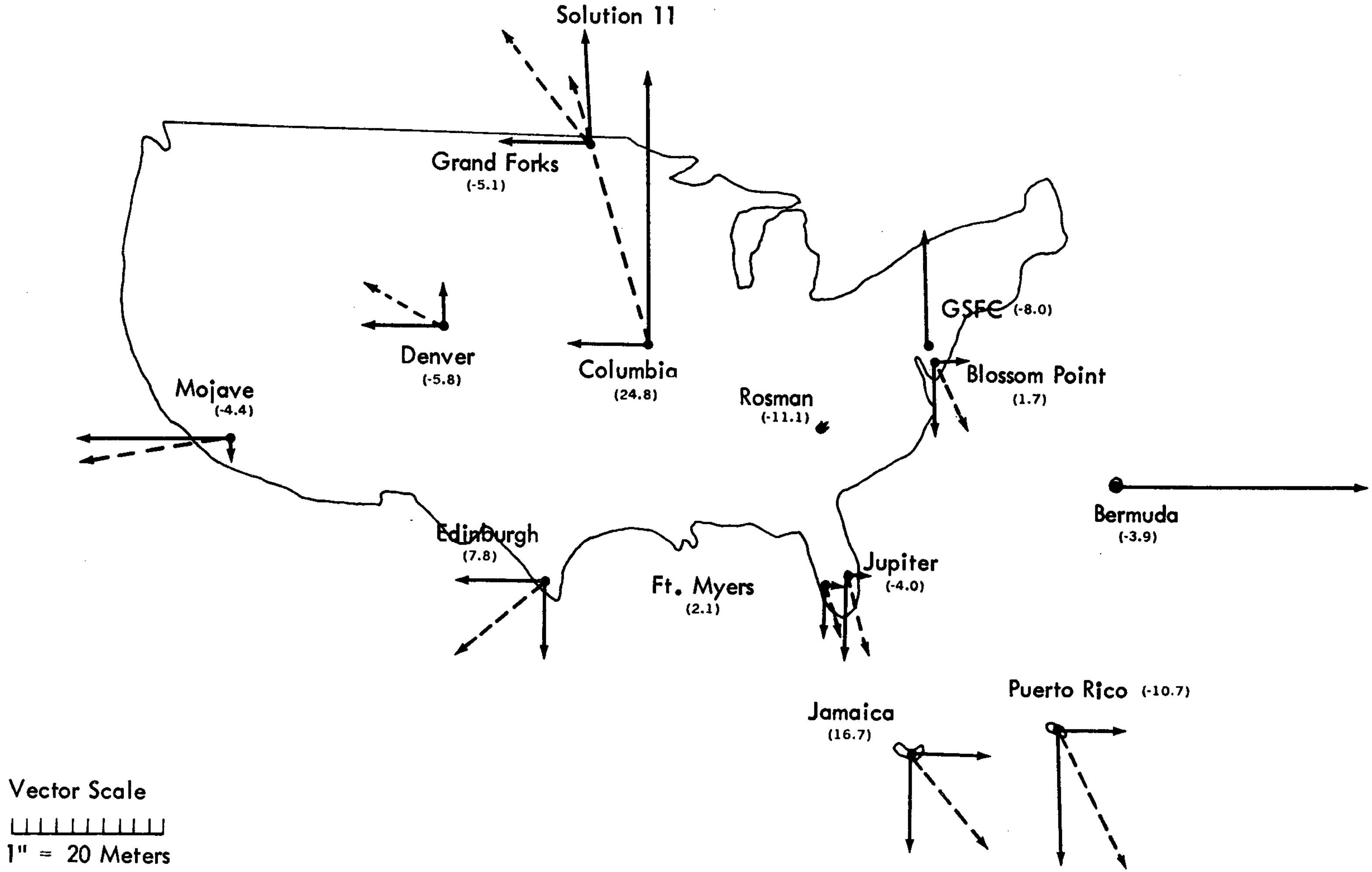

Figure 15. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 11

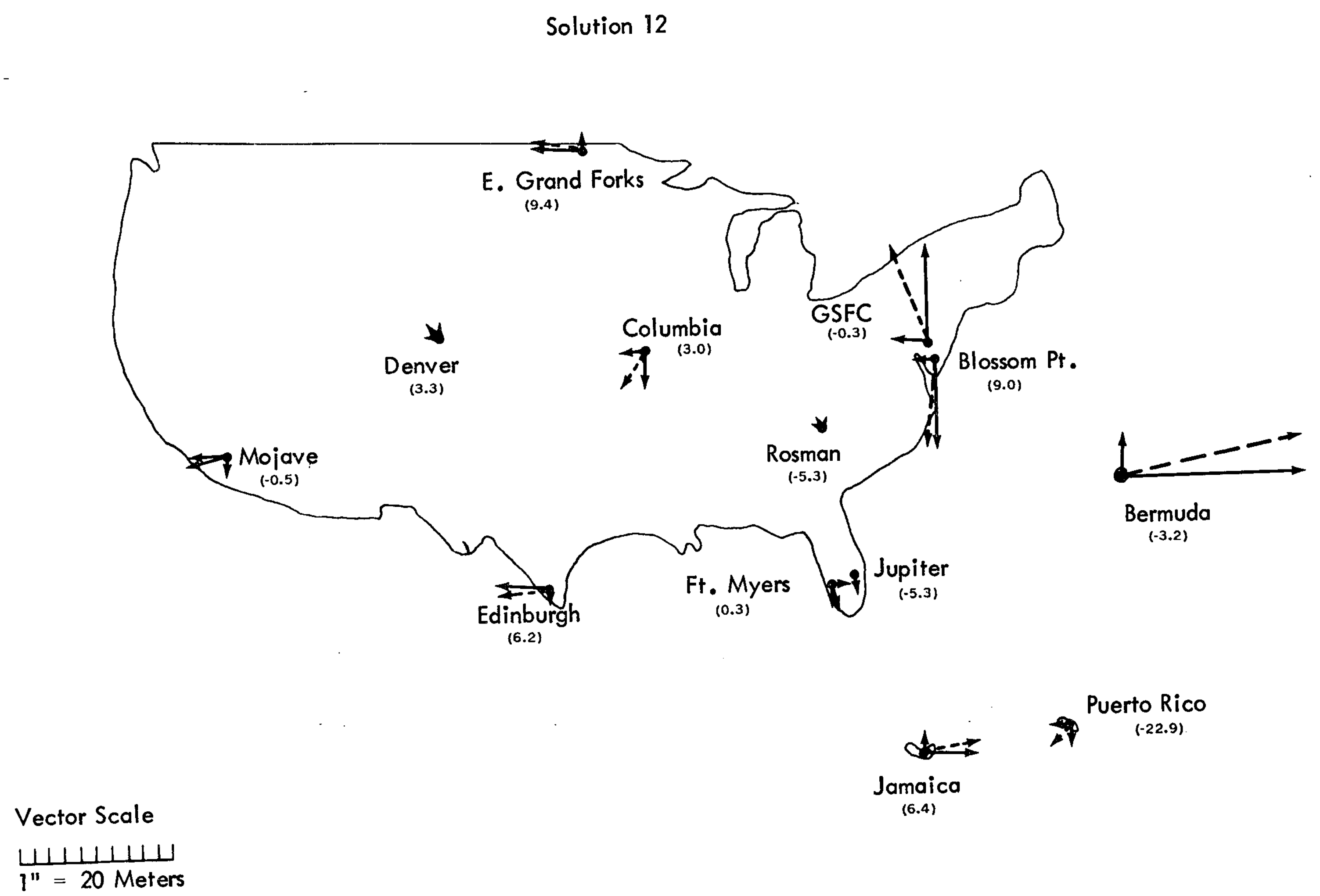

Figure 16. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 12

Solution 13

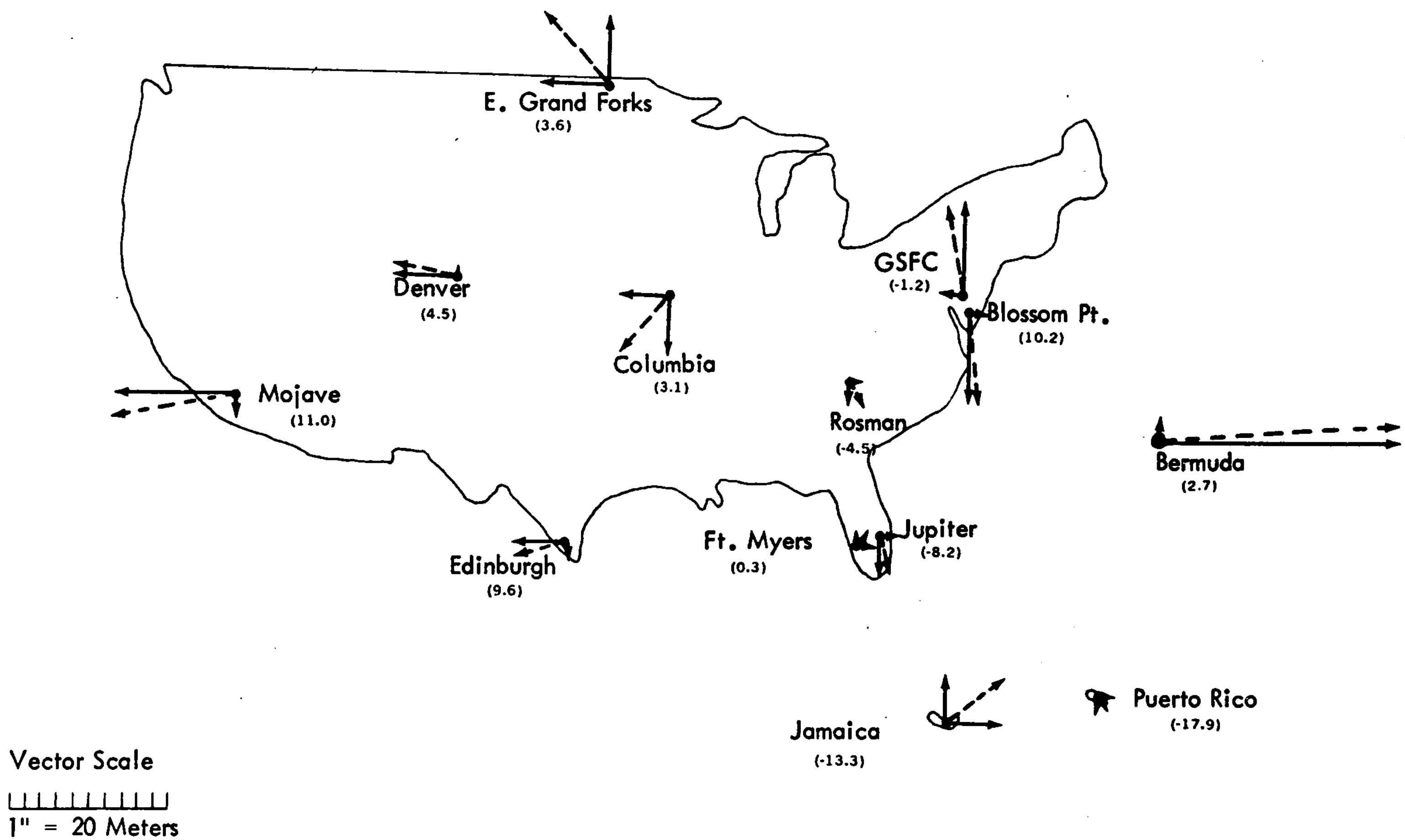

Figure 17. Horizontal Displacements Between Initial Survey and Satellite Survey — Solution 13

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