

## Report of evaluation of APOS RTK Services for Project „ Alpine Ski World and European Cup - Digital Gates Measurement with support of GNSS Services“

During the season 2023-24 had been implemented the pilot project „ Alpine Ski World and European Cup - Digital Gates Measurement with support of GNSS Services“.

Leading organization of project are The Slovak Sport Innovation Center under cooperation with the Department of Theoretical Geodesy and Geoinformatics, Faculty of Civil Engineering, Slovak University of Technology in Bratislava Radlinskeho 11 810 05 Bratislava and MBCD Sport Innovation entity.

The International Ski and Snowboard Federation FIS continues the digital transformation and Alpine Race Skiing Development based on digital data. The digital transformation in this respect is able to get more and new set of data and applications running of digital technology which has impact to support development and decisions in various aspects.

The Project „ Alpine Ski World and European Cup - Digital Gates Measurement with support of GNSS Services“ is focused to receive, collect, store and processed the data of Alpine Ski Racing course with respect of Course Setting as:

- course setting is one of the most important and relevant item of Alpine Ski Racing
- very high precision measurement of gates position in racing slopes during and after course setting offers multiple set of new - structured data of course setting, topology and structure of race slope to be used as follow:
- to deliver data of race course to racing teams, coaches, athletes etc.
- to deliver data for analysis, statistics, predictors and more other applications and post-processing project in order to develop and support alpine ski racing.

### **Technology:**

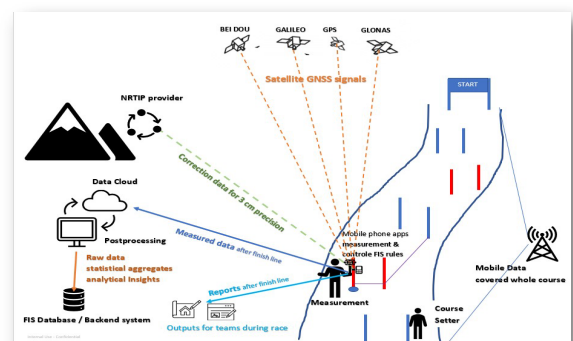
The technological solution is based on that each gate position is measured by Global Navigation Satellite System (GNSS) device with Real Time Correction system RTK, running on backbone of mobile data providers with cm precision. The geodetic coordinates of the gates as raw data are proceeded by:

#### **a. Hardware device/ unit** consists of

- GNSS receiver
- multi-band & multi- frequency GNSS antenna
- battery 12 V, 10000 mAh
- stick pole with spirit bubble
- mobile phone, OS Android

#### **b. Software application:**

- new special developed software running on OS Android



Upon the request from us to the BEV – Federal Office of Metrology and Surveying, Section Satellite Positioning with GNSS, the accounts were provided. This support from BEV significantly helped to use APOS RTK cm services for all the FIS World Cup and FIS European Cup organized in Austria in following events:

<b>WC and EC 2023/24 Digital Gates Measurement</b>						
<b>Date of race</b>	<b>Day</b>	<b>Site</b>	<b>Country</b>	<b>Discipline</b>	<b>Genger</b>	<b>Race</b>
28/10/2023	Saturday	Solden	AUT	GS	W	WC
29/10/2023	Sunday	Solden	AUT	GS	M	WC
18/11/2023	Saturday	Hochgurgl	AUT	SL	M	WC
09/12/2023	Saturday	Mayrhofen	AUT	GS	W	EC
10/12/2023	Sunday	Mayrhofen	AUT	SL	W	EC
28/12/2023	Thursday	Lienz	AUT	GS	W	WC
29/12/2023	Friday	Lienz	AUT	SL	W	WC
08/01/2024	Monday	Saalbach	AUT	SG	M	EC
09/01/2024	Tuesday	Saalbach trening	AUT	DH	M	EC
11/01/2024	Thursday	Saalbach	AUT	DH	M	EC
12/01/2024	Friday	Saalbach	AUT	DH	M	EC
12/01/2024	Friday	Zell am See	AUT	GS	W	EC
13/01/2024	Saturday	Zell am See	AUT	GS	W	EC
14/01/2024	Sunday	Zauchensee	AUT	SG	W	WC
16/01/2024	Tuesday	Flachau	AUT	SL	W	WC
16/01/2024	Tuesday	Zauchensee	AUT	SG	M	EC
17/01/2024	Wednesday	St.Anton	AUT	DH	W	EC
17/01/2024	Wednesday	Zauchensee	AUT	SG	M	EC
18/01/2024	Thursday	St.Anton	AUT	DH	W	EC
19/01/2024	Friday	Reiteralm	AUT	GS	M	EC
20/01/2024	Saturday	Reiteralm	AUT	GS	M	EC
21/01/2024	Sunday	Kitzbuhel	AUT	SL	M	WC
23/01/2024	Tuesday	Schladming	AUT	GS	M	WC
24/01/2024	Wednesday	Schladming	AUT	SL	M	WC
26/02/2024	Monday	Pass Thurn	AUT	GS	M	EC
27/02/2024	Tuesday	Pass Thurn	AUT	GS	M	EC
16/03/2024	Saturday	Sallbach - Finals	AUT	GS	M	WC
16/03/2024	Saturday	Sallbach - Finals	AUT	SL	W	WC
17/03/2024	Sunday	Sallbach - Finals	AUT	SL	M	WC
17/03/2024	Sunday	Sallbach - Finals	AUT	GS	W	WC
22/03/2024	Friday	Sallbach - Finals	AUT	SG	W	WC
22/03/2024	Friday	Sallbach - Finals	AUT	SG	M	WC

## Evaluation of Services:

The provided quality of APOS RTK cm services had been on top level and significantly support the application of mentioned project of races done in Austria Alpine Ski Races.

During the usage of services there appeared NO technical problems, services ran continuously, properly, and very satisfy.

In this respect the BEV – Federal Office of Metrology and Surveying, Section Satellite Positioning with GNSS and APOS RTK cm services significantly support and contribute to the implementation of Project.

It was approved that APOS RTK cm services are very well used and provide TOP level quality also in mountains areas, on ski slopes in different meteorological situations.

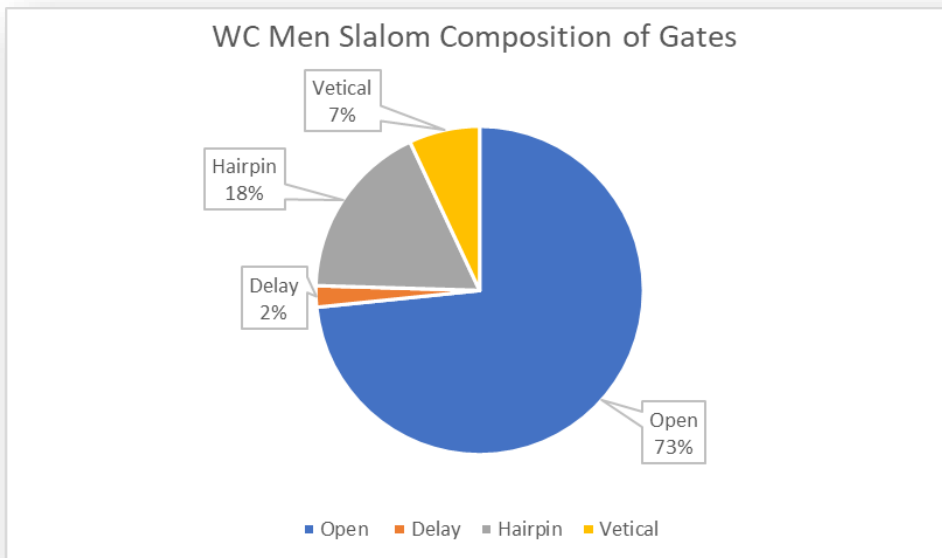
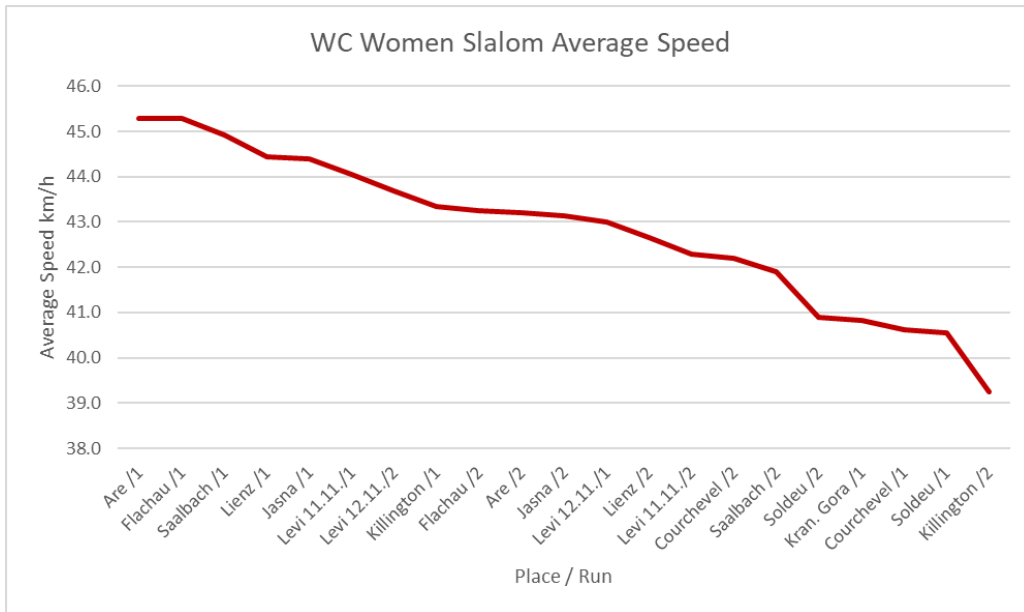
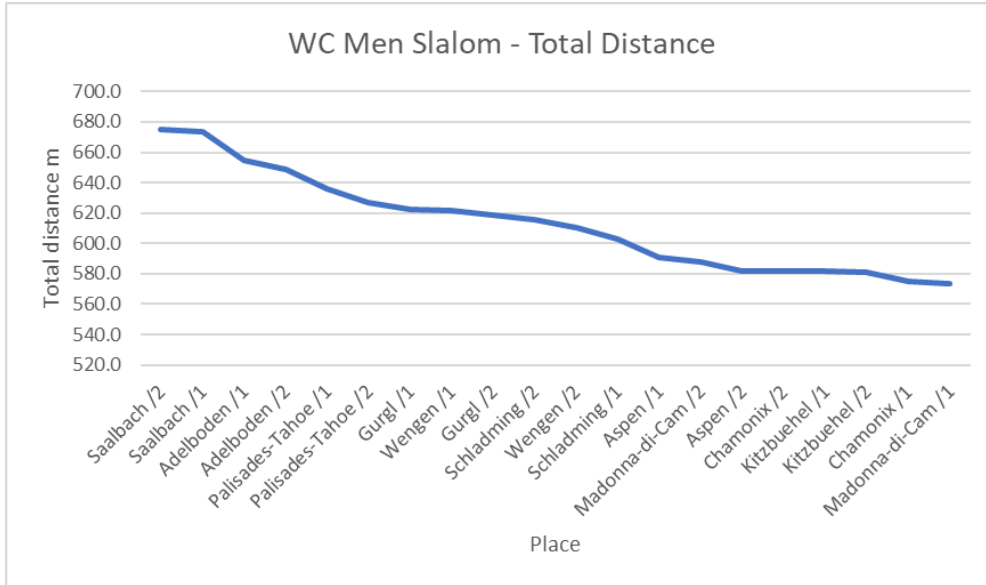
Below are some examples from Project *outputs* :

- Details of Data of World Cup course setting, which is used by FIS, coaches and athletes before races:

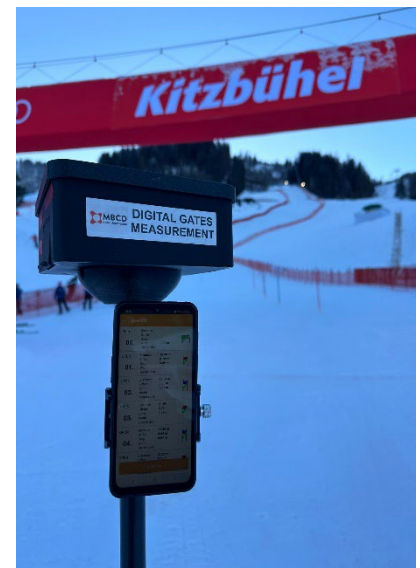
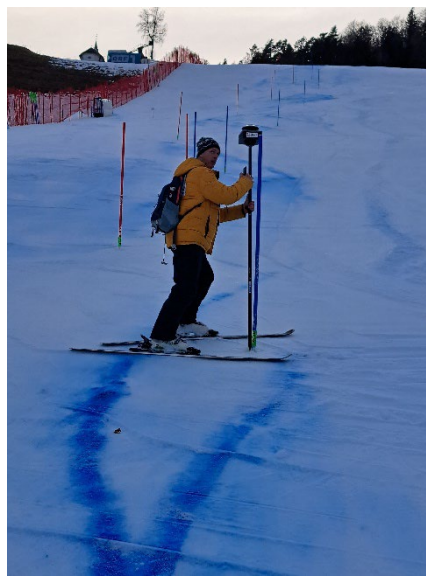
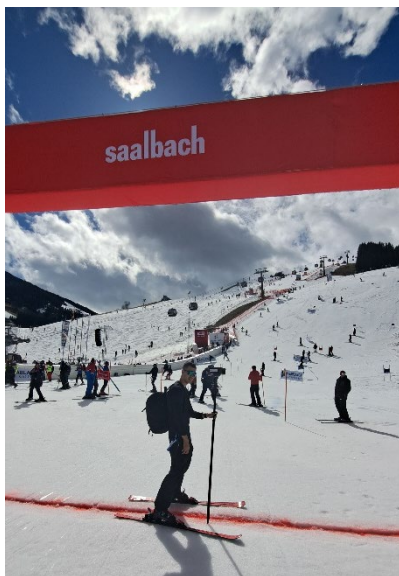
No	Type	Distance [m]	Offset [m]	Pitch [%]	Angle [°]
1	Open	15.48	1.14	44	-7
2	Open	24.21	5.44	25	26
3	Open	25.87	5.75	21	-26
4	Open	26.64	5.62	18	24
5	Open	27.55	6.84	22	-30
6	Open	26.79	6.85	22	30
7	Open	27.56	7.18	22	-31
8	Open	27.64	5.08	20	22
9	Open	25.47	4.86	14	-22
10	Open	24.81	7.83	11	40
11	Open	23.01	1.94	37	-10
12	Open	25.43	11.75	28	56
13	Open	26.93	6.82	28	-31
14	Open	25.79	9.31	26	43
15	Open	26.47	7.92	27	-37
16	Open	25.70	9.29	31	43
17	Open	27.49	10.63	31	-52
18	Open	25.31	9.07	43	47
19	Open	25.60	8.48	44	-45
20	Open	23.58	9.46	44	50
21	Open	26.39	9.20	43	-45
22	Open	26.50	9.40	43	46
23	Open	26.35	8.90	43	-44
24	Open	25.48	8.26	41	42
25	Open	26.27	7.72	46	-40
26	Open	24.31	7.26	40	38
27	Open	26.37	7.73	51	-40
28	Open	25.06	9.09	45	49
29	Open	25.41	8.29	51	-43
30	Open	26.22	7.47	42	37
31	Open	26.16	7.30	42	-35
32	Open	26.89	8.27	34	39
33	Open	26.22	6.71	41	-32
34	Open	26.13	7.42	36	35
35	Open	26.49	6.41	34	-29
36	Open	27.00	6.02	26	28
37	Open	25.39	5.06	26	-24
38	Open	25.71	5.33	22	25
39	Open	24.55	2.33	21	-19
40	Delayed	10.12	1.02	20	-8
41	Open	24.75	4.18	17	16
42	Open	28.85	4.39	24	-20
43	Open	24.29	3.44	13	16
44	Open	26.18	4.71	14	-21
45	Open	27.05	2.16	9	9
46	Open	26.74	4.45	10	-20
47	Open	24.91	1.93	10	9
48	Open	22.70	1.97	12	-10
49	Open	22.09	0.11	11	11
Finish	Finish	8.24		9	



b. Examples from Analytical Outputs done on measured data.



Within the Alpine Ski races in Austria one of the most important was the World Cup Finals in Saalbach on March 2024, there **APOS RTK cm services were run very well in all ski course**. It is so important as Saalbach will host the Alpine World Cup Championships 2025.



We do present many thanks for prompt and very positive client approach done the BEV – Federal Office of Metrology and Surveying, Section Satellite Positioning with GNSS and APOS persons and staff. We are giving the rights to use above mentioned text incl. foto for any kind of BEV PR and media communication.

Finally, we do present great respect of the BEV – Federal Office of Metrology and Surveying, Section Satellite Positioning with GNSS and APOS services and support Project there the GNSS are well applied in real applications and usage in sport events, sport development, athletes' improvement and injury prevention.

Hoping that our cooperation will have a force to continue in next Alpine ski season in Austria.

Many thanks and best regards

Juraj Papco

A handwritten signature in blue ink, appearing to read 'Juraj' followed by a stylized initial.