

# MONITORING THE MOVEMENT OF VISITORS IN THE TATRA NATIONAL PARK USING BATTERY-POWERED ONLINE COUNTERS

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## Abstract

Mapotic, in collaboration with Hardwario, has developed an innovative device for monitoring the movement of tourists and tracking environmental factors in the natural environment. The battery-powered, long-life devices are connected to the internet and allow for easy and quick collection, including in mountain locations and during extreme weather conditions. IoT (internet of things devices) can be connected via NB-IoT or satellite network and are capable of providing real-time data. It has been developed with low acquisition cost in mind and easy integration into various projects where there is a need to collect visitor or environmental data from natural sites. As a result, this allows for data driven decision making by operators to better manage tourism in the area, plan the development of hiking trails and overall help conservation.

**Key words:** Tourism monitoring and visitor measurement in nature, outdoor movement counters, outdoor battery counters, monitoring of protected areas and national parks, monitoring of public spaces

## Introduction

The Tatra National Park (TANAP) team has long struggled with insufficient information on the number of visitors to the Tatras. Insufficient statistics and inaccurate ways of measuring visitor numbers made it impossible to plan new investments and made tourism management difficult. As they were already using the Mapotic platform to visualize tourism-related maps, they turned to us for flexible monitoring of tourist movements. In collaboration with Hardwario, we developed a system based on battery-powered online connected counters that can be freely deployed in the countryside to collect near real-time data on passageways in a given location. The technology uses connectivity over the now widespread NB-IoT "internet of things" networks and an optimised configuration that ensures battery life for up to several years, including deployment in mountains and freezing temperatures. Existing software tools were then used for data visualization and processing, thus achieving the optimal combination of operating costs and flexibility in processing and visualizing the measured values to provide the operators with the greatest benefit by providing clear visualizations of site utilization during the day but also summary reports during the season or over any time period.

## Materials and methods

The universal hardware platform Chester was selected as the optimal technology for the enumerators. This has been developed by Hardwario for a long time and has been proven in hundreds of implementations in the last few years, both domestically and abroad on several continents, including for example shot detection during poaching in the Sahara desert. Chester was conceived to be widely used for telemetry and online transmission of measured data, whether in industry or the environment. During the testing and pilot period, the device was calibrated primarily in terms of the field of view of the newly installed sensor and the range and distance that the sensor is able to monitor. The latter can be adjusted using several types of sensor occlusion and a software adjustable passage period of the moving object. The sensor itself works on the principle of detecting major thermal changes in the monitored perimeter of the environment - in outdoor the risk of false totals is eliminated, e.g. when branches move during wind etc. The device itself is equipped with a robust, waterproof housing with IP67 rating for harsh conditions and optimized for long-term battery operation. The latter is related to the specific needs of the project, where data can be sent at daily or hourly or even smaller intervals - in the case of Tatra Park, the period was set to 15min, which allows monitoring of trends during the day, but also more detailed reports on the utilization of footpaths or forest paths during the busiest hours.

The NB-IoT network is used for data transmission, which has more than 90% signal coverage of the Tatra National Park. The individual devices send data packets with newly measured values at set intervals, which provides both a real-time view of the occupancy of the sites, but also reduces the risk of data loss if the devices are damaged or stolen. The device measures the number of new passes from the sensor, temperature and instantaneous position - thanks to a microcomputer inside the

device, this data can be further calibrated or processed directly by the device. For example, the number of new movements and their total can be sent and the number of necessary operations can be optimised in the statistics processing itself.

For maximum versatility, Google sheets are used, which add another level of versatility with their high compatibility and ease of use. In addition to the map display, the data is also used in Google Looker studio, which generates tailored charts and reports with the possibility of filtering by date and time, device groups, etc.

## Results

In the first phase, 15 devices were installed in the Tatra Park in July 2021. Some installations were made on official hiking trails, others in the deep forest to monitor the frequency of use of unofficial paths and shortcuts. Several devices were also installed on cycle paths to monitor the frequency of their use at different times of the day and according to the season.

Tab. 1: General overview of most important figures

<b>15</b> installed devices in the first phase (2021)	<b>10</b> in the second phase (2023)	<b>+1.5M</b> data points sent by telemetry during 2 years	<b>60.000</b> number of people counted in single month on most frequent place
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- The data and results are provided to other organizations and help to better plan sustainable tourism in the Tatras, with the maintenance of hiking trails, planning of new ones and nature conservation.
- Tourist information offices - can inform visitors about less or more visited places and use this data to evaluate which trips they can take.
- Nature conservation - the TANAP administration carries out a visitor count once a year at the most visited places, but this way we have a year-round overview of visitor movements
- It is a good argumentative tool in cases where there are disputes about how many people visit which places. This way it's in black and white.
- Also, in view of rising electricity prices, it is a good tool for evaluating where the municipality can switch off or regulate public lighting according to the density of visitors.
- In winter, counters are also placed on cross-country ski trails, which is important for monitoring which sections are visited, which is also related to the evaluation of the maintenance of trails for which we receive subsidies from the Ministry of Transport.



Fig. 1: Sample installation

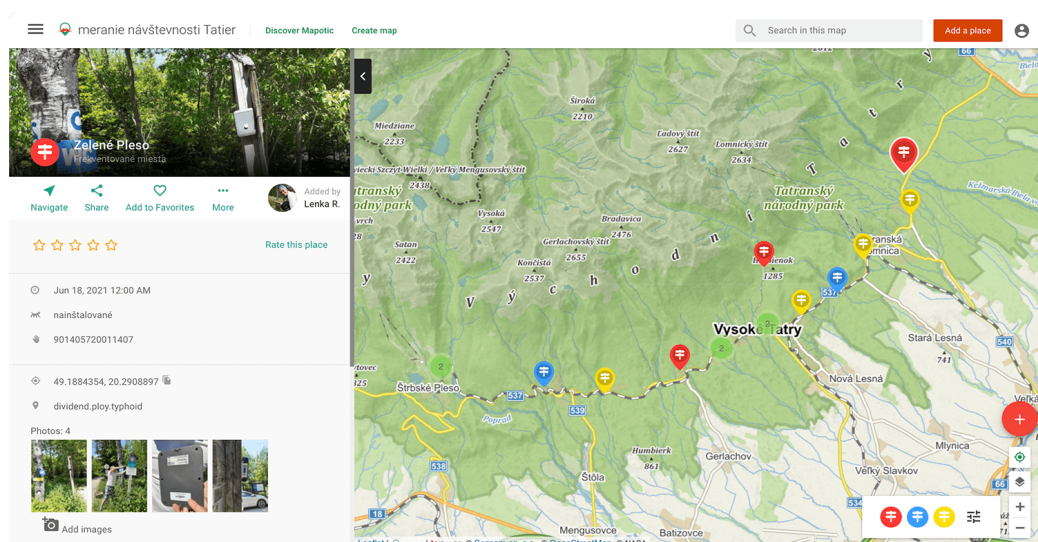


Fig. 2: Map with placements during the pilot phase

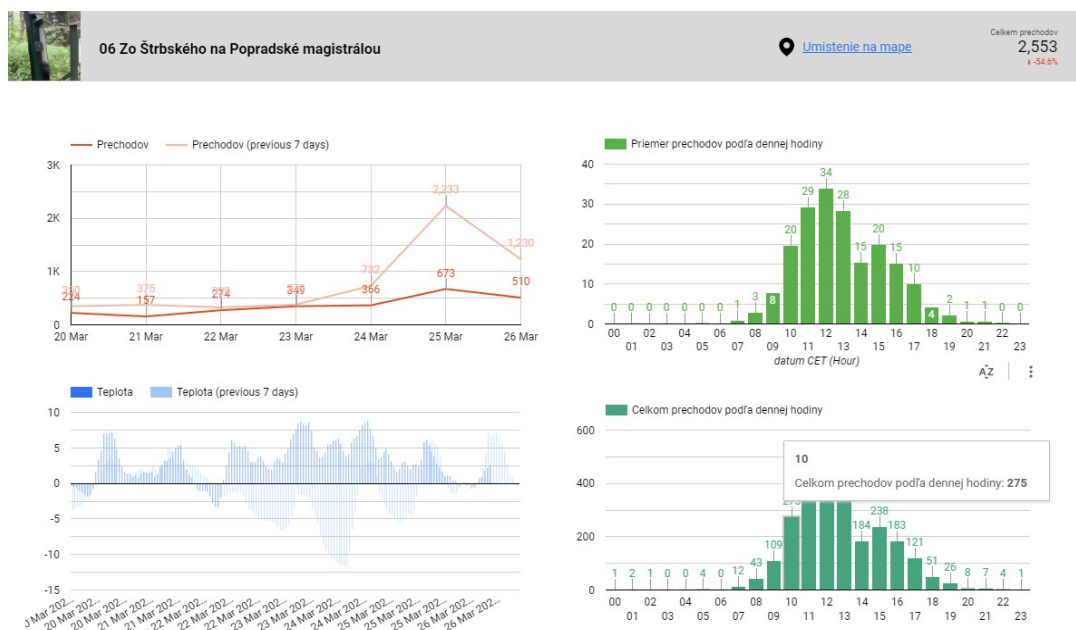


Fig. 3: Sample of report from one place

Tab. 2: Sample of data automatically collected in Google sheet middleware

1	datum (utc)	teplota	počet pohybů	přírůstek	day
29855	2023-03-25 16:10:17+00:00	8.18	48430	5	3/25/2023
29856	2023-03-25 16:40:20+00:00	7.25	48432	2	3/25/2023
29857	2023-03-25 17:10:12+00:00	5.68	48432	0	3/25/2023
29858	2023-03-25 17:40:08+00:00	5.12	48432	0	3/25/2023
29859	2023-03-25 18:10:12+00:00	5	48432	0	3/25/2023
29860	2023-03-25 18:40:13+00:00	4.75	48432	0	3/25/2023
29861	2023-03-25 19:10:15+00:00	4.12	48432	0	3/25/2023
29862	2023-03-25 19:40:17+00:00	3.5	48434	2	3/25/2023



Tab. 3: Data points aggregated in Google sheet

Date	60cc462dccb61500191d...	60cc4691ccb61500191d...	60cc4646ccb61500191d...	60c1c325ccb615001916...	60c332f2ccb61500192d...	60c3334f2ccb61500192d...	60c49d8ccb61500192b...	60c333c9ccb61500192b7...	60c333a0ccb61500192b7...
7/10/2021	299	546	1309	0	0	1049	566	0	0
7/11/2021	215	541	869	0	0	979	1472	0	507
7/12/2021	187	278	527	0	109	458	0	479	0
7/13/2021	211	457	590	0	905	609	326	2286	11
7/14/2021	196	392	736	0	459	508	418	1523	142
7/15/2021	171	477	384	0	294	446	288	810	75
7/16/2021	225	415	678	0	724	673	354	1800	67
7/17/2021	215	474	586	0	2398	1142	1196	1600	98
7/18/2021	309	427	589	0	903	638	553	1513	79
7/19/2021	205	445	597	0	314	490	425	1401	74
7/20/2021	220	488	395	0	301	468	477	1396	140
7/21/2021	200	470	1173	0	763	943	527	2304	100
7/22/2021	272	550	1045	0	642	696	528	2204	137
7/23/2021	202	505	1070	0	700	722	526	2052	153
7/24/2021	319	519	1650	0	1341	1296	945	3127	149
7/25/2021	293	553	1186	0	667	683	517	2111	67
7/26/2021	352	523	848	0	698	727	728	1983	86
7/27/2021	332	583	1104	0	936	930	1230	2350	163
7/28/2021	253	577	1158	0	996	1088	1301	2546	94
7/29/2021	304	594	905	0	753	838	540	3012	108
7/30/2021	325	566	1156	530	1240	1141	1578	2744	130
7/31/2021	181	417	401	14	265	778	399	1097	97
8/1/2021	185	394	416	33	238	687	438	815	53
8/2/2021	281	547	644	34	464	837	614	2296	115
8/3/2021	353	572	1562	88	1119	1063	587	3431	131
8/4/2021	295	566	665	92	427	725	730	1955	117
8/5/2021	160	180	225	2	149	233	339	619	258
8/6/2021	359	558	718	62	716	759	691	1636	316
8/7/2021	450	644	2121	431	1959	1864	1439	4246	340
8/8/2021	391	617	922	216	711	1058	1098	2188	160
8/9/2021	375	523	1016	73	688	856	618	2498	189
8/10/2021	302	557	1217	349	1050	1123	1051	3154	201
8/11/2021	311	536	859	91	752	1174	600	2605	170
8/12/2021	321	524	1640	136	1027	1070	613	3382	182
8/13/2021	449	609	1361	87	877	1133	639	2962	209
8/14/2021	519	604	1507	136	1077	1170	639	3094	262
8/15/2021	414	551	1441	132	1132	978	677	2917	149
8/16/2021	319	452	881	496	666	819	1037	1888	252
8/17/2021	197	454	322	19	265	431	443	979	138
8/18/2021	328	457	1302	73	914	802	457	2735	160

#### Priechody podľa zariadenia

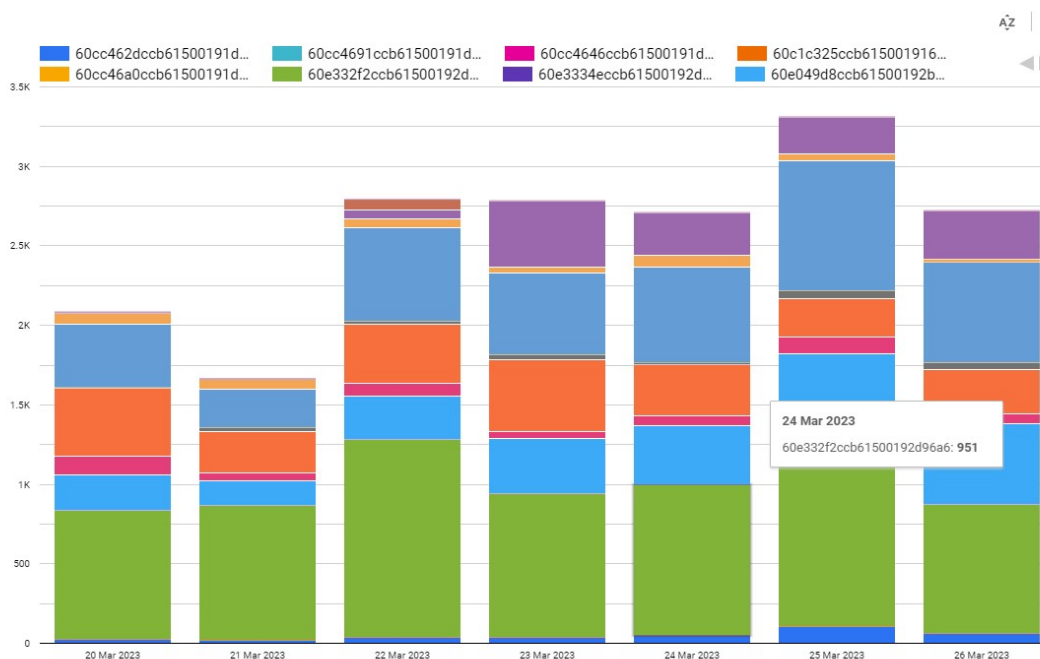


Fig. 4: Overview dashboard automatically generated by Google looker studio

## Discussion

- The price and operating costs are significantly lower than those of refurbished EcoCounter manufacturers. However, a more in-depth comparison of the total volume of functions and the accuracy of the counting itself needs to be worked out, where in basic tests we are at the level of lower or medium class but the quality of measurement under different conditions is lower than manufacturers specializing in this type of equipment for decades.
- We will continue to work on improving the device in terms of measurement technology (direction, calibration capability by location, etc.), measurement technology (infrared vs. laser, etc.).

- With reputable long-standing suppliers we want to improve the process of installation and placement of the equipment in the field, as well as the operation and maintenance of the equipment - e.g. reset or adjustment when changing location, etc.

## Conclusion

Looking back on the project, we can say that the concept of Hardwario's innovative Chester hardware combined with Mapotic's data processing and visualization has been proven to work. It thus represents an interesting and affordable alternative for monitoring and counting the movements of hikers on conventional trails and in the wild. The main advantage is the mix of acquisition and operating costs with continuously uploaded data and the longevity of the equipment.

The reports were modified several times during the project for better usability by the operator. Some complications arise from moving equipment, where it is advisable to reset the equipment in question and create a new report to separate the historically measured data - which is not always possible due to processes and changes in personnel etc.

More information at [www.mapotic.com](http://www.mapotic.com)

## References

Hardwario, s.r.o.

Mapotic, s.r.o.

Telecom SK

Google data studio / Looker

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## Souhrn

Mapotic ve spolupráci s Hardwario vyvinul inovativní zařízení pro monitoring pohybu turistů a sledování environmentálních faktorů v přírodním prostředí. Bateriová zařízení s dlouhou životností jsou připojena k internetu a umožňují snadný a rychlý sběr včetně umístění v horách a během extrémních klimatických podmínek. Zařízení poskytují data téměř v reálném čase a jsou snadno integrovatelná do různých projektů, kde je potřeba získávat údaje o návštěvnosti či environmentálních datech z přírodních lokalit a možnost efektivně řídit turistiku v dané oblasti, plánovat rozvoj turistických stezek a celkově pomáhat ochraně přírody v národním parku.

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