Interactive 3D skimap for the Skiwelt resort

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Abstract

Nearly all skiing areas and resorts have a skimap available on their website which helps getting an overview of the resort and how to get to a certain location. While this works fine for smaller areas like (insert small ski area) it can get confusing quickly for bigger resorts which extend over multiple mountains, as the map can only be viewed from one perspective. This project is about the creation of an interactive 3D map for the SkiWelt resort which can be viewed on a browser, where the perspective can be changed to the users liking. The main use case of this project is to have a less confusing way to navigate while skiing and displaying useful information in form of pop ups etc., which could be a way to attract more tourists and increase safety in the area as less people get lost outside the official slopes. A Digital elevation model which covers the entire area is clipped accordingly in a GIS program. This DEM is the base for the 3D map and is used as elevation data for additional height information on the slopes and lifts. A 2D basemap is available in form of an orthographic image of February 2023 and a basemap from ArcGIS online, the preferred can be chosen. This basemap sits below all other information. With tools like ArcGIS scene viewer and the ArcGIS Experience Builder, the model is made interactive and includes useful information like names of skilifts, locations of restaurants and toilets or height profiles of slopes. As the results are made for browsers, they can be accessed with multiple devices, making it interoperable. The stakeholders for this project are people that like to go skiing and people managing the ski resorts. This project is also interesting for other applications where interactive maps could be used, e.g., a hiking and biking application for a certain area.

1 Introduction

Skiing is one of the most popular things to do during winter, especially in Austria. Steiger and Scott (2020) state that Austria has the third largest ski market in the world (behind the US and France) with annual sale volumes of about €1,3 billion. Furthermore, 125900 jobs are made possible through the skiing industry, that is about 2,8% of all people working in Austria (Statistik Austria; (statistik.at), WKO (2022)). Regarding the huge popularity and importance of ski resorts, it is very surprising to not find a lot more tools for navigating through such a resort, then just basic 2D maps. Especially when looking at the technological advances and possibilities we have now, the current way of navigating in a skiing area seem kind of outdated.

2D maps work fine for smaller skiing areas, like the Zinkenlifte in Hallein/Dürrenberg or the Hochalmbahnen – Raurisertal, which extend over only one mountain side and just have a few lifts and slopes. However, when skiing areas are bigger, have a lot of lifts and stretch over multiple mountains, it gets confusing quickly as it is a lot harder to orientate. With a 2.5D

view from one angle, thus no change of perspective, the real scale of objects gets lost. Lifts that seem very short on the map, could take ages to ride, or a seemingly shallow slope could make a huge challenge for the skier when the slope suddenly is not so flat anymore. Another problem of the popular 2D maps is the lack of interactivity. While most skiing areas offer a webmap with some kind of interactivity on their website, they are often not optimized for smartphone usage. From own personal experiences, when being on site, only paper maps are offered. Even when apps are existing, they are not often promoted when buying a ski pass or anywhere else when entering the skiing area. This “market gap”, made the base idea for this project: Creating interactive 3D maps for skiing areas, where viewing perspectives can be changed, and useful information can be gathered in form of pop-ups. The project *SkiMap*, not only is applicable for skiing but also for other outdoor activities with elevation changes like hiking, mountain-biking etc. as the methodology is very similar.

With this manuscript, the creation of interactive 3D maps using easily accessible methods is explained. The methods are applied at the example of the SkiWelt resort where navigating with paper maps can be, from own experience, overwhelming and confusing when visiting for the first time. The aim of the *SkiMap* project is, to set up an interactive 3D map which should increase the experience of skiing in big resorts, with a smaller likelihood to get lost. In the long run, this could increase safety (less rescue operations) and attract more tourists.

2 Materials and Methods

2.1 The SkiWelt resort

The SkiWelt is in Tirol near Kufstein in the Brixen-valley. It is one of Austria’s largest interconnected skiing areas, with 90 lifts, 284km of slopes, connecting 8 villages with each other. Due to its immense size and its close location to the highway (making it easily accessible from big cities like Munich, Innsbruck, or Salzburg) it is a very popular area, especially for day-tourists. Being easy reachable by train is another big plus. The size of the skiing area and its popularity, makes it the perfect study area for this project, as a great amount of people benefit from having a more usable product to navigate through the resort. As mentioned briefly in the introduction, the existing 2D skimap (see figure 1) is quite complex and can be very confusing, so an alternative solution is needed.

Figure 1. 2D Skimap of the SkiWelt resort; small and confusing (image from bergfex.at)

2.2 Data Acquisition and Preparation

For the creation of the 3D map, data had to be acquired and prepared. The data needed is very similar to the data that is needed when making a map in 2D, with the addition of a digital elevation model (DEM) for the elevation data. Just like in a normal 2D skiing map, the most important features are the ski lifts and the skiing slopes. While ski lifts can be found easy, slopes are often only sparsely displayed and available on the commonly known mapping websites (Google Maps, OpenStreetMap, etc.). Furthermore, a “normal” skimap mostly includes restaurants and toilets. Next to features that are overlayed and can be turned off or on in the resulting 3D map, a basemap for orientation is needed. The following chapters describe the information and the preparation of the needed data. Figure 2 shows an overview of the workflow from data acquisition to the finished map.

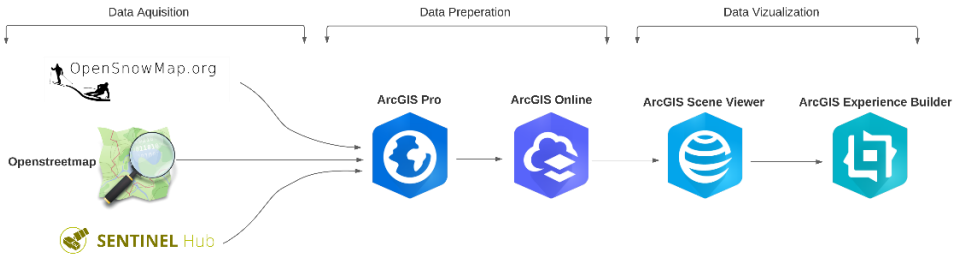

Figure 2. Workflow of *SkiMap*

2.2.1 Digital Elevation Model

A 5m digital terrain model (DTM) of Tirol was downloaded from data.gv.at and clipped accordingly to the study area. The DTM is needed to calculate additional surface information for lifts and slopes. It can also be used as elevation data for the 3D model.

2.2.2 Orthophoto

The basemap for the map is displayed beneath all layers. As creating a winter themed basemap would either take very long (manual) or would not look good, I decided to use an orthographic image taken during the winter. The orthophoto finally used is from sentinel 2 with 10m spatial resolution. It was downloaded from the sentinel hub. The data is from 12. February 2023, a day where high snow coverage was given, and the sky was cloudless. The image was clipped to the study area accordingly.

2.2.3 Slopes and Skilifts

The original idea was to manually map the slopes and skilifts using common maps and satellite imagery, as downloadable data was hard to find. Luckily, opensnowmap.org exists, a website where 2D skiing maps with line and polygon features can be found. The data there, is stored in the openstreetmap database and thus could be downloaded as OSM format. This is opened with QGIS and the wished features (in this case line features) exported to a feature class. As the further methods required to use ESRI products, further preparation of the data happened in ArcGIS Pro. As the data downloaded from opensnowmap.org contained data from the entire world, the data was clipped to the study area. A snippet of the data can be seen in figure 3. Here the unedited features are seen in the attribute table of ArcGIS Pro.

	fid *	geom *	osm_id	name	highway	waterway	aerialway	barrier	man_made	z_order	other_tags
334	334	Polyline	327269964	KÃ¤lberalm SÃ¼dabfa...	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
335	335	Polyline	329572590	31	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
336	336	Polyline	329573972	Kraftalm - Kasbichl a	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
337	337	Polyline	329576754	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
338	338	Polyline	329576755	Kraftalm - Kasbichl b	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
339	339	Polyline	329578560	31	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
340	340	Polyline	329582779	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
341	341	Polyline	329582784	Hohe Salve - Rigi	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
342	342	Polyline	329582785	LÃ¤rchenhang	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
343	343	Polyline	329586503	Ã¤bungswiese Schne...	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...
344	344	Polyline	329586504	Familienabfahrt	<Null>	<Null>	<Null>	<Null>	<Null>	0	"lit"=>"no","oneway"=...

Figure 3. Unedited features, downloaded from opensnowmap.org

Using the *select by attributes* function, blue, red, and black slopes, as well as the skilifts were filtered and exported to separate features. Additionally, information from the *other_tags* column was copied into new columns (see figure 4).

	OBJECTID *	Shape *	osm_id	name	aerialway	z_order	other_tags	Shape_Length	Speed	Time	Z_Min	Z_Max	SLength
39	42	Polyline	31099586	Maxlift	Tellerlift	0	"ref"=>"...	545,011841	5	1,626836	790,654215	836,841714	546,650696
40	43	Polyline	47659786	Knolln	Tellerlift	0	"ref"=>"...	520,126808	5	1,738306	708,158939	738,115031	521,491819
41	44	Polyline	47679129	Schernthannbahn	Sesselbahn	0	"aerialwa...	1851,110765	5	6,366115	1143,511769	1536,44636	1909,834415
42	45	Polyline	47679132	Hans im Glück	Gondelbahn	0	"aerialwa...	601,900083	5	2,050392	1097,067645	1204,893566	615,117685
43	46	Polyline	47679137	Rinner	Sesselbahn	0	"aerialwa...	785,41087	3	4,486659	1098,721783	1247,797506	807,598645
44	47	Polyline	48389470	4EUB Brandstadl	Gondelbahn	0	"aerialwa...	4556,964285	5	15,942378	678,929403	1642,714849	4782,713512
45	48	Polyline	48390126	Schmiedalm	Schlepplift	0	"ref"=>"...	1937,03853	3,5	9,450314	951,889362	1323,338299	1984,565972
46	49	Polyline	48390127	Ellmi´s 6er	Sesselbahn	0	"aerialwa...	1796,471834	5	6,115375	1216,2376	1522,587971	1834,612569
47	50	Polyline	50592416	Hohe Salve I	Sesselbahn	0	"aerialwa...	1527,484898	3	8,845841	1156,411647	1529,653831	1592,251331
48	51	Polyline	50593052	Brandstadl II	Gondelbahn	0	"aerialwa...	1517,755134	5	5,333416	1234,160003	1642,196477	1600,024756
49	52	Polyline	53553814	Ostlift	Schlepplift	0	"ref"=>"...	448,704173	3,5	2,153951	1555,489456	1593,17793	452,329813

Figure 4. Finished dataset containing all skilifts in the skiwelt

Also seen in figure 3 are the columns like *Z_Min* or *Time*. These were calculated using the field calculator and the *add Z information* function, that uses the DEM to add surface information. The speed of the lifts is generalized and only varies depending on being a fixed or detachable skilift. For skiing an average speed of 25km/h was chosen.

2.2.4 Restaurants and Toilets

Similar to the slopes and skilifts, no official data is available in a form that can be easily spatially enabled. Again, user created data from openstreetmap was the best solution. Using overpass turbo, a website designed to download custom OSM data, restaurants and toilets were filtered by using the *wizard* (see figure 5) and downloaded. Figure 5 shows the query to filter the toilets. Here a map extend could be chosen before downloading the data.

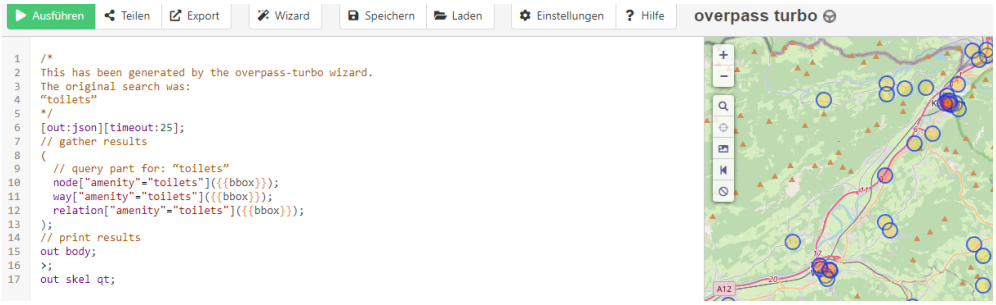

Figure 5. Overpass turbo, query to download specific features.

The downloaded data is opened with QGIS and exported to a reusable file format and further processed in ArcGIS Pro

2.3 Routing in ArcGIS Pro

One of the things that is still missing for skiing is a routing service, just like we are used to with other transportation modes with Google Maps. Even for more specific activities like hiking or cycling, several applications like Komoot are existing. It is surprising that there are no real products which take routing to skiing areas as it would make navigating a lot easier. This is one of the features that would make a 3D skimap even more usable, so I tried to implement it, using the ESRI solution.

In ArcGIS Pro it is possible to create a routing network with custom rules. For skiing for example, the slopes should act as one way "streets", while it is also possible to ride some lifts in the opposite direction. After storing all features in a feature dataset, it is possible to build a network, define the custom rules and do various types of analysis. Whilst it is sadly not possible to take this network dataset to the online world of ESRI and do custom routing in the apps, routes can be calculated in ArcGIS Pro and published online. With this limitation in mind, I created a recommended skiing route, using the custom network, which covers all valley stations in the skiwelt. Of course, this is not a solution, however it showcases the possibilities of routing for skiing purposes.

2.4 Publishing to ArcGIS Online

After preparing all datasets and creating the according metadata, they can be published to ArcGIS Online directly within ArcGIS Pro by sharing them as a web layer. This also includes the orthophoto as a tiled service and the DEM as elevation data. The rest of the data is published as features.

2.5 ArcGIS Scene Viewer

The ArcGIS Scene Viewer has been a very useful tool to create scenes in 3D, in case of this project, the map in 3D. Like the Map Viewer, it is possible to load own layers as well as the living atlas or similar. It is a bit restricted in some ways, as not everything can be loaded in and there are no analysis functions available (e.g., routing not possible). For the 3D data the already available terrain from ESRI was used, as its detailed enough (especially regarding the spatial resolution of the basemap). In the scene viewer all the visualization settings of the map are set, the styling of the layers, labeling and pop-up configurations. This works very similar to the Map Viewer in ArcGIS Online, however a little bit restricted in terms of labeling. Labeling only works for point layers, so extra work in ArcGIS Pro was required to label other types too. Here, copies of the line features were made and converted to point data, which then after publishing could be labeled as well, while having no style (which makes them invisible in the map).

2.6 Webpage design

2.6.1 Experience Builder

After finishing the configuration in ArcGIS Scene Viewer, the map is presented on a website. There are various options within the ESRI environment to build a page, or one could design a webpage and just embed the scene there. With project SkiMap the ArcGIS Experience Builder is used, as its GUI and templates allow a quick build with additional functionality, like displaying height profiles from features. All kinds of Webpage elements and those centered towards maps, can be chosen, and dragged to the desired place (see figure 6).

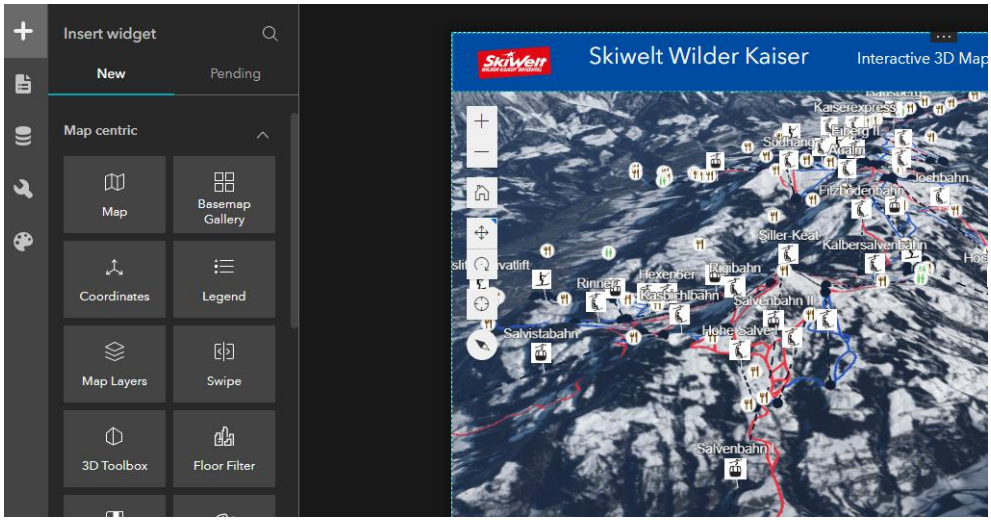

Figure 6. Widget options in the experience builder

2.6.2 ArcGIS Maps SDK for JavaScript

Another option for developing a 3D map from ESRI, is the ArcGIS Maps SDK for JavaScript. Like other JavaScript libraries, it can enable functions and tools for the website. It is designed to embed content from ArcGIS Online or Enterprise, while still allowing a completely custom website interface. Some key features are animation of features, interactive 3D mapping or data-driven visualization (arcgis.com). For people with lots of coding experience, this is a very good option, for showcase purposes or for a quick set up, the experience builder is fine too.

3 Results

Figure 7 shows a screenshot of the finished webmap. When launching the website for the first time, a window with information on how to use the site is displayed.

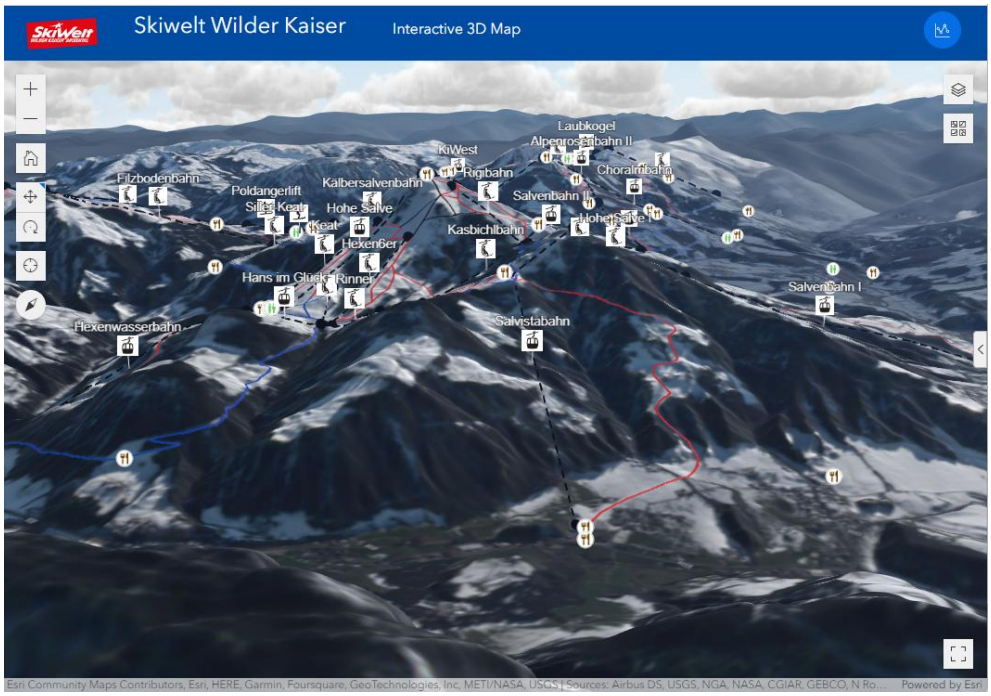

Figure 7. Final interactive 3D map (link to website)

As you can see, from launch on skilifts, slopes, restaurants and toilets are displayed. The skiing lifts are labeled with custom images as icons. The layer item on the top right, allows enabling and disabling layers. The arrow on the right opens a sidebar with additional information of the skiing area and how to use the website.

It is possible to click on all elements on the map, which will display pop-ups giving additional information like slope length or time needed (for skiing an average speed of 25km/h is used to calculate the time). When clicking on the icon in the banner on the right, elevation profiles can be displayed. Either one of the line features can be selected, or a custom profile can be drawn. Figure 8 shows the visualization of the height profile and the pop-up of a slope.

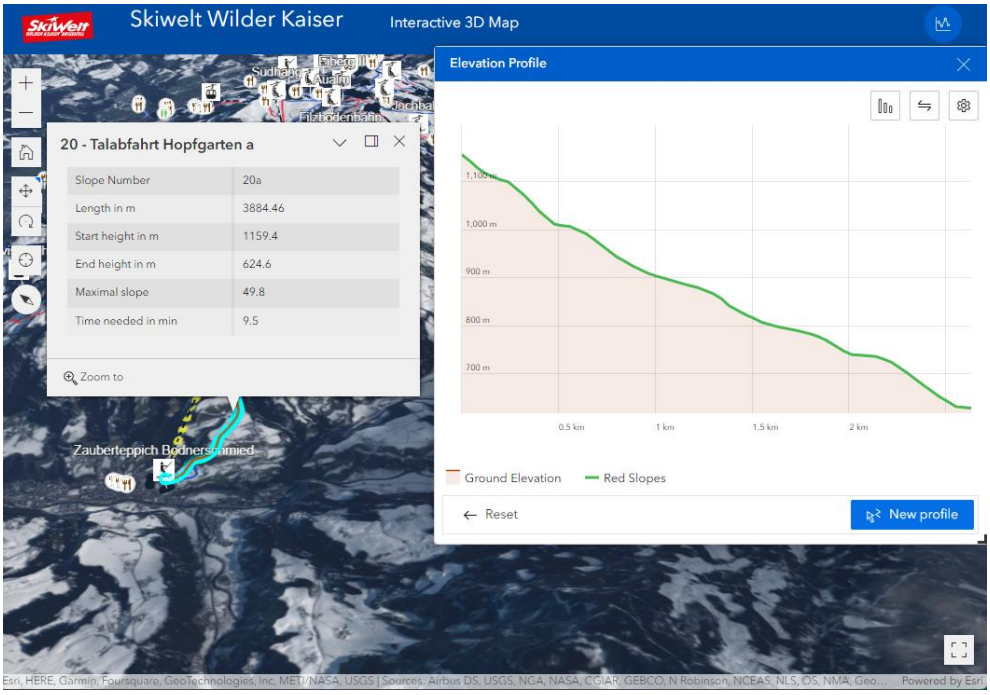

Figure 8. Pop-ups and height profiles also can be displayed in the webmap

When launching the map on the smartphone, the current location also can be displayed, making it easier to navigate around the resort.

4 Discussion

Looking at the aim of this project, to make navigation in a big skiing area easier and increase the experience for skiers, I would generally say that this aim is fulfilled. With the possibilities of shifting and changing the perspective as you like and by bringing in useful information, the skimap already is less confusing than a classic paper map. The tools from ESRI allow for a not to difficult way of creating 3D maps, that can also be used for different purposes like hiking or mountain-biking. One of the features that is missing and was originally planned to be integrated is the possibility to navigate to different locations on the map. Whilst in theory everything is set up for this to work, it is not yet possible to do this with the methods used for this project. With this working, the experience would be even better.

When coming up with this project idea, I originally had an entirely different plan on how to get to the finished product. With my original idea, the terrain and features would have been prepared in a 3D modeling software and then exported to a game engine like unity. There features like routing and interactivity would have been enabled. While I am convinced that this method would work fine and maybe even lead to a better product, due to my inexperience with game engines, it would have taken a lot more time to finish. Additionally, it has to be said that I did not find very much information on different approaches in other scientific papers, although there might be different methods that make more sense.

5 Conclusion

In conclusion, I showed a way to create a useful skiing map that also can be used on different devices, compared to the classical 2D skimaps which are somewhat outdated. While there are some features missing and the final product is not perfect, the main aim of the project was fulfilled.

6 Outlook

Next to obvious possible feature goals like implementing a routing service or having a better basemap, creating a similar 3D map using open-source solutions would be ideal. The method would be available to more people, leading to a faster development in this sector. With an ideal solution running, additional features like live status of lifts and slopes, capacity status and estimation with dynamic routing could be implemented.

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