CompassData

# FEMA Region IX – San Diego County, CA
# Ground Control Project Report for STARR II
# Flyer: Quantum Spatial

## June 6, 2016

## Project Information

| | |
|---|---|
| **CDI Project Number:** | **FSG4321** |
| **FEMA Task Order Number:** | **HSFE09-15-J-0001** |
| **STARR II Project Number:** | **400000298** |
| **STARR II Partner Tracking No:** | **CD S2 R09 15 T001** |
| **WO Period of Performance:** | **10/1/15 – 9/30/2016** |
| **Task Code:** | **R0901.06.F** |
| **Geographic Location:** | **San Diego< CA** |
| **Number of GCPs Requested:** | **157** |
| **Number of GCPs Collected:** | **157** |

## Project Specifications

| | |
|---|---|
| **Precision (Horizontal/Vertical):** | **CDI Quality 1 ≤ 6.5 cm H/V** |
| **Coordinate System:** | **State Plane California Zone 6** |
| **Datum:** | **NAD83(2011)** |
| **Zone:** | **FIPS 0406** |
| **Altitude Reference:** | **NAVD88 (Geoid12B)** |
| **Units:** | **US Survey Feet** |

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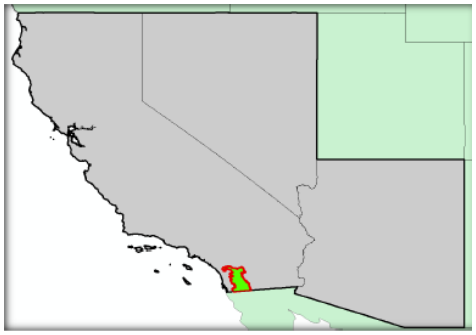
## Summary

The purpose of this project was to locate and survey ground control points (GCPs) in multiple areas of interest as defined by FEMA-supplied shape and kml files. The GCP coordinates are to be used to control the vertical aspect of all newly-flown LiDAR data during post-processing and subsequent deliverables creation. CompassData visited the project area, found suitable GCPs, and determined accurate coordinates for each GCP according to the customer's specifications.

## Area Specification and Request



The San Diego County AOI encompasses ~4,194 square km. The flier has requested 40 ground control points for their processing. In adherence to the USGS v.1.2 quality level 2 requirements, an addition 40 checkpoints will be collected. These numbers are derived from a requirement for 117 checkpoints for over 2500 sq.km. (First 2500 sq.km. 100 test points, than add 5 points per additional 500 sq.km). The division of these points will be 65 NVA points and 52 VVA points. Distribution will be determined through discussions with the flier and based on locations of different land classifications.

## Equipment

CompassData used a Trimble R10 to perform the Control survey. This device is accurate to within 1 cm on a position-by-position basis per Trimble specifications. Operating within the VRS network provided accurate coordinate values at or around 6.5 cm H/V. CompassData has consistently demonstrated this level of accuracy on many GCP collection jobs across North and South America, Europe, Asia and Africa. Specifications for the Trimble R8 are available upon request.

## Survey Methodology

CompassData has met the required precision for this project by using a high-quality GPS receiver with differential corrections provided by a RTK network setup in the area. The GPS antenna used to survey the control and test points sat atop a bubble-leveled, fixed-height range pole that was placed over the center of the desired GCP. At least 180 positions (captured at a rate of one per second) were geometrically averaged to calculate a single coordinate for each GCP. All required field documentation was filled out and the points were identified on web-based imagery. Digital pictures of each GCP location were collected in the field.

## Quality Control Procedures

CompassData collects GCPs with an unobstructed view of the sky to ensure proper GPS-operation. CompassData works to avoid potential sources of multipath error such as trees, buildings, and fences that may adversely affect the GPS accuracy. Additional quality control comes from the fact that at least 180 GPS positions are collected for each GCP. While operating within a RTK network, valid solutions are reached within seconds; however, we continue to collect additional data to ensure meeting collection specifications. To ensure project integrity, a GCP will be reobserved or moved to a more suitable location if it does not meet project specifications.

In addition to the aforementioned procedures, CompassData "surveys" existing geodetic control monuments to see if our coordinates match the published coordinates to the required accuracy. These monuments are usually established by the National Geodetic Survey (NGS) in the United States. If it is found that our coordinates are outside the acceptable accuracy, the reason for the difference will be found or the GCPs will be re-observed under different GPS constellation constraints. There are certain geodetic considerations that must be taken into account that affect whether a GPS-derived coordinate will line up with a survey monument, especially when these monuments reference local coordinate systems or the systems of another country. Sometimes the published coordinates for a monument are not accurate, although this is very infrequent.

CompassData visited multiple survey monuments during the course of this project. The results of those monument measurements are summarized in the Accuracy Report.

## Deliverables

Deliverables for this project include:

- Coordinates (in spreadsheet format)
- Digital Pictures
- QA/QC Data

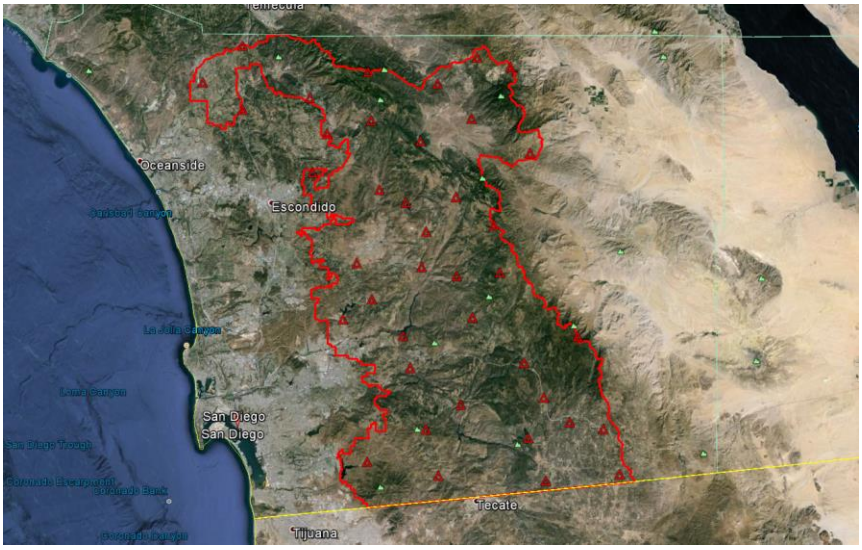
## Project Notes

All collected points were retrieved from the Trimble Survey Controller and processed with the Trimble Business Center software. The GPS survey is producing in this step heights above ellipsoid (HAEs).

Geoid12B was then used to generate the geoid separation at every Lat/Long location. NAVD88 orthometric heights were then generated in spreadsheet form using the formula HAE - Geoid = Orthometric Height. Those values were then included into the final delivery coordinate CSV files and have been tested against NGS monuments collected during the course of this survey and are showing millimeter-level agreement.

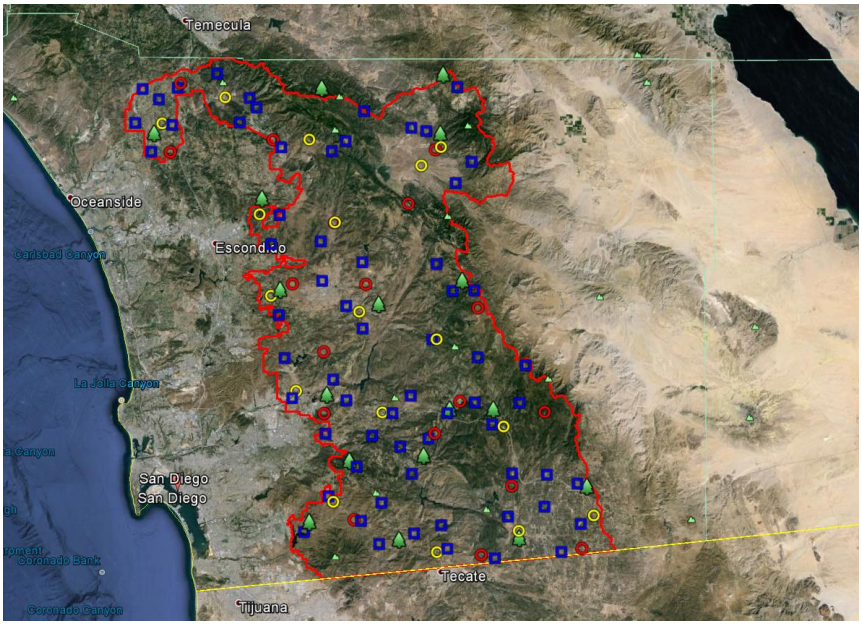
The Horizontal and Vertical accuracies reported in the Final Coordinates file were obtained from field measurements and post-processing. The report contains all points collected during each daily survey deployment, including NVA, VVA and Ground Control.

## Area with Ground Control Points




## Area with NVA and VVA Test Points

Blue Squares – NVA Test Points
Yellow Circles – VVA Grass
Red Circles – VVA Crop and Brush
Green Trees – VVA Forest



## Results of NVA Test

| Point ID | Easting | Northing | MSL NAVD88 | QSI_Z LiDAR | Δ Z (FT) | Δ $Z^2$ |
|---|---|---|---|---|---|---|
| NVA601 | 6256462.32 | 2062162.163 | 524.833 | 524.87 | **0.037** | 0.001 |
| NVA602 | 6271173.346 | 2076426.527 | 544.287 | 544.21 | **-0.077** | 0.006 |
| NVA603 | 6307328.911 | 2091828.175 | 864.055 | 864.15 | **0.095** | 0.009 |
| NVA604 | 6327144.91 | 2076714.468 | 1109.34 | 1109.45 | **0.11** | 0.012 |
| NVA605 | 6346475.926 | 2046513.192 | 944.636 | 944.97 | **0.334** | 0.112 |
| NVA606 | 6386022.887 | 2049642.925 | 4637.872 | 4637.89 | **0.018** | 0.000 |
| NVA607 | 6397388.141 | 2067629.101 | 5154.401 | 5154.43 | **0.029** | 0.001 |
| NVA608 | 6435459.878 | 2055607.392 | 2980.217 | 2980.14 | **-0.077** | 0.006 |
| NVA609 | 6453189.724 | 2023791.462 | 3351.917 | 3351.9 | **-0.017** | 0.000 |
| NVA611 | 6486801.872 | 1846988.974 | 3145.609 | 3145.52 | **-0.089** | 0.008 |
| NVA612 | 6345266.674 | 2005150.67 | 1911.469 | 1911.62 | **0.151** | 0.023 |
| NVA613 | 6339966.61 | 1987411.414 | 1548.063 | 1548.03 | **-0.033** | 0.001 |
| NVA614 | 6371176.962 | 1964780.074 | 1537.485 | 1537.74 | **0.255** | 0.065 |
| NVA615 | 6395861.32 | 1976006.041 | 2303.168 | 2303.41 | **0.242** | 0.059 |
| NVA616 | 6441194.97 | 1974587.714 | 3632.27 | 3632.42 | **0.15** | 0.023 |
| NVA617 | 6464216.811 | 1958323.931 | 4681.605 | 4681.8 | **0.195** | 0.038 |
| NVA619 | 6447538.983 | 1883797.035 | 3316.2 | 3316.18 | **-0.02** | 0.000 |
| NVA620 | 6425112.544 | 1894532.844 | 2508.291 | 2508.22 | **-0.071** | 0.005 |
| NVA621 | 6413819.266 | 1883906.857 | 2191.819 | 2191.85 | **0.031** | 0.001 |
| NVA622 | 6377638.858 | 1904594.822 | 505.776 | 505.93 | **0.154** | 0.024 |
| NVA623 | 6352309.861 | 1893313.847 | 385.565 | 385.71 | **0.145** | 0.021 |
| NVA624 | 6391722.754 | 1851465.008 | 1933.146 | 1933.06 | **-0.086** | 0.007 |
| NVA625 | 6401276.976 | 1870299.818 | 1681.541 | 1681.6 | **0.059** | 0.003 |
| NVA626 | 6474789.679 | 1876860.298 | 3882.439 | 3882.47 | **0.031** | 0.001 |
| NVA628 | 6495196.63 | 1912771.992 | 5340.347 | 5340.22 | **-0.127** | 0.016 |
| NVA629 | 6526772.29 | 1840629.207 | 4336.488 | 4336.29 | **-0.198** | 0.039 |
| NVA630 | 6528764.591 | 1815973.796 | 3392.437 | 3392.45 | **0.013** | 0.000 |
| NVA631 | 6506669.596 | 1826537.492 | 3225.077 | 3224.97 | **-0.107** | 0.011 |
| NVA632 | 6516935.808 | 1798955.702 | 3519.05 | 3518.94 | **-0.11** | 0.012 |
| NVA633 | 6476237.915 | 1795154.265 | 2206.101 | 2206.16 | **0.059** | 0.003 |
| NVA634 | 6447046.63 | 1801040.399 | 2288.284 | 2288.13 | **-0.154** | 0.024 |
| NVA635 | 6405276.219 | 1804132.368 | 1431.699 | 1431.79 | **0.091** | 0.008 |
| NVA636 | 6394268.24 | 1818338.567 | 863.473 | 863.49 | **0.017** | 0.000 |
| NVA637 | 6374371.195 | 1833237.842 | 818.516 | 818.55 | **0.034** | 0.001 |
| NVA638 | 6359159.557 | 1811410.813 | 512.367 | 512.28 | **-0.087** | 0.008 |
| NVA639 | 6406856.546 | 1829377.113 | 2116.433 | 2116.18 | **-0.253** | 0.064 |

| | | | | | | |
|---|---|---|---|---|---|---|
| NVA640 | 6425562.643 | 1846901.278 | 2222.561 | 2222.57 | **0.009** | 0.000 |
| NVA641 | 6443399.374 | 1815461.655 | 2588.315 | 2588.38 | **0.065** | 0.004 |
| NVA642 | 6484206.602 | 1820652.378 | 3073.107 | 3073.13 | **0.023** | 0.001 |
| NVA643 | 6508154.303 | 1846103.967 | 3378.612 | 3378.53 | **-0.082** | 0.007 |
| NVA644 | 6418496.661 | 1863539.739 | 2049.409 | 2049.63 | **0.221** | 0.049 |
| NVA645 | 6426763.451 | 1810398.446 | 912.488 | 912.51 | **0.022** | 0.000 |
| NVA646 | 6372674.467 | 1871530.302 | 1513.012 | 1513.22 | **0.208** | 0.043 |
| NVA647 | 6435772.949 | 1868362.333 | 2826.763 | 2826.74 | **-0.023** | 0.001 |
| NVA650 | 6385617.879 | 1891825.806 | 1279.416 | 1279.55 | **0.134** | 0.018 |
| NVA651 | 6347757.279 | 1917828.016 | 1082.217 | 1082.31 | **0.093** | 0.009 |
| NVA652 | 6344350.196 | 1944087.34 | 1842.209 | 1842.37 | **0.161** | 0.026 |
| NVA653 | 6395850.973 | 1935590.098 | 1947.298 | 1947.18 | **-0.118** | 0.014 |
| NVA654 | 6385842.921 | 1949330.164 | 1446.754 | 1446.7 | **-0.054** | 0.003 |
| NVA655 | 6438428.83 | 1928767.035 | 3151.576 | 3151.47 | **-0.106** | 0.011 |
| NVA656 | 6450949.222 | 1958193.127 | 4386.678 | 4386.6 | **-0.078** | 0.006 |
| NVA657 | 6462963.24 | 2036485.349 | 3881.092 | 3881.04 | **-0.052** | 0.003 |
| NVA658 | 6454404.094 | 2081851.185 | 4922.949 | 4922.78 | **-0.169** | 0.029 |
| NVA659 | 6426348.075 | 2057637.559 | 2927.533 | 2927.61 | **0.077** | 0.006 |
| NVA660 | 6377533.231 | 2043604.592 | 2193.968 | 2193.69 | **-0.278** | 0.077 |
| NVA662 | 6320846.734 | 2062077.031 | 999.077 | 999.03 | **-0.047** | 0.002 |
| NVA663 | 6370374.024 | 1988927 | 1668.804 | 1669.02 | **0.216** | 0.047 |
| NVA664 | 6331389.656 | 2070822.861 | 1182.568 | 1182.73 | **0.162** | 0.026 |
| NVA665 | 6282895.743 | 2083319.881 | 531.621 | 531.89 | **0.269** | 0.072 |
| NVA666 | 6261153.143 | 2082847.808 | 738.219 | 738.56 | **0.341** | 0.116 |
| NVA667 | 6279157.478 | 2060649.955 | 245.636 | 245.54 | **-0.096** | 0.009 |
| NVA668 | 6266314.626 | 2044479.011 | 596.368 | 596.03 | **-0.338** | 0.114 |
| NVA618 | 6465561.863 | 1916996.536 | 4144.477 | 4144.29 | **-0.187** | 0.035 |
| VVA911_TS | 6475458.824 | 1879586.956 | 3727.642 | 3727.36 | **-0.282** | 0.080 |

| | | | **US Survey Feet** | **Meters** |
|---|---|---|---|---|
| **Z Average** | **0.00** | **RMSE:** | **0.15** | **0.046** |
| **Z Min:** | **-1.07** | *** 1.9600** | **0.29** | **0.09** |
| **Z Max:** | **0.34** | | | |

Datum: NAD83(2011)
Epoch: 2010
Geoid: 12B
State Plane: California Zone 6

Units: US Survey Feet

Excluded Points:

**NVA649** - This point was located between some paint features and a speed bump, which appears to have caused inaccuracy. Given the high accuracy of the points in the area, and including extra points we tested, we feel confident the accuracy of the LiDAR data meets requirements and that NVA649 is a true outlier.

## Results of VVA Test

| Point ID | Easting | Northing | MSL NAVD88 | QSI_Z LiDAR | Δ Z (FT) | Δ $Z^2$ |
|---|---|---|---|---|---|---|
| VVA701 | 6273242.998 | 2061608.102 | 252.83 | 253.456 | **0.626** | 0.391 |
| VVA702 | 6312065.67 | 2077363.141 | 437.172 | 437.176 | **0.004** | 0.000 |
| VVA703 | 6363850.348 | 2050732.66 | 2683.036 | 2683.337 | **0.301** | 0.091 |
| VVA704 | 6432367.631 | 2034547.953 | 2849.793 | 2849.809 | **0.016** | 0.000 |
| VVA705 | 6333023.698 | 2005530.498 | 1470.091 | 1470.356 | **0.265** | 0.070 |
| VVA706 | 6379277.423 | 2000297.402 | 1036.286 | 1036.935 | **0.649** | 0.421 |
| VVA707 | 6444428.743 | 2045644.268 | 3131.32 | 3131.669 | **0.349** | 0.122 |
| VVA708 | 6441135.373 | 1928715.214 | 3425.793 | 3426.133 | **0.340** | 0.116 |
| VVA709 | 6393912.601 | 1945738.461 | 1450.497 | 1451.089 | **0.592** | 0.351 |
| VVA710 | 6339772.457 | 1955811 | 1604.383 | 1604.915 | **0.532** | 0.283 |
| VVA712 | 6354764.657 | 1897533.51 | 415.462 | 416.056 | **0.594** | 0.352 |
| VVA713 | 6407708.973 | 1884277.89 | 2059.774 | 2059.966 | **0.192** | 0.037 |
| VVA714 | 6481780.774 | 1875511.542 | 4104.385 | 4104.338 | **-0.047** | 0.002 |
| VVA715 | 6536848.428 | 1821015.464 | 3669.566 | 3669.706 | **0.140** | 0.019 |
| VVA716 | 6490983.351 | 1811786.13 | 2728.338 | 2728.195 | **-0.143** | 0.020 |
| VVA717 | 6440816.097 | 1798838.302 | 1915.081 | 1914.125 | **-0.956** | 0.915 |
| VVA718 | 6377324.193 | 1829753.493 | 814.877 | 814.829 | **-0.048** | 0.002 |
| VVA801 | 6278135.321 | 2044046.01 | 247.179 | 247.369 | **0.190** | 0.036 |
| VVA802 | 6284792.076 | 2085940.076 | 830.432 | 830.923 | **0.491** | 0.241 |
| VVA803 | 6341488.898 | 2051008.977 | 834.834 | 835.108 | **0.274** | 0.075 |
| VVA804 | 6440967.258 | 2044053.186 | 3035.064 | 3035.039 | **-0.025** | 0.001 |
| VVA805 | 6378806.114 | 2000073.772 | 1017.977 | 1018.466 | **0.489** | 0.240 |
| VVA806 | 6424237.677 | 2011285.111 | 2957.053 | 2957.368 | **0.315** | 0.099 |
| VVA807 | 6352993.764 | 1962945.316 | 1402.082 | 1402.423 | **0.341** | 0.116 |
| VVA808 | 6398008.748 | 1962304.283 | 1983.543 | 1983.925 | **0.382** | 0.146 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VVA809 | 6466314.264 | 1947625.347 | 4642.784 | 4643.164 | **0.380** | 0.144 |
| VVA810 | 6455231.73 | 1890890.065 | 3510.874 | 3511.014 | **0.140** | 0.020 |
| VVA811 | 6439696.907 | 1871384.37 | 3058.173 | 3058.149 | **-0.024** | 0.001 |
| VVA812 | 6371967.338 | 1883757.706 | 836.712 | 836.739 | **0.027** | 0.001 |
| VVA814 | 6486618.931 | 1839208.267 | 3069.341 | 3069.383 | **0.042** | 0.002 |
| VVA815 | 6506774.735 | 1884236.057 | 5836.815 | 5836.611 | **-0.204** | 0.041 |
| VVA816 | 6529555.851 | 1800912.746 | 3583.844 | 3583.870 | **0.026** | 0.001 |
| VVA817 | 6467876.128 | 1797131.19 | 2414.726 | 2414.729 | **0.003** | 0.000 |
| VVA818 | 6390069.122 | 1818806.705 | 777.217 | 777.240 | **0.023** | 0.001 |
| VVA819 | 6372039.954 | 1921389.542 | 1339.789 | 1339.978 | **0.189** | 0.036 |
| VVA901 | 6268088.824 | 2049398.092 | 169.885 | 170.061 | **0.176** | 0.031 |
| VVA902 | 6371618.013 | 2075117.532 | 5450.19 | 5450.142 | **-0.048** | 0.002 |
| VVA903 | 6445771.77 | 2083132.642 | 4623.802 | 4623.837 | **0.035** | 0.001 |
| VVA904 | 6387279.553 | 1848555.018 | 1634.554 | 1634.760 | **0.206** | 0.042 |
| VVA905 | 6444005.561 | 2047521.689 | 3103.138 | 3103.536 | **0.398** | 0.158 |
| VVA906 | 6345324.414 | 1953108.646 | 1483.564 | 1483.716 | **0.152** | 0.023 |
| VVA907 | 6456803.536 | 1957976.487 | 4125.343 | 4125.412 | **0.069** | 0.005 |
| VVA908 | 6334439.871 | 2008853.005 | 1517.338 | 1517.402 | **0.064** | 0.004 |
| VVA909 | 6448838.395 | 1879761.162 | 3535.812 | 3535.821 | **0.009** | 0.000 |
| VVA910 | 6373637.268 | 1888956.145 | 796.149 | 796.259 | **0.110** | 0.012 |
| VVA911 | 6475457.239 | 1879694.435 | 3724.777 | 3724.436 | **-0.341** | 0.117 |
| VVA912 | 6432813.276 | 1851474.899 | 2456.893 | 2456.601 | **-0.292** | 0.085 |
| VVA913 | 6362398.862 | 1811164.426 | 487.369 | 487.431 | **0.062** | 0.004 |
| VVA914 | 6417512.503 | 1800112.625 | 831.916 | 831.693 | **-0.223** | 0.050 |
| VVA915 | 6491103.89 | 1800989.349 | 2472.739 | 2472.170 | **-0.569** | 0.324 |
| VVA916 | 6532547.138 | 1832414.27 | 3996.386 | 3995.848 | **-0.538** | 0.290 |
| VVA917 | 6405707.549 | 1944007.581 | 1654.562 | 1655.040 | **0.478** | 0.228 |

| **Summary is in US Survey Feet** | | | **US Survey Feet** | **Meters** |
|---|---|---|---|---|
| **Z Average** | **0.12** | **RMSE:** | **0.333** | **0.102** |
| **Z Min:** | **-0.96** | *** 1.9600** | **0.653** | **0.199** |
| **Z Max:** | **0.65** | **95-Percentile** | **0.605** | **0.184** |

Datum: NAD83(2011)
Epoch: 2010
Geoid: 12B
State Plane: California Zone 6
Units: US Survey Feet

CompassData

## Contact Information

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