# Procedure for measuring Mass and C.G. of the RRV/ATV

1. The craft is put on the ground in the lab B242. Weighing Scales are aligned with the front and rear wheels at each of the spines/pods. That is, 2 scales at each station for a total of ten scales. These are laid out at pre-marked positions on the ground (usually aligned with a tile marking for consistency).
2. The craft is then put on the scales with the help of another person (min. 2 people needed for this procedure).
3. Ensure all the wheels are approximately on the center of the plates on the scales. This is done by having markings on the plates that indicate where the wheel should rest.
4. The readings on the front and rear wheels are recorded at each spine.
5. The sum of the front balances, and the sum of the rear balances is calculated, which allows for calculating the total mass of the craft.
6. The total moment about the front wheels is calculated as the

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Here, 18.4 cm is the arm (the distance between the front and rear wheels). In other words, the net mass at the rear wheels creates a certain moment about the front wheels. This is calculated.

1. This allows for the calculation of the center of gravity (in the x direction) of the craft by using
2. However, because the C.G is required with respect to the leading edge, and as a function of the chord length, the equation shown above is used in the following way.

This is done because the center of the front wheel is 8.1cm in front of the leading edge of the wings. And 20cm is the chord length of the wings.

Now that the C.G of the overall craft is calculated, the C.G. of the individual pods is calculated in the same way, with all the equations being the same, but only being applied to the specific station.

1. The span-wise C.G (in the Y-direction) can be calculated in a similar way by doing a summation of the moments along the center, and then finding the position of the Y-axis C.G normalized by the chord. In such a calculation the mass of the center station is not accounted for since the moment is being calculated around the center, in the y-direction.
2. A table showing a sample of the results is attached from the RRV measurements and adjustments done in Nov. 17.

|  |  |  |  |
| --- | --- | --- | --- |
| **Configuration:** | RRV Nov 17 | | |
| Notes on Configuration: | Adjustment 1 - Run 3 | Adjustment 1 - Run 2 | Adjustment 2 - Run 5 |
|  | Description of Adjustments | | |
| spine 3 | none | |  |
| spine 1 | 20g plate removed | |  |
| spine 0 | removed 25g from each camera | | ballast mass swap |
| spine 2 | shifted both screws forward by one | | ballast mass swap |
| spine 4 | shifted both screws back by 2 | |  |
|  |  |  |  |
| **Balance 1 - #3 Front** | 293.0 | 368.0 | 433.3 |
| **Balance 2 - #1 Front** | 312.0 | 258.0 | 271.8 |
| **Balance 3 - #0 Front** | 174.0 | 173.0 | 31.4 |
| **Balance 4 - #2 Front** | 268.0 | 181.0 | 103.6 |
| **Balance 5 - # 4 Front** | 698.0 | 742.0 | 863.5 |
| **SubTotal (1-5)(g)** | **1745.0** | **1722.0** | **1703.6** |
|  |  |  |  |
| **Balance 6 - # 3 Rear** | 1959.0 | 1926.0 | 1901.8 |
| **Balance 7 - #1 Rear** | 1560.0 | 1549.0 | 1462.0 |
| **Balance 8 - #0 Rear** | 3143.0 | 3145.4 | 3251.8 |
| **Balance 9 - #2 Rear** | 1320.0 | 1436.0 | 1506.0 |
| **Balance 10 - #4 Rear** | 1578.0 | 1530.5 | 1487.0 |
| **SubTotal(6-10)(g)** | **9560.0** | **9586.9** | **9608.6** |
|  |  |  |  |
| **TotalMass(g)** | 11305.0 | 11308.9 | 11312.2 |
| **TotalMoment (g-cm)** | 175904.0 | 176399.0 | 176798.2 |
| **CG (% of chord)** | 37.30% | 37.49% | 37.64% |
|  |  |  |  |
| **Weight S3** | 2252.0 | 2294.0 | 2335.1 |
| **Weight S1** | 1872.0 | 1807.0 | 1733.8 |
| **Weight S0** | 3317.0 | 3318.4 | 3283.2 |
| **Weight S2** | 1588.0 | 1617.0 | 1609.6 |
| **Weight S4** | 2276.0 | 2272.5 | 2350.5 |
|  |  |  |  |
| **Moment S3 (g-cm)** | 36045.6 | 35438.4 | 34993.1 |
| **Moment S1 (g-cm)** | 28704.0 | 28501.6 | 26900.8 |
| **Moment S0 (g-cm)** | 57831.2 | 57875.4 | 59833.1 |
| **Moment S2 (g-cm)** | 24288.0 | 26422.4 | 27710.4 |
| **Moment S4 (g-cm)** | 29035.2 | 28161.2 | 27360.8 |
|  |  |  |  |
| **Xcg S3 (%)** | 39.53020 | 36.74150 | 34.42853 |
| **Xcg S1 (%)** | 36.16667 | 38.36442 | 37.07758 |
| **Xcg S0 (%)** | 46.67395 | 46.70371 | 50.62013 |
| **Xcg S2 (%)** | 35.97355 | 41.20192 | 45.57853 |
| **Xcg S4 (%)** | 23.28559 | 21.46084 | 17.70208 |
|  |  |  |  |
| **Y moment front** | 766.00000 | 671.00000 | 692.20000 |
| **YCG front** | 0.34% | 0.30% | 0.31% |
| **Y moment rear** | -1002.00000 | -904.00000 | -785.60000 |
| **YCG rear** | -0.44% | -0.40% | -0.35% |
| **Net YCG** | -0.10% | -0.10% | -0.04% |