**AES Übung 4, Labor „Motorenmessungen und Gesamtantriebsstrang“**

**2 Gesamtantriebssyteme und Simulationen: Messung an einem Ebike Antrieb**

**2.1 Energiemessfahrt mit dem Stromer-Ebike**

Die Strecke rund um das Areal der T&A wurde mit dem E-Bike abgefahren. Dabei wurde kontinuierlich die Spannung und den Strom zwischen dem Akku und dem Kontroller gemessen und geloggt. Aus diesen Datenkann in etwa berechnen werden, wie viel Energie für die Probefahrt vom Fahrer aufgewendet wurde und wie viel vom Motor geleistet wurde.

Um den Strom zu messen, wurde eine Stromzange in die Leitung zwischen Akku und Kontroller gehängt. Ebenfalls wird bei den Eingangsbuchsen des Akkus an der Box die Spannung abgegriffen. Die Messleitungen führen zu je einem MetraHit-Loggerät, welche wiederum auf je ein MetraHit-Multimeter aufgesteckt sind. Die beiden Loggeräte werden zusammengesteckt und über einen USB-RS232 Wandler mit einem Laptop verbunden. Auf dem Laptop ist das Tool MetraWin 10 installiert, über welches das Datenlogging läuft. Der Laptop wurde zusammen mit den Messgeräten in einen Rucksack gepackt, welcher während der Fahrt vom Fahrer mitgeführt wurde.

**Berechnung der Energie aus Antrieb:**

Aus den geloggten Daten (siehe Anhang) kann die benötigte Energie des Motors während der Testfahrt wie folgt berechnet werden:

Das Ergebnis lautet:

**Berechnung der Energie aus GPS-Daten:**

Aus den geloggten GPS-Daten (siehe Anhang) kann ebenfalls die benötigte Energie für die Festfahrt berechnet werden. Für die Berechnung werden aber einige Vereinfachungen gemacht; der Luftwiderstand sowie die Höhendifferenz werden nicht beachtet und es wird nur die Energie für die positive Beschleunigung berechnet. Negative Beschleunigung wird in der Berechnung mit 0Ws ersetzt, da davon ausgegangen wird das die Bremsenergie nicht Rekuperiert wird. Das Gesamtgewicht wird auf 90kg geschätzt. Die Energie wurde wie folgt berechnet:

Das Ergebnis lautet:

**Diskussion**

Vergleicht man die beiden Ergebnisse, fällt auf das sie sehr nahe beieinander liegen. Die Differenz zwischen der benötigten Energie des Motors und der der berechneten Energie aus den GPS Daten beträgt genau eine Wattstunde. Dies ist die Energie, die der Fahrer selbst aufgewendet hat, um das Ebike zu beschleunigen. Der Fahrer hat nach eigenen Angaben nur sehr selten in die Pedalen getreten, da das Ebike über einen Handgasgriff verfügte. Das Treten in die Pedale war also nicht unbedingt nötig. Berücksichtigt man diese Angaben ist das Ergebnis der Testfahrt plausibel.

**Anhang**

**Geloggter Daten von MetraHit-Geräten**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| t [h:m:s] | U DC [V] | I DC [A] | U DC [V] | P [W] | dE [Ws] |  |
| 00:04:26 | 3.30E-05 | 0.033 | 39.761 | 1.312113 | 1.312 |  |
| 00:04:27 | 3.80E-05 | 0.038 | 39.76 | 1.51088 | 1.511 |  |
| 00:04:28 | 3.45E-03 | 3.447 | 39.083 | 134.719101 | 134.719 |  |
| 00:04:29 | 2.06E-02 | 20.588 | 36.173 | 744.729724 | 744.730 |  |
| 00:04:30 | 2.83E-02 | 28.307 | 35.071 | 992.754797 | 992.755 |  |
| 00:04:31 | 6.31E-03 | 6.307 | 38.888 | 245.266616 | 245.267 |  |
| 00:04:32 | 1.00E-02 | 10.046 | 37.737 | 379.105902 | 379.106 |  |
| 00:04:33 | 5.05E-03 | 5.053 | 38.822 | 196.167566 | 196.168 |  |
| 00:04:34 | 3.78E-04 | 0.378 | 39.468 | 14.918904 | 14.919 |  |
| 00:04:35 | 3.00E-03 | 3.004 | 39.013 | 117.195052 | 117.195 |  |
| 00:04:36 | 3.88E-04 | 0.388 | 39.535 | 15.33958 | 15.340 |  |
| 00:04:37 | -1.39E-04 | -0.139 | 39.634 | -5.509126 | -5.509 |  |
| 00:04:38 | -2.70E-03 | -2.702 | 40.065 | -108.25563 | -108.256 |  |
| 00:04:39 | -3.18E-03 | -3.183 | 40.183 | -127.902489 | -127.902 |  |
| 00:04:40 | -5.08E-03 | -5.084 | 40.506 | -205.932504 | -205.933 |  |
| 00:04:41 | -3.10E-03 | -3.099 | 40.175 | -124.502325 | -124.502 |  |
| 00:04:42 | -5.47E-04 | -0.547 | 39.748 | -21.742156 | -21.742 |  |
| 00:04:43 | 6.80E-05 | 0.068 | 39.673 | 2.697764 | 2.698 |  |
| 00:04:44 | 5.50E-05 | 0.055 | 39.671 | 2.181905 | 2.182 |  |
| 00:04:45 | 1.17E-02 | 11.658 | 37.55 | 437.7579 | 437.758 |  |
| 00:04:46 | 2.57E-02 | 25.705 | 35.356 | 908.82598 | 908.826 |  |
| 00:04:47 | 2.79E-02 | 27.908 | 34.935 | 974.96598 | 974.966 |  |
| 00:04:48 | 2.84E-02 | 28.438 | 34.792 | 989.414896 | 989.415 |  |
| 00:04:49 | 2.64E-02 | 26.391 | 35.031 | 924.503121 | 924.503 |  |
| 00:04:50 | 2.49E-02 | 24.926 | 35.214 | 877.744164 | 877.744 |  |
| 00:04:51 | 2.35E-02 | 23.496 | 35.404 | 831.852384 | 831.852 |  |
| 00:04:52 | 2.15E-02 | 21.509 | 35.688 | 767.613192 | 767.613 |  |
| 00:04:53 | 1.91E-02 | 19.148 | 36.025 | 689.8067 | 689.807 |  |
| 00:04:54 | 1.77E-02 | 17.666 | 36.23 | 640.03918 | 640.039 |  |
| 00:04:55 | 1.66E-02 | 16.558 | 36.4 | 602.7112 | 602.711 |  |
| 00:04:56 | 5.33E-03 | 5.325 | 38.406 | 204.51195 | 204.512 |  |
| 00:04:57 | 4.79E-03 | 4.789 | 38.19 | 182.89191 | 182.892 |  |
| 00:04:58 | 1.82E-02 | 18.155 | 36.121 | 655.776755 | 655.777 |  |
| 00:04:59 | 1.86E-02 | 18.636 | 36.071 | 672.219156 | 672.219 |  |
| 00:05:00 | 1.74E-02 | 17.437 | 36.228 | 631.707636 | 631.708 |  |
| 00:05:01 | 1.60E-02 | 16.028 | 36.427 | 583.851956 | 583.852 |  |
| 00:05:02 | 1.53E-02 | 15.251 | 36.532 | 557.149532 | 557.150 |  |
| 00:05:03 | 1.48E-02 | 14.836 | 36.588 | 542.819568 | 542.820 |  |
| 00:05:04 | 1.45E-02 | 14.455 | 36.626 | 529.42883 | 529.429 |  |
| 00:05:05 | 1.45E-02 | 14.513 | 36.63 | 531.61119 | 531.611 |  |
| 00:05:06 | 1.41E-02 | 14.057 | 36.675 | 515.540475 | 515.540 |  |
| 00:05:07 | 1.24E-02 | 12.411 | 37.039 | 459.691029 | 459.691 |  |
| 00:05:08 | 1.85E-04 | 0.185 | 38.916 | 7.19946 | 7.199 |  |
| 00:05:09 | 6.50E-05 | 0.065 | 38.977 | 2.533505 | 2.534 |  |
| 00:05:10 | -2.80E-03 | -2.803 | 39.575 | -110.928725 | -110.929 |  |
| 00:05:11 | -3.08E-03 | -3.081 | 39.502 | -121.705662 | -121.706 |  |
| 00:05:12 | 3.30E-05 | 0.033 | 39.084 | 1.289772 | 1.290 |  |
| 00:05:13 | 9.10E-05 | 0.091 | 39.091 | 3.557281 | 3.557 |  |
| 00:05:14 | 2.25E-03 | 2.251 | 38.707 | 87.129457 | 87.129 |  |
| 00:05:15 | 2.38E-02 | 23.817 | 35.155 | 837.286635 | 837.287 |  |
| 00:05:16 | 2.69E-02 | 26.880 | 34.752 | 934.13376 | 934.134 |  |
| 00:05:17 | 2.59E-02 | 25.856 | 34.879 | 901.831424 | 901.831 |  |
| 00:05:18 | 2.35E-02 | 23.452 | 35.194 | 825.369688 | 825.370 |  |
| 00:05:19 | 2.13E-02 | 21.279 | 35.472 | 754.808688 | 754.809 |  |
| 00:05:20 | 2.03E-02 | 20.345 | 35.615 | 724.587175 | 724.587 |  |
| 00:05:21 | 1.88E-02 | 18.800 | 35.85 | 673.98 | 673.980 |  |
| 00:05:22 | 1.47E-02 | 14.732 | 36.46 | 537.12872 | 537.129 |  |
| 00:05:23 | 1.35E-02 | 13.452 | 36.653 | 493.056156 | 493.056 |  |
| 00:05:24 | 1.29E-02 | 12.857 | 36.739 | 472.353323 | 472.353 |  |
| 00:05:25 | 1.27E-02 | 12.739 | 36.755 | 468.221945 | 468.222 |  |
| 00:05:26 | 1.28E-02 | 12.769 | 36.753 | 469.299057 | 469.299 |  |
| 00:05:27 | 1.33E-02 | 13.262 | 36.666 | 486.264492 | 486.264 |  |
| 00:05:28 | 1.40E-02 | 14.009 | 36.532 | 511.776788 | 511.777 |  |
| 00:05:29 | 1.46E-02 | 14.551 | 36.444 | 530.296644 | 530.297 |  |
| 00:05:30 | 1.49E-02 | 14.856 | 36.399 | 540.743544 | 540.744 |  |
| 00:05:31 | 1.55E-02 | 15.516 | 36.276 | 562.858416 | 562.858 |  |
| 00:05:32 | 1.68E-02 | 16.760 | 36.063 | 604.41588 | 604.416 |  |
| 00:05:33 | 1.72E-02 | 17.196 | 35.989 | 618.866844 | 618.867 |  |
| 00:05:34 | 1.78E-02 | 17.778 | 35.864 | 637.590192 | 637.590 |  |
| 00:05:35 | 1.85E-02 | 18.505 | 35.756 | 661.66478 | 661.665 |  |
| 00:05:36 | 8.84E-03 | 8.841 | 37.528 | 331.785048 | 331.785 |  |
| 00:05:37 | 1.57E-04 | 0.157 | 38.647 | 6.067579 | 6.068 |  |
| 00:05:38 | 1.65E-02 | 16.511 | 35.942 | 593.438362 | 593.438 |  |
| 00:05:39 | 1.91E-02 | 19.148 | 35.846 | 686.379208 | 686.379 |  |
| 00:05:40 | 2.46E-04 | 0.246 | 38.62 | 9.50052 | 9.501 |  |
| 00:05:41 | 3.23E-04 | 0.323 | 38.64 | 12.48072 | 12.481 |  |
| 00:05:42 | 1.52E-02 | 15.180 | 35.986 | 546.26748 | 546.267 |  |
| 00:05:43 | 2.67E-02 | 26.675 | 34.581 | 922.448175 | 922.448 |  |
| 00:05:44 | 2.71E-02 | 27.138 | 34.447 | 934.822686 | 934.823 |  |
| 00:05:45 | 2.26E-02 | 22.637 | 35.109 | 794.762433 | 794.762 |  |
| 00:05:46 | 2.02E-02 | 20.176 | 35.453 | 715.299728 | 715.300 |  |
| 00:05:47 | 1.81E-02 | 18.131 | 35.743 | 648.056333 | 648.056 |  |
| 00:05:48 | 1.69E-02 | 16.946 | 35.905 | 608.44613 | 608.446 |  |
| 00:05:49 | 1.67E-02 | 16.729 | 35.941 | 601.256989 | 601.257 |  |
| 00:05:50 | 1.65E-02 | 16.467 | 35.96 | 592.15332 | 592.153 |  |
| 00:05:51 | 1.63E-02 | 16.258 | 35.996 | 585.222968 | 585.223 |  |
| 00:05:52 | 1.65E-02 | 16.450 | 35.955 | 591.45975 | 591.460 |  |
| 00:05:53 | 1.66E-02 | 16.578 | 35.935 | 595.73043 | 595.730 |  |
| 00:05:54 | 1.66E-02 | 16.626 | 35.914 | 597.106164 | 597.106 |  |
| 00:05:55 | 1.65E-02 | 16.534 | 35.932 | 594.099688 | 594.100 |  |
| 00:05:56 | 1.61E-02 | 16.137 | 35.984 | 580.673808 | 580.674 |  |
| 00:05:57 | 1.59E-02 | 15.881 | 36.014 | 571.938334 | 571.938 |  |
| 00:05:58 | 1.60E-02 | 15.987 | 35.997 | 575.484039 | 575.484 |  |
| 00:05:59 | 1.59E-02 | 15.910 | 36.004 | 572.82364 | 572.824 |  |
| 00:06:00 | 1.57E-02 | 15.654 | 36.042 | 564.201468 | 564.201 |  |
| 00:06:01 | 1.53E-02 | 15.324 | 36.089 | 553.027836 | 553.028 |  |
| 00:06:02 | 1.53E-02 | 15.278 | 36.093 | 551.428854 | 551.429 |  |
| 00:06:03 | 1.53E-02 | 15.255 | 36.093 | 550.598715 | 550.599 |  |
| 00:06:04 | 1.51E-02 | 15.091 | 36.116 | 545.026556 | 545.027 |  |
| 00:06:05 | 1.48E-02 | 14.847 | 36.155 | 536.793285 | 536.793 |  |
| 00:06:06 | 1.44E-02 | 14.366 | 36.221 | 520.350886 | 520.351 |  |
| 00:06:07 | 1.40E-02 | 14.046 | 36.269 | 509.434374 | 509.434 |  |
| 00:06:08 | 1.38E-02 | 13.839 | 36.305 | 502.424895 | 502.425 |  |
| 00:06:09 | 1.33E-02 | 13.309 | 36.39 | 484.31451 | 484.315 |  |
| 00:06:10 | 1.24E-02 | 12.372 | 36.534 | 451.998648 | 451.999 |  |
| 00:06:11 | 1.17E-02 | 11.682 | 36.641 | 428.040162 | 428.040 |  |
| 00:06:12 | 1.16E-02 | 11.607 | 36.654 | 425.442978 | 425.443 |  |
| 00:06:13 | 1.15E-02 | 11.527 | 36.675 | 422.752725 | 422.753 |  |
| 00:06:14 | 1.12E-02 | 11.240 | 36.725 | 412.789 | 412.789 |  |
| 00:06:15 | 1.09E-02 | 10.948 | 36.763 | 402.481324 | 402.481 |  |
| 00:06:16 | 1.14E-02 | 11.389 | 36.695 | 417.919355 | 417.919 |  |
| 00:06:17 | 1.09E-02 | 10.946 | 36.789 | 402.692394 | 402.692 |  |
| 00:06:18 | 9.41E-03 | 9.410 | 37.017 | 348.32997 | 348.330 |  |
| 00:06:19 | 9.42E-03 | 9.419 | 37.03 | 348.78557 | 348.786 |  |
| 00:06:20 | 9.08E-03 | 9.082 | 37.087 | 336.824134 | 336.824 |  |
| 00:06:21 | 8.86E-03 | 8.863 | 37.122 | 329.012286 | 329.012 |  |
| 00:06:22 | 8.82E-03 | 8.822 | 37.132 | 327.578504 | 327.579 |  |
| 00:06:23 | 8.95E-03 | 8.952 | 37.117 | 332.271384 | 332.271 |  |
| 00:06:24 | 9.39E-03 | 9.393 | 37.053 | 348.038829 | 348.039 |  |
| 00:06:25 | 8.95E-03 | 8.952 | 37.197 | 332.987544 | 332.988 |  |
| 00:06:26 | 4.71E-04 | 0.471 | 38.476 | 18.122196 | 18.122 |  |
| 00:06:27 | -1.58E-03 | -1.575 | 38.834 | -61.16355 | -61.164 |  |
| 00:06:28 | -4.29E-03 | -4.289 | 39.259 | -168.381851 | -168.382 |  |
| 00:06:29 | -3.16E-03 | -3.164 | 39.109 | -123.740876 | -123.741 |  |
| 00:06:30 | -8.70E-04 | -0.870 | 38.764 | -33.72468 | -33.725 |  |
| 00:06:31 | 5.20E-05 | 0.052 | 38.667 | 2.010684 | 2.011 |  |
| 00:06:32 | 4.20E-05 | 0.042 | 38.682 | 1.624644 | 1.625 |  |
| 00:06:33 | 1.97E-02 | 19.741 | 35.521 | 701.220061 | 701.220 |  |
| 00:06:34 | 5.87E-03 | 5.871 | 37.78 | 221.80638 | 221.806 |  |
| 00:06:35 | 1.30E-02 | 13.032 | 36.879 | 480.607128 | 480.607 |  |
| 00:06:36 | 4.50E-05 | 0.045 | 38.618 | 1.73781 | 1.738 |  |
| 00:06:37 | 3.20E-05 | 0.032 | 38.66 | 1.23712 | 1.237 |  |
| 00:06:38 | 2.10E-05 | 0.021 | 38.69 | 0.81249 | 0.812 |  |
| 00:06:39 | 2.50E-05 | 0.025 | 38.706 | 0.96765 | 0.968 |  |
| 00:06:40 | 2.40E-05 | 0.024 | 38.717 | 0.929208 | 0.929 |  |
| 00:06:41 | 2.40E-05 | 0.024 | 38.73 | 0.92952 | 0.930 |  |
| 00:06:42 | -9.07E-04 | -0.907 | 38.906 | -35.287742 | -35.288 |  |
| 00:06:43 | -1.32E-03 | -1.323 | 38.969 | -51.555987 | -51.556 |  |
| 00:06:44 | -1.16E-03 | -1.155 | 38.94 | -44.9757 | -44.976 |  |
| 00:06:45 | -8.61E-04 | -0.861 | 38.944 | -33.530784 | -33.531 |  |
| 00:06:46 | -2.36E-03 | -2.364 | 39.18 | -92.62152 | -92.622 |  |
| 00:06:47 | -3.28E-03 | -3.277 | 39.34 | -128.91718 | -128.917 |  |
| 00:06:48 | -2.92E-03 | -2.923 | 39.286 | -114.832978 | -114.833 |  |
| 00:06:49 | -1.96E-03 | -1.964 | 39.158 | -76.906312 | -76.906 |  |
| 00:06:50 | 5.43E-03 | 5.430 | 37.833 | 205.43319 | 205.433 |  |
| 00:06:51 | 2.45E-02 | 24.521 | 35.095 | 860.564495 | 860.564 |  |
| 00:06:52 | 2.56E-02 | 25.604 | 34.883 | 893.144332 | 893.144 |  |
| 00:06:53 | 2.85E-02 | 28.531 | 34.371 | 980.639001 | 980.639 |  |
| 00:06:54 | 2.80E-02 | 27.984 | 34.454 | 964.160736 | 964.161 |  |
| 00:06:55 | 2.51E-02 | 25.146 | 34.768 | 874.276128 | 874.276 |  |
| 00:06:56 | 2.27E-02 | 22.651 | 35.119 | 795.480469 | 795.480 |  |
| 00:06:57 | 1.82E-02 | 18.181 | 35.772 | 650.370732 | 650.371 |  |
| 00:06:58 | 1.48E-02 | 14.768 | 36.273 | 535.679664 | 535.680 |  |
| 00:06:59 | 1.29E-02 | 12.903 | 36.552 | 471.630456 | 471.630 |  |
| 00:07:00 | 1.06E-02 | 10.608 | 36.888 | 391.307904 | 391.308 |  |
| 00:07:01 | 8.46E-03 | 8.455 | 37.229 | 314.771195 | 314.771 |  |
| 00:07:02 | 7.39E-03 | 7.387 | 37.399 | 276.266413 | 276.266 |  |
| 00:07:03 | 6.96E-03 | 6.959 | 37.457 | 260.663263 | 260.663 |  |
| 00:07:04 | 6.48E-03 | 6.476 | 37.547 | 243.154372 | 243.154 |  |
| 00:07:05 | 6.27E-03 | 6.266 | 37.593 | 235.557738 | 235.558 |  |
| 00:07:06 | 6.11E-03 | 6.113 | 37.627 | 230.013851 | 230.014 |  |
| 00:07:07 | 5.86E-03 | 5.859 | 37.662 | 220.661658 | 220.662 |  |
| 00:07:08 | 6.02E-03 | 6.021 | 37.65 | 226.69065 | 226.691 |  |
| 00:07:09 | 6.39E-03 | 6.391 | 37.595 | 240.269645 | 240.270 |  |
| 00:07:10 | 6.91E-03 | 6.907 | 37.515 | 259.116105 | 259.116 |  |
| 00:07:11 | 8.00E-03 | 8.004 | 37.345 | 298.90938 | 298.909 |  |
| 00:07:12 | 9.06E-03 | 9.055 | 37.194 | 336.79167 | 336.792 |  |
| 00:07:13 | 9.28E-03 | 9.278 | 37.219 | 345.317882 | 345.318 |  |
| 00:07:14 | 3.61E-04 | 0.361 | 38.541 | 13.913301 | 13.913 |  |
| 00:07:15 | 5.00E-06 | 0.005 | 38.594 | 0.19297 | 0.193 |  |
| 00:07:16 | 0 | 0.000 | 38.621 | 0 | 0.000 |  |
| 00:07:17 | -9.85E-04 | -0.985 | 38.82 | -38.2377 | -38.238 |  |
| 00:07:18 | -4.12E-03 | -4.124 | 39.322 | -162.163928 | -162.164 |  |
| 00:07:19 | -4.05E-03 | -4.045 | 39.277 | -158.875465 | -158.875 |  |
| 00:07:20 | -2.95E-03 | -2.945 | 39.129 | -115.234905 | -115.235 |  |
| 00:07:21 | 6.48E-03 | 6.477 | 37.518 | 243.004086 | 243.004 |  |
| 00:07:22 | 2.87E-02 | 28.746 | 34.352 | 987.482592 | 987.483 |  |
| 00:07:23 | 2.87E-02 | 28.744 | 34.281 | 985.373064 | 985.373 |  |
| 00:07:24 | 2.89E-02 | 28.918 | 34.184 | 988.532912 | 988.533 |  |
| 00:07:25 | 2.81E-02 | 28.083 | 34.291 | 962.994153 | 962.994 |  |
| 00:07:26 | 2.65E-02 | 26.537 | 34.462 | 914.518094 | 914.518 |  |
| 00:07:27 | 2.54E-02 | 25.401 | 34.59 | 878.62059 | 878.621 |  |
| 00:07:28 | 2.26E-02 | 22.567 | 34.978 | 789.348526 | 789.349 |  |
| 00:07:29 | 2.05E-02 | 20.518 | 35.261 | 723.485198 | 723.485 |  |
| 00:07:30 | 2.01E-02 | 20.120 | 35.295 | 710.1354 | 710.135 |  |
| 00:07:31 | 2.05E-02 | 20.469 | 35.225 | 721.020525 | 721.021 |  |
| 00:07:32 | 2.12E-02 | 21.218 | 35.1 | 744.7518 | 744.752 |  |
| 00:07:33 | 2.19E-02 | 21.859 | 34.983 | 764.693397 | 764.693 |  |
| 00:07:34 | 4.35E-03 | 4.349 | 37.78 | 164.30522 | 164.305 |  |
| 00:07:35 | -1.15E-03 | -1.147 | 38.536 | -44.200792 | -44.201 |  |
| 00:07:36 | -1.66E-03 | -1.657 | 38.642 | -64.029794 | -64.030 |  |
| 00:07:37 | -6.81E-04 | -0.681 | 38.521 | -26.232801 | -26.233 |  |
| 00:07:38 | 4.00E-05 | 0.040 | 38.444 | 1.53776 | 1.538 |  |
| 00:07:39 | 4.90E-05 | 0.049 | 38.471 | 1.885079 | 1.885 |  |
| 00:07:40 | 2.90E-05 | 0.029 | 38.5 | 1.1165 | 1.117 |  |
| 00:07:41 | 2.90E-05 | 0.029 | 38.521 | 1.117109 | 1.117 |  |
| 00:07:42 | 3.20E-05 | 0.032 | 38.533 | 1.233056 | 1.233 |  |
| 00:07:43 | 2.90E-05 | 0.029 | 38.551 | 1.117979 | 1.118 |  |
| 00:07:44 | 3.10E-05 | 0.031 | 38.573 | 1.195763 | 1.196 |  |
| 00:07:45 | 3.00E-05 | 0.030 | 38.593 | 1.15779 | 1.158 |  |
| 00:07:46 | 2.60E-05 | 0.026 | 38.607 | 1.003782 | 1.004 |  |
| 00:07:47 | 2.80E-05 | 0.028 | 38.617 | 1.081276 | 1.081 |  |
| 00:07:48 | 2.60E-05 | 0.026 | 38.628 | 1.004328 | 1.004 |  |
| 00:07:49 | 2.80E-05 | 0.028 | 38.646 | 1.082088 | 1.082 |  |
| 00:07:50 | 2.50E-05 | 0.025 | 38.659 | 0.966475 | 0.966 |  |
| 00:07:51 | 2.30E-05 | 0.023 | 38.665 | 0.889295 | 0.889 |  |
| 00:07:52 | 2.30E-05 | 0.023 | 38.676 | 0.889548 | 0.890 |  |
| 00:07:53 | 2.40E-05 | 0.024 | 38.689 | 0.928536 | 0.929 |  |
| 00:07:54 | 2.30E-05 | 0.023 | 38.698 | 0.890054 | 0.890 |  |
| 00:07:55 | 2.40E-05 | 0.024 | 38.706 | 0.928944 | 0.929 |  |
| 00:07:56 | 2.70E-05 | 0.027 | 38.715 | 1.045305 | 1.045 |  |
| 00:07:57 | 3.00E-05 | 0.030 | 38.727 | 1.16181 | 1.162 |  |
| 00:07:58 | 2.90E-05 | 0.029 | 38.738 | 1.123402 | 1.123 |  |
| 00:07:59 | 2.90E-05 | 0.029 | 38.746 | 1.123634 | 1.124 |  |
| 00:08:00 | 2.60E-05 | 0.026 | 38.749 | 1.007474 | 1.007 |  |
| 00:08:01 | 2.00E-06 | 0.002 | 38.756 | 0.077512 | 0.078 |  |
| 00:08:02 | -2.41E-04 | -0.241 | 38.81 | -9.35321 | -9.353 |  |
| 00:08:03 | -6.43E-04 | -0.643 | 38.879 | -24.999197 | -24.999 |  |
| 00:08:04 | -2.00E-04 | -0.200 | 38.815 | -7.763 | -7.763 |  |
| 00:08:05 | 3.50E-05 | 0.035 | 38.793 | 1.357755 | 1.358 |  |
| 00:08:06 | 4.20E-05 | 0.042 | 38.797 | 1.629474 | 1.629 |  |
| 00:08:07 | 3.80E-05 | 0.038 | 38.802 | 1.474476 | 1.474 |  |
| 00:08:08 | 2.90E-05 | 0.029 | 38.809 | 1.125461 | 1.125 |  |
| 00:08:09 | 2.70E-05 | 0.027 | 38.816 | 1.048032 | 1.048 |  |
| 00:08:10 | 2.00E-05 | 0.020 | 38.819 | 0.77638 | 0.776 |  |
| 00:08:11 | 1.10E-05 | 0.011 | 38.824 | 0.427064 | 0.427 |  |
| 00:08:12 | 7.00E-06 | 0.007 | 38.827 | 0.271789 | 0.272 |  |
| 00:08:13 | 8.71E-04 | 0.871 | 38.685 | 33.694635 | 33.695 |  |
| 00:08:14 | 4.39E-03 | 4.392 | 38.153 | 167.567976 | 167.568 |  |
| 00:08:15 | 4.57E-03 | 4.566 | 38.158 | 174.229428 | 174.229 |  |
| 00:08:16 | 6.74E-04 | 0.674 | 38.764 | 26.126936 | 26.127 |  |
| 00:08:17 | 5.50E-05 | 0.055 | 38.821 | 2.135155 | 2.135 |  |
| 00:08:18 | -5.50E-05 | -0.055 | 38.846 | -2.13653 | -2.137 |  |
| 00:08:19 | 2.20E-05 | 0.022 | 38.844 | 0.854568 | 0.855 |  |
| 00:08:20 | 1.50E-05 | 0.015 | 38.849 | 0.582735 | 0.583 |  |
| 00:08:21 | 1.40E-05 | 0.014 | 38.856 | 0.543984 | 0.544 |  |
| 00:08:22 | 1.60E-05 | 0.016 | 38.856 | 0.621696 | 0.622 |  |
| 00:08:23 | 1.30E-05 | 0.013 | 38.866 | 0.505258 | 0.505 |  |
| 00:08:24 | 8.00E-06 | 0.008 | 38.872 | 0.310976 | 0.311 |  |
| 00:08:25 | 8.00E-06 | 0.008 | 38.876 | 0.311008 | 0.311 |  |
| 00:08:26 | 9.00E-06 | 0.009 | 38.884 | 0.349956 | 0.350 |  |
| 00:08:27 | 8.00E-06 | 0.008 | 38.886 | 0.311088 | 0.311 |  |
| 00:08:28 | 7.00E-06 | 0.007 | 38.889 | 0.272223 | 0.272 |  |
| 00:08:29 | 5.00E-06 | 0.005 | 38.895 | 0.194475 | 0.194 |  |
| 00:08:30 | 9.00E-06 | 0.009 | 38.899 | 0.350091 | 0.350 |  |
| 00:08:31 | 1.10E-05 | 0.011 | 38.904 | 0.427944 | 0.428 |  |
| 00:08:32 | 1.00E-05 | 0.010 | 38.905 | 0.38905 | 0.389 |  |
| 00:08:33 | 1.00E-05 | 0.010 | 38.906 | 0.38906 | 0.389 |  |
| 00:08:34 | 8.00E-06 | 0.008 | 38.912 | 0.311296 | 0.311 |  |
| 00:08:35 | 1.30E-05 | 0.013 | 38.915 | 0.505895 | 0.506 |  |
| 00:08:36 | 1.30E-05 | 0.013 | 38.919 | 0.505947 | 0.506 |  |
| 00:08:37 | 2.00E-06 | 0.002 | 38.925 | 0.07785 | 0.078 |  |
| 00:08:38 | 2.00E-06 | 0.002 | 38.929 | 0.077858 | 0.078 |  |
| 00:08:39 | -9.00E-06 | -0.009 | 38.93 | -0.35037 | -0.350 |  |
| 00:08:40 | -9.00E-06 | -0.009 | 38.932 | -0.350388 | -0.350 |  |
| 00:08:41 | -1.20E-05 | -0.012 | 38.934 | -0.467208 | -0.467 |  |
| 00:08:42 | -1.50E-05 | -0.015 | 38.94 | -0.5841 | -0.584 |  |
| 00:08:43 | -1.70E-05 | -0.017 | 38.942 | -0.662014 | -0.662 |  |
| 00:08:44 | -1.20E-05 | -0.012 | 38.944 | -0.467328 | -0.467 |  |
| 00:08:45 | -1.30E-05 | -0.013 | 38.948 | -0.506324 | -0.506 |  |
| 00:08:46 | -1.00E-05 | -0.010 | 38.947 | -0.38947 | -0.389 |  |
| 00:08:47 | -1.30E-05 | -0.013 | 38.954 | -0.506402 | -0.506 |  |
| 00:08:48 | -1.00E-05 | -0.010 | 38.958 | -0.38958 | -0.390 |  |
| 00:08:49 | -8.00E-06 | -0.008 | 38.959 | -0.311672 | -0.312 |  |
| 00:08:50 | -1.30E-05 | -0.013 | 38.961 | -0.506493 | -0.506 |  |
| 00:08:51 | -1.20E-05 | -0.012 | 38.964 | -0.467568 | -0.468 |  |
| 00:08:52 | -1.20E-05 | -0.012 | 38.967 | -0.467604 | -0.468 |  |
| 00:08:53 | -9.00E-06 | -0.009 | 38.97 | -0.35073 | -0.351 |  |
| 00:08:54 | -8.00E-06 | -0.008 | 38.973 | -0.311784 | -0.312 |  |
| 00:08:55 | -1.10E-05 | -0.011 | 38.976 | -0.428736 | -0.429 |  |
| 00:08:56 | -1.10E-05 | -0.011 | 38.979 | -0.428769 | -0.429 |  |
| 00:08:57 | -1.40E-05 | -0.014 | 38.977 | -0.545678 | -0.546 |  |
| 00:08:58 | -1.50E-05 | -0.015 | 38.98 | -0.5847 | -0.585 |  |
| 00:08:59 | -1.50E-05 | -0.015 | 38.983 | -0.584745 | -0.585 |  |

**Geloggter GPS-Daten**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| t [s] | Lat[grad] | Lon[grad] | s[m] | v[m/s] | dE [Ws] |
| 69018 | 47.014732 | 8.305753 | 0 | 0 | 0 |
| 69021 | 47.014726 | 8.305745 | 0.87 | 0.87 | 0 |
| 69022 | 47.014722 | 8.305747 | 0.5 | 0.5 | 0 |
| 69023 | 47.014722 | 8.305751 | 0.32 | 0.32 | 0 |
| 69024 | 47.014723 | 8.305752 | 0.13 | 0.13 | 0 |
| 69025 | 47.014722 | 8.305752 | 0 | 0 | 0 |
| 69035 | 47.014677 | 8.305802 | 6.35 | 6.35 | 0 |
| 69036 | 47.014682 | 8.305825 | 1.9 | 0.63333333 | 18.05 |
| 69039 | 47.014695 | 8.305931 | 8.11 | 8.11 | 0 |
| 69040 | 47.014706 | 8.305997 | 5.2 | 2.6 | 304.2 |
| 69042 | 47.014731 | 8.30616 | 12.69 | 3.1725 | 452.914031 |
| 69046 | 47.014783 | 8.306567 | 31.38 | 31.38 | 0 |
| 69047 | 47.014795 | 8.306662 | 7.34 | 7.34 | 0 |
| 69048 | 47.014804 | 8.306742 | 6.18 | 6.18 | 0 |
| 69049 | 47.014811 | 8.30681 | 5.23 | 5.23 | 1230.8805 |
| 69050 | 47.014831 | 8.306899 | 7.11 | 7.11 | 0 |
| 69051 | 47.014875 | 8.307006 | 9.47 | 4.735 | 0 |
| 69053 | 47.014989 | 8.307111 | 14.99 | 3.7475 | 631.969031 |
| 69057 | 47.015233 | 8.307159 | 27.36 | 4.56 | 935.712 |
| 69063 | 47.015695 | 8.307159 | 51.52 | 8.58666667 | 3317.888 |
| 69069 | 47.01618 | 8.307072 | 54.37 | 10.874 | 5320.97442 |
| 69074 | 47.016604 | 8.306885 | 49.27 | 12.3175 | 6827.43628 |
| 69078 | 47.016881 | 8.306748 | 32.53 | 32.53 | 0 |
| 69079 | 47.016928 | 8.306697 | 6.48 | 2.16 | 209.952 |
| 69082 | 47.017005 | 8.306473 | 19.03 | 6.34333333 | 0 |
| 69085 | 47.016976 | 8.306176 | 22.8 | 5.7 | 1462.05 |
| 69089 | 47.016916 | 8.305744 | 33.5 | 33.5 | 0 |
| 69090 | 47.016901 | 8.305628 | 8.89 | 8.89 | 3556.4445 |
| 69091 | 47.016886 | 8.30551 | 9.13 | 9.13 | 3751.0605 |
| 69092 | 47.016866 | 8.305389 | 9.43 | 9.43 | 0 |
| 69093 | 47.016846 | 8.305271 | 9.28 | 2.32 | 242.208 |
| 69097 | 47.016757 | 8.304816 | 35.9 | 35.9 | 0 |
| 69098 | 47.016744 | 8.304701 | 8.84 | 8.84 | 0 |
| 69099 | 47.016738 | 8.30459 | 8.5 | 8.5 | 0 |
| 69100 | 47.016726 | 8.304483 | 8.18 | 8.18 | 0 |
| 69101 | 47.016708 | 8.304385 | 7.72 | 7.72 | 0 |
| 69102 | 47.016689 | 8.304288 | 7.68 | 7.68 | 0 |
| 69103 | 47.016668 | 8.304208 | 6.47 | 3.235 | 470.935125 |
| 69105 | 47.016628 | 8.30404 | 13.53 | 4.51 | 915.3045 |
| 69108 | 47.016558 | 8.303764 | 22.31 | 22.31 | 0 |
| 69109 | 47.016512 | 8.303722 | 6.04 | 3.02 | 410.418 |
| 69111 | 47.016326 | 8.303705 | 20.81 | 10.405 | 4871.88113 |
| 69113 | 47.01615 | 8.303753 | 19.89 | 19.89 | 0 |
| 69114 | 47.016066 | 8.303782 | 9.59 | 9.59 | 4138.5645 |
| 69115 | 47.01598 | 8.303808 | 9.79 | 9.79 | 0 |
| 69116 | 47.015899 | 8.303841 | 9.4 | 9.4 | 0 |
| 69117 | 47.015822 | 8.303866 | 8.71 | 2.1775 | 213.367781 |
| 69121 | 47.015518 | 8.304004 | 35.52 | 5.92 | 1577.088 |
| 69127 | 47.015054 | 8.304235 | 54.52 | 27.26 | 0 |
| 69129 | 47.014898 | 8.304314 | 18.33 | 18.33 | 0 |
| 69130 | 47.014826 | 8.304347 | 8.36 | 8.36 | 3145.032 |
| 69131 | 47.014753 | 8.30438 | 8.51 | 8.51 | 3258.9045 |
| 69132 | 47.014681 | 8.304416 | 8.55 | 8.55 | 0 |
| 69133 | 47.014606 | 8.304451 | 8.75 | 1.45833333 | 95.703125 |
| 69139 | 47.014132 | 8.304614 | 54.17 | 54.17 | 0 |
| 69140 | 47.014056 | 8.304651 | 8.89 | 4.445 | 0 |
| 69142 | 47.013899 | 8.304683 | 17.73 | 2.53285714 | 288.691439 |
| 69149 | 47.013307 | 8.304801 | 66.43 | 11.0716667 | 5516.18113 |
| 69155 | 47.01282 | 8.304893 | 54.7 | 18.2333333 | 0 |
| 69158 | 47.012666 | 8.304942 | 17.48 | 17.48 | 0 |
| 69159 | 47.012639 | 8.304966 | 3.58 | 3.58 | 0 |
| 69160 | 47.01262 | 8.305004 | 3.56 | 3.56 | 570.312 |
| 69161 | 47.012602 | 8.305054 | 4.27 | 4.27 | 820.4805 |
| 69162 | 47.012585 | 8.305119 | 5.26 | 5.26 | 0 |
| 69163 | 47.012572 | 8.305203 | 6.59 | 2.19666667 | 217.1405 |
| 69166 | 47.012563 | 8.305461 | 19.56 | 19.56 | 0 |
| 69167 | 47.012559 | 8.305549 | 6.69 | 6.69 | 2014.0245 |
| 69168 | 47.012556 | 8.305638 | 6.8 | 6.8 | 2080.8 |
| 69169 | 47.012554 | 8.305731 | 7.06 | 7.06 | 2242.962 |
| 69170 | 47.012559 | 8.305831 | 7.58 | 7.58 | 0 |
| 69171 | 47.012563 | 8.305921 | 6.89 | 6.89 | 0 |
| 69172 | 47.012565 | 8.306009 | 6.63 | 6.63 | 1978.0605 |
| 69173 | 47.012566 | 8.306103 | 7.19 | 7.19 | 0 |
| 69174 | 47.012566 | 8.306186 | 6.25 | 6.25 | 0 |
| 69175 | 47.012567 | 8.306243 | 4.37 | 4.37 | 0 |
| 69176 | 47.01257 | 8.306293 | 3.77 | 3.77 | 639.5805 |
| 69177 | 47.012578 | 8.306362 | 5.32 | 5.32 | 1273.608 |
| 69178 | 47.012611 | 8.306439 | 6.92 | 6.92 | 0 |
| 69179 | 47.012661 | 8.306495 | 7.01 | 1.7525 | 138.206531 |
| 69183 | 47.012904 | 8.306811 | 36.14 | 7.228 | 2350.97928 |
| 69188 | 47.013329 | 8.306913 | 47.94 | 9.588 | 0 |
| 69193 | 47.013786 | 8.306965 | 50.99 | 8.49833333 | 3249.97512 |
| 69199 | 47.01432 | 8.307052 | 59.83 | 11.966 | 6443.33202 |
| 69204 | 47.014724 | 8.307155 | 45.66 | 45.66 | 0 |
| 69205 | 47.014789 | 8.307182 | 7.5 | 3.75 | 632.8125 |
| 69207 | 47.014879 | 8.307198 | 10.15 | 10.15 | 0 |
| 69208 | 47.01493 | 8.307181 | 5.82 | 2.91 | 381.0645 |
| 69210 | 47.015006 | 8.307049 | 13.13 | 6.565 | 1939.46513 |
| 69212 | 47.014984 | 8.306888 | 12.49 | 12.49 | 0 |
| 69213 | 47.014979 | 8.306799 | 6.78 | 1.695 | 129.286125 |
| 69217 | 47.01496 | 8.306385 | 31.47 | 31.47 | 0 |
| 69218 | 47.014951 | 8.306272 | 8.62 | 8.62 | 0 |
| 69219 | 47.014942 | 8.30616 | 8.55 | 8.55 | 0 |
| 69220 | 47.014931 | 8.306054 | 8.15 | 8.15 | 0 |
| 69221 | 47.014918 | 8.30596 | 7.32 | 7.32 | 0 |
| 69222 | 47.014907 | 8.305875 | 6.54 | 6.54 | 0 |
| 69223 | 47.014893 | 8.305817 | 4.68 | 4.68 | 0 |
| 69224 | 47.014895 | 8.305791 | 1.98 | 1.98 | 0 |
| 69225 | 47.014893 | 8.305781 | 0.8 | 0.8 | 0 |
| 69226 | 47.014895 | 8.305768 | 1.01 | 0.12625 | 0 |
| 69234 | 47.014874 | 8.305754 | 2.49 | -3.60E-05 | 0 |