CO-043

IS PANORAMIC PRACTICAL? EVALUATING A SCHEMATIC APPROACH TO MAPPING SKI RESORT TRAILS

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ABSTRACT

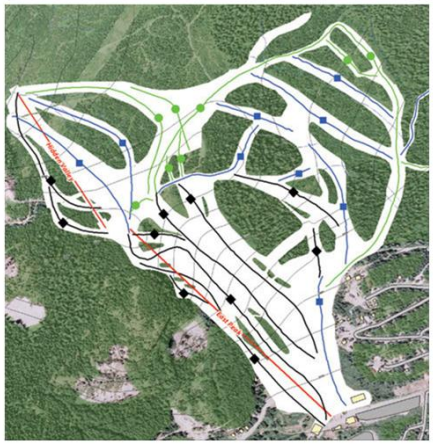
In mapping ski resorts, there are generally three alternative approaches: panoramic, planimetric and profile with panoramas being by far the most common. However, using panoramic maps for navigating on mountain is not always easy since conditions, map perspective, orientation and the illustrative form often make reading the map awkward. In this paper, a brief review of the panoramic style of ski resort mapping provides an appreciation of this dominant form of representation. A new map of the Breckenridge Ski resort has then been designed based on a schematic form of representation. The traditional trail map is re-engineered to reduce the mountain and its trails to topological primitives for the primary purpose of navigation. Built using ArcGIS, ArcGIS Network Analyst and the Schematics extension, the new map illustrates the 176 trails in Breckenridge presented in profile form such that they flow down the map page. User testing establishes the value of the approach but the continued preference for the panoramic style.

1. INTRODUCTION

Panoramas are an especially unique type of map which are expressly artistic. They are extremely popular for depicting mountainous areas since they create a visually stimulating version of the landscape that people can readily identify. For ski resorts and the mapping of trails they have become the de facto standard. Of the 428 resorts Tait (2008) analysed, 368 (86%) used a panoramic approach to map the mountain and if the minor resorts are discounted, all of the top 100 major resorts in North America used a panoramic style.

In mapping ski resorts, there are generally three alternative approaches: planimetric, profile, and panoramic. Planimetric maps are created in plan view and take on the depiction of a standard topographic map (Figure 1a). Profile maps tend to be a simple view of the elevation of a mountain from ground level or a low oblique view (Figure 1b). Panoramas might be described as an oblique perspective view of the mountain and contain depth of field, shadows and an artificial horizon (Figure 1c).

(a) plan



(b) profile

Figure 1a Planimetric map style, Snoqualmie (USA)
Figure 1b Profile map style, Dizin (Iran)

(c) panorama

Figure 1c Panoramic map style, Heavenly (USA)

Patterson (2000) suggests that panoramas are evocative and give skiers a sense of flying down a mountain since they can relate the experience to the panoramic depiction closely. As ski areas have become larger, so there has been a shift from simple wayfinding to panoramas used as a marketing tool (Fry, 2007). As Phillips (2007) and Niehues (2009) explain, accurate portrayal of the mountain for navigation is sometimes secondary to the requirements of marketing.

In this paper, a brief review of the panoramic style of ski resort mapping provides an appreciation of this dominant form of representation. A new map is proposed for the Breckenridge ski resort based on a schematic form of representation. Usability testing is undertaken to explore the new map's effectiveness for on-mountain navigation and to comment on its relative merits compared with the traditional panorama.

2. THE TRADITION OF PANORAMIC MAPPING OF SKI RESORTS

One of the main reasons why panoramas are useful is they are less abstract than their planimetric counterparts. As such, they might be easier as a mechanism to visualize a landscape by people with limited map reading skills. Panoramas have been largely ignored by mainstream cartography since they bear little resemblance to many of the familiar map types that are derived from ground survey and subject to cartographic design and control. Their accuracy is often relaxed in favour of artistic depiction; and they do not make use of standard visual variables and symbolisation. Patterson (2000) describes the work of Heinrich Berann (1915-1999) as possibly the most accomplished artist of the panoramic style whose work across Europe and also in North America for the National Park Service was exceptional.

Most panoramas are created through painting, illustration or by computer rendering. Painted maps remain the most common production method with 89% of the top 100 North American resorts being illustrated in this way (Tait, 2008). They generally exhibit excellent natural colouring, a realistic depth of field and a good mix of textures to accurately reflect the terrain and trees. Key to the realism is the way in which blurring and haze effects are used in the distance to focus the reader's eye on the figural mountain element which is usually exaggerated in size to emphasize it in its surroundings. Terrain is often distorted in relation to the point of view so that all elements of the mountain can be seen without recourse to insets (Niehues, 2009). and progressive projections used with the foreground appearing much steeper than the background (Jenny, 2004). The effect of the progressive projection is to make the foreground almost planimetric, the figural mountain dominant in the map view and with a background that rolls away from the viewer creating both a depth of field and an horizon.

The impetus for the research presented here stemmed from visits to Breckenridge ski resort, Colorado USA, during a period which saw a shift in the cartographic depiction of its mountain. Breckenridge, like

many other resorts, used a painted panorama as a backdrop to overprinted trail information for many years. Figure 2 illustrates the 2006/7 trail map which became the last painted panorama used by Vail Resorts (the owners of Breckenridge ski resort).

Figure 2. Official Breckenridge Trail map 2006/7

In 2007/8 Vail Resorts replaced the map with a digital version. They became the first large resort to use satellite data directly as a base image for the trail map. The new map used IKONOS 4.5m imagery draped over a Digital Elevation Model .

Figure 3 shows that, whilst attempting to be panoramic through the use of airbrushed shading the image appears more profile-like. There is no depth of field, no progressive projection and with a single point of view many parts of the mountain are now obscured and dealt with through the use of insets printed on the reverse of the map. The trail detail only occupies approximately 50% of the map image and the vertical scale implied by the new, squarer, map shape belies the truth of the relatively low profile rolling terrain.

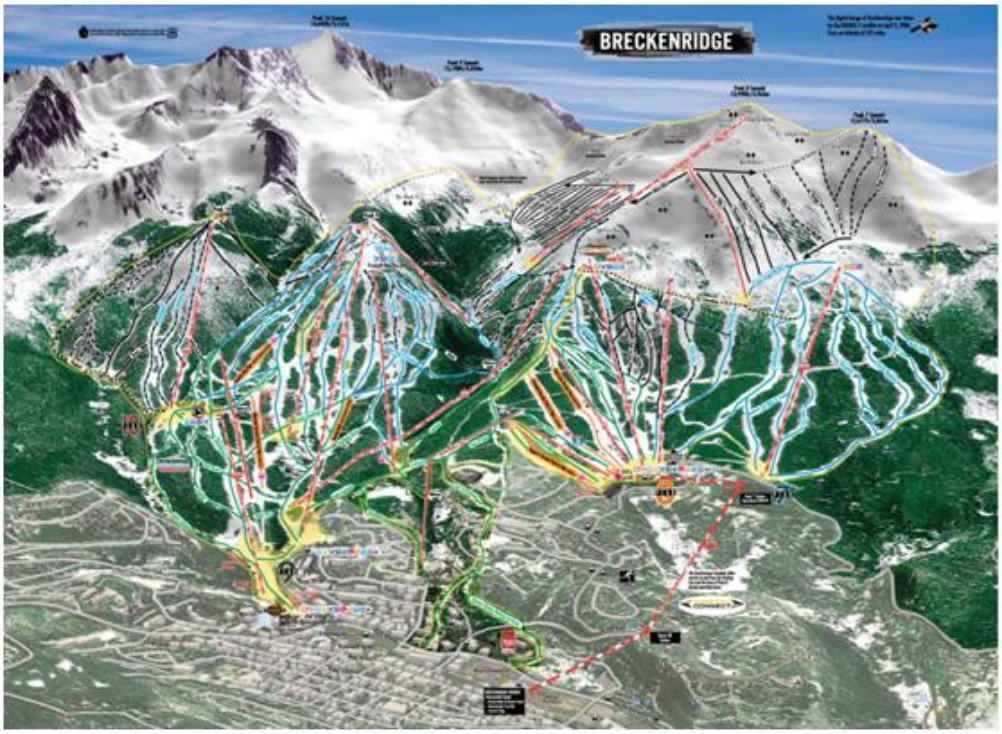


Figure 3. Official Breckenridge Trail map 2007/8

The colouring is poor with a flat white being used to represent trails that contain little variation and are often airbrushed to portray gentle, rolling terrain when in fact reality is very different. This is particularly problematic in the area above tree-line where extreme terrain in the bowls is represented invitingly. The cloudscape does not reflect the cloud types and atmospheric conditions likely, even on a clear bright day. Figure 4 illustrates some of the detailed differences between the 2006/7 painted panorama and the 2007/8

draped DEM version that can be seen when the maps are compared more closely. These are discussed in more detail in Field (2010).

The convention for panoramic mapping of ski resorts has not generally been challenged. It might be contended that panoramas are not easily navigable since the emphasis on a pictorial representation of the landscape often leaves the trail network poorly positioned in the stylized landscape.

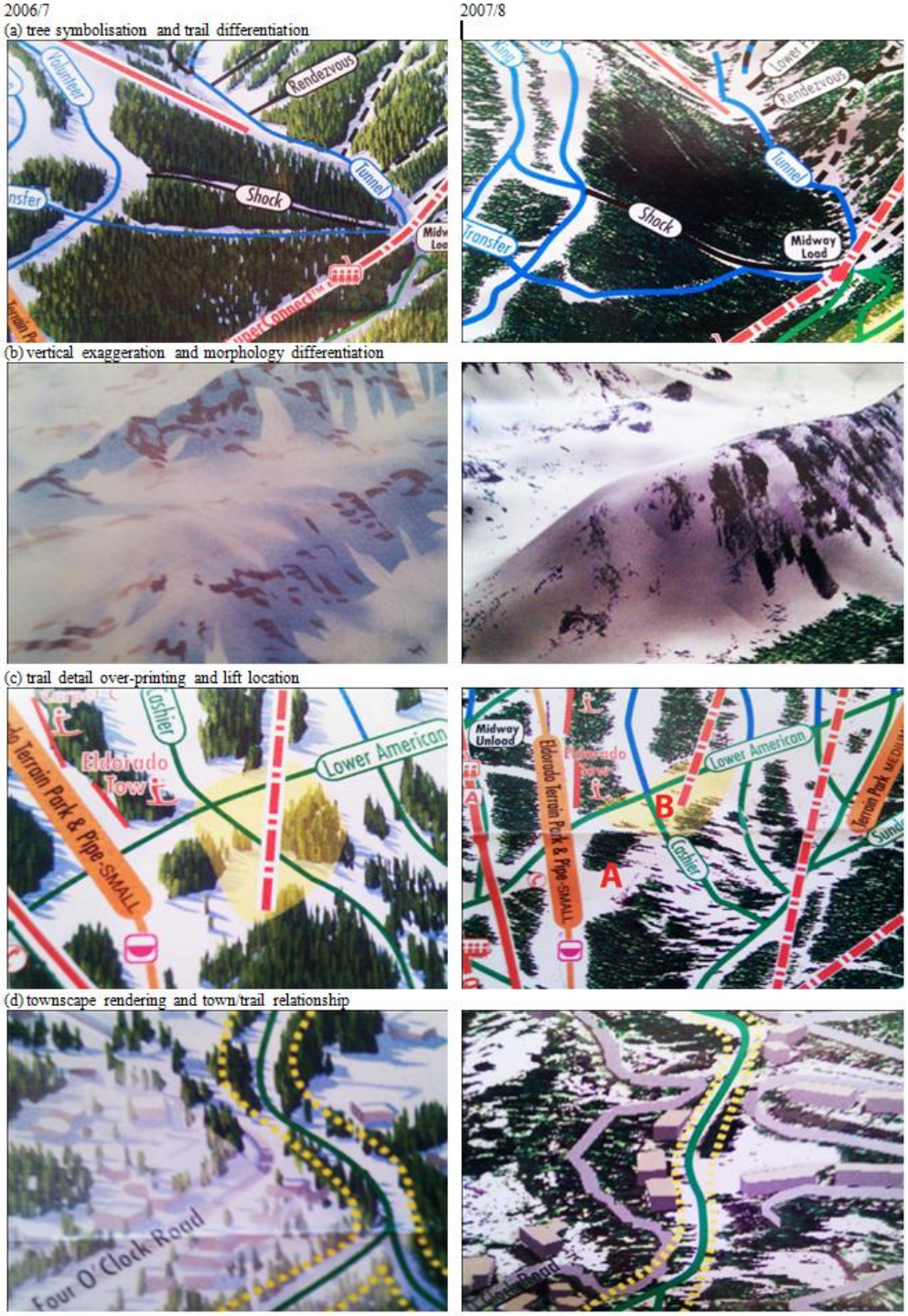


Figure 4. Comparison between 2006/7 and 2007/8 Breckenridge trail maps

Overprinting of trail information is often haphazard and does not always sit comfortably on the underlying illustration. This often leads to confusion, particularly at the start and end of trails where overprinted trail lines often end and the illustration is insufficiently clear to support navigation in the local area.

3. DEVELOPING A SCHEMATIC APPROACH TO MAPPING MOUTAIN TRAILS

The common view that a mountain landscape can be used to navigate from is very often not the case and a trail is conventionally navigated by locating the starting point (usually the top of a lift station), determining the downhill direction of travel and locating the destination (usually a base area and lift station), much like a mass transit network. Weather conditions, speed of travel and trails channelled through felled forested areas also provide little to visibly navigate from.

Users of schematic transit maps tend to have a tolerance for the style and also an acceptance of the geographical inaccuracies inherent in such a design. Bartram (1980) indicated that users were able to more effectively navigate, and with increased speed, when using schematic maps as opposed to topographic versions. The most recognizable and imitated schematic map of a transit network is that designed by Harry Beck in 1931, published in 1933, of the London Underground transit system (Garland, 1994). Beck simplified the route of the underground using only horizontal, vertical and 45 degree lines. He also exaggerated congested areas and truncated others. Beck's London Underground map is, arguably, one of the finest examples of effective (carto)graphical communication for network data and formed the basis for many other transit maps across the world. As a map style, it is identifiable, recognisable and easily understood which increases its effectiveness being based on the principle that that the network structure does not need to be the same as real route directions (Tversky and Lee, 1999).

Schematic maps like the London Underground map do, though, require the inclusion of other cartographic features (Garland, 1994, Morrison, 1996; Avelar and Hurni, 2006). Whilst the main feature of the map is reduced to a network of lines and connectors, it is still necessary to select a range of other map elements that appear on the map page to create an effective cartographic representation.

For the Breckenridge schematic map, the route data was acquired by capturing GPS tracklogs which was cleaned to remove errors and processed to create a single mean linear feature for each trail (Figure 5a).

Figure 5a GPS captured tracklog breadcrumb data for Breckenridge ski resort

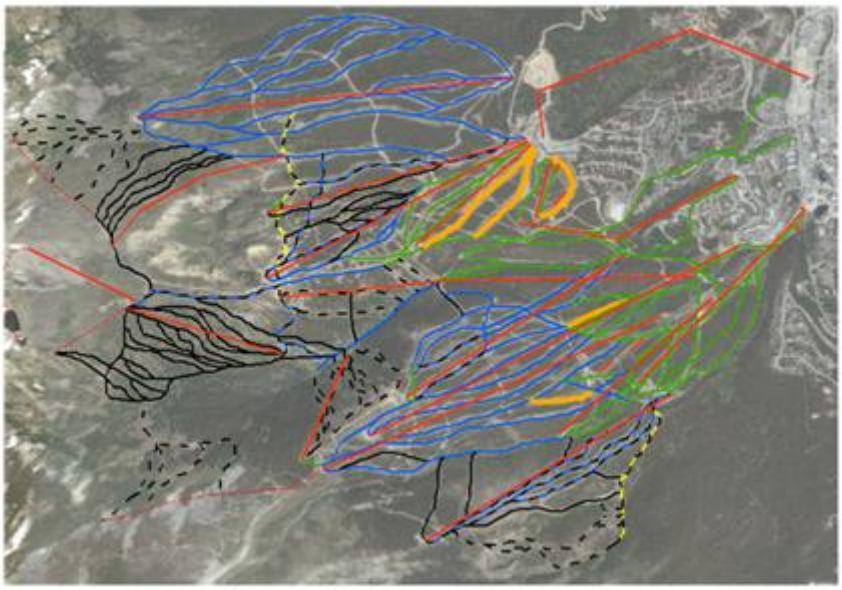


Figure 5b Mean linear features derived from tracklog data

Aerial photography was used to provide a reference for the GPS data to allow minor corrections to be applied where, for instance, GPS signal quality was poor in areas of high tree canopy. The resulting dataset is seen in Figure 5b with each trail, lift and their interconnectivity being shown in their projected topographical context with the coloured trails reflecting the difficulty classification (lifts are red, north is to the top).

On the topographical version, all distances of lines between connectors are meaningful, coordinate space is fixed and the relative position of lines and connectors is also fixed. ArcGIS® Network Analyst™ was used to define topology and create a network dataset that established correct connectivity which could then be used in the ArcGIS® Schematics™ extension to generate a geo-angled directed schematic diagram characterised by horizontal, vertical and 45 degree lines. ArcEditor™ was used to exaggerate and contract areas according to the density of route information (to design a better spread of map detail across the map) and to manually adjust linear feature class data appropriately to ensure the underlying network dataset is maintained so that flow through the network is correct (i.e. movement uphill is not permitted). Links in the schematic map are based on from-to node topology, relative position of and distance between features is meaningless and coordinate space fluctuates.

In panoramas, mountain peaks and a horizon provides a context to ensure users naturally infer direction. In contrast, schematic maps usually contain bi-directional lines and there is no ‘up’ or ‘down’. An innovative feature of the Breckenridge schematic map is that the top of the map represents the top of the mountains so the map is viewed in profile. All lifts (in red) flow vertically up the page and all trails flow down the page. Map design was performed entirely within ArcGIS® using Cartographic Representations™ and Maplex™ tools to design and apply the symbology. Figure 6 illustrates a reduced size version of the final schematic map of which a full size version can be seen in Field (2009a, see also Field, 2009b, 2010).

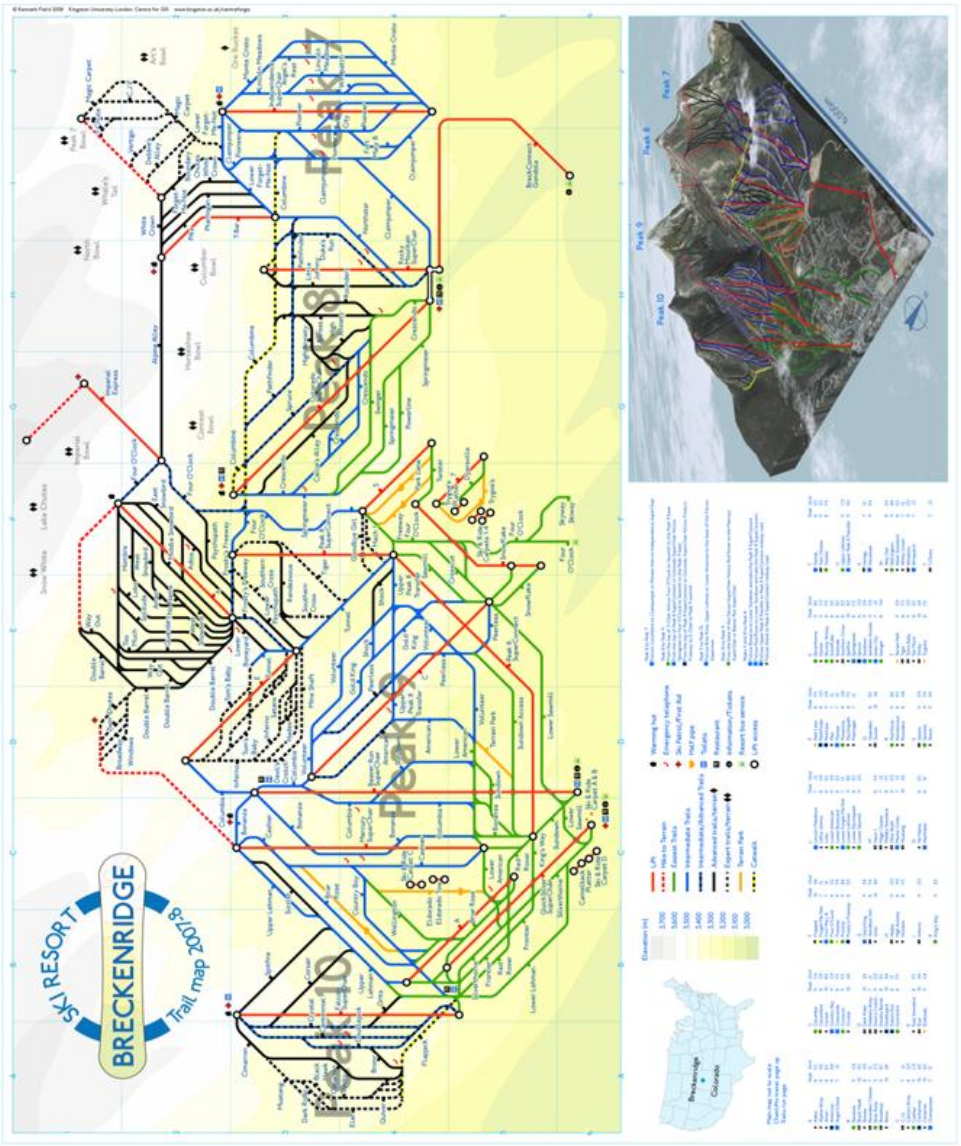


Figure 6 Breckenridge schematic trail map (25% actual size)

Line thicknesses are equal throughout to create a uniform visual hierarchy of trails. Intersections between lift stations and trails are symbolised using a symbol similar to that of station intersections on Beck's map and trail names are depicted in the same way as non-intersection stations with a small peck line perpendicular to the main line and labelled with horizontal textual information depicting the trail name. These labels are a means of clarifying to which run a horizontally-printed label is meant to apply which enables the user to treat a link in the network as a discrete feature and avoided the use of angled text which can be hard to read when orienting the map. Line colours reflect those used to denote trail difficulty on North American trail maps and align with those used to classify trails at Breckenridge ski resort. The lines used to denote lifts have been raised in visual importance through the use of an overpass symbol where they cross trail lines. This aids the user in determining that the lifts are distinct and that trails flow under the lift lines, as they do on the mountain.

A 10m USGS DEM of the region was spatially adjusted to fit the schematic map. The resulting raster dataset was converted into polygons representing elevation bands at equal intervals and symbolised. A transparency was applied to create a subtle background which gives the map a context and assists the user in visualising the flow of trails from top to bottom (i.e. from higher altitudes to lower ones).

A progressively projected panoramic block diagram of the mountainscape occupies the lower right portion of the map display providing a visual reference and support for the main map and in many ways demonstrating how a simplified, computer rendered panorama and schematic can work together to provide complimentary information. The foreground and middleground remain map-like, while the background

appears realistic, complete with a horizon. The lifts and trails have been overprinted to show the position relative to the mountain scene using the same colour symbolisation as the main map.

4. USER TESTING

The focus of user testing was to determine the general effectiveness of schematic maps as a means of representing trails and supporting navigation at ski resorts rather than a critical examination of particular design choices (though some of these emerged). Over a period of two weeks, 26 people who had not been to Breckenridge before and who were not complete skiing or snowboarding novices took part in the research. Upon arrival in resort, the schematic map was distributed to participants. For each participant, a route was created that involved 3 lift journeys and 3 descents that were within their technical ability. Routes were chosen across different parts of the mountain and the different levels of experience allowed different aspects of the map to be tested.

The navigation exercise was undertaken with the researcher present and with a GPS device to capture their tracklog. Once the navigation exercise was completed using the schematic map, participants were then provided with the panoramic map and asked to navigate a different route. The route was different to the one they had previously tackled but one that someone else had undertaken using the schematic map so there was some basis for comparison of navigation between map types. Participants were asked to vocalize their thoughts and opinions while interacting with the maps on-mountain. This allowed the researcher to record the process of them performing navigation tasks as part of the user scenario (using a helmet camera).

Post exercise, a debriefing session was held to allow participants to provide feedback on their experience of using the two maps. Table 1 illustrates the main findings of the usability testing. Most people found the schematic map provided a very good overall aid. Participants were less certain about the map's value in mapping mountain trails but through discussion it became clear that familiarity of the panoramic mapping genre was so well established and understood that any alternative would be challenging.

	Likert response				
	1	2	3	4	5
GENERAL QUESTIONS					
How do you rate the map overall for mapping the trails? (1-very poor, 5-very good)	0	1	4	4	17
Is the map style appropriate for mapping mountain trails? (1-very unsuitable, 5-very suitable)	3	5	6	7	5
To what extent is the schematic map better at supporting navigation than the panoramic map? (1-much worse, 5-much better)	5	7	3	8	3
Do you think the schematic map would be a good marketing tool (1-not at all, 5-very marketable)	0	0	5	6	15
QUESTIONS ABOUT NAVIGATION USING THE SCHEMATIC MAP					
Is the map suitable for accurate navigation? (1-very unsuitable, 5-very suitable)	0	4	5	10	7
Is the map able to rapidly provide route information? (1-not at all, 5-yes, readily)	0	2	4	14	6
Is the map logically organised so you can you easily locate the information you want? (1-not at all, 5-very logical)	0	1	9	10	6
How easy was it to locate your position on the map? (1-not at all, 5-very easy)	1	2	4	12	7
How easy was it to identify the start of a route on the map (1-not at all, 5-very easy)	0	4	7	10	5
Did you find the map intuitive to use? (1-not at all, 5-very intuitive)	2	2	10	8	4
Did you find any difficulties in using the map for navigation? (1-alot of difficulties, 5-no difficulties)	0	1	6	12	7
Did you feel the map was sufficient to make you feel safe and knowleagable on mountain? (1-not at all, 5-very sufficient)	3	5	10	4	4
Were you able to relate the map to the real world environment effectively? (1-not at all, 5-very effective)	5	10	8	2	1
QUESTIONS ABOUT THE SCHEMATIC MAP DESIGN					
Is the overall design one that you find unambiguous? (1-not at all, 5-yes, very clear)	0	3	7	8	8
Are the graphics recognisable and easily understood? (1-not at all, 5-very recognisable)	0	4	7	7	8
Was the orientation of the map on the page appropriate? (1-not at all, 5-very appropriate)	0	5	8	9	4
How did you rate the gazetteer as a way of locating trails? (1-uneccessary, 5-very useful)	0	2	4	6	14
Did you find the inclusion of a panoramic inset map useful (1-not at all, 5-very useful)	0	1	4	13	8
How do you rate the aesthetic appearance of the map? (1-very poor, 5-very good)	0	0	3	8	15

Table 1. Summary results of questionnaire analysis (number of responses)

Opinion was split as to whether the schematic map was better at supporting navigation with discussion revealing that those who used such maps for navigating transit systems found it easier to interpret than the panoramic version. Most expressed a view that the map was an accurate way of representing trail information and provided a mechanism to rapidly find route information. Map detail was reported to be logically organized and easily located and it was easy to locate your position on the map. The map made it easy to locate the start of a route, more so at the top of a lift but also where trails merged and a new trail began. Perhaps unsurprisingly, some found the map not particularly intuitive to use but again, these tended to be people unfamiliar with the style of map and who use them routinely with transit networks. The

majority of particpants reported they found no difficulties in navigating. What was noticeable when navigating from the schematic map, participants related the map to on-mountain signage more whereas those who used the panoramic map tended to try and locate features in the environment (despite the stylized rendering). This suggests that a clear link between features and the map is crucial for orientation but that it varies depending on map type.

Participants were split in terms of whether the map made them feel safe and this related specifically to their desire to be able to 'see' what part of the mountain they are on in its real setting rather than an abstract setting. For those that felt the schematic map provided a good aid to safety the dominant view was that it gave a clear way of seeing the shortest path to a base area.

In relation to the map design, the symbols and graphical treatment all received favourable comments. There was a very positive response to the aesthetic of the map and many expressed an interest in it as a novel way of viewing the trails suggesting a schematic map might have just as much commercial value for marketing purposes as a panorama. Table 2. illustrates some summary results of questions specifically exploring the comparison of the two map styles. The panoramic map is still preferred by users over the schematic alternative used in testing in general terms and also for navigation. This is ostensibly due to familiarity of the style. With a schematic, the mountain context is removed so that initial link between the trip planning and development of a spatial awareness of the resort is missing.

	Schematic	Panoramic	Neither	Both equally
Which map did you prefer using?	5	8	0	13
Which map did you prefer for navigation?	4	14	0	8
Which map style would you prefer resorts made available?	3	8	0	15

Table 2. Summary results of map comparison questions

In particular, users explained that the way in which the schematic contorts trail distance sometimes caused confusion and a more lengthy trail than might otherwise have been expected. Of course, distance is not represented accurately on panoramas either but in terms of user appeal, such cartographic truisms, the pictorial style of panoramas and, in terms of the 2007/8 Breckenridge trail map, the quality of the work seem to be of little concern. When analysing the GPS tracklog data captured and the participant observation data from the helmet-cam recordings there were a number of interesting observations. Table 3 provides summary data of the key variables for the 52 routes completed by the participants, 26 using the schematic map and 26 repeating the same routes using the panoramic map.

			Total route time (secs)		Map stops (secs)		Average route speed (m.p.s)	
	Route	Distance (m)	Schematic	Panoramic	Schematic	Panoramic	Schematic	Panoramic
Beginner	1	15,472	5870	5713	476	457	2.64	2.71
	2	14,893	5435	5340	472	445	2.74	2.79
	3	12,284	4576	4486	427	413	2.68	2.74
	4	12,032	4046	3972	434	427	2.97	3.03
	5	12,563	4458	4396	429	428	2.82	2.86
	6	13,529	4915	4795	452	446	2.75	2.82
	7	12,736	4574	4318	447	416	2.78	2.95
	8	13,984	5318	5301	458	418	2.63	2.64
Intermediate	9	13,445	3638	3497	309	297	3.70	3.84
	10	12,537	3473	3497	304	284	3.61	3.59
	11	12,269	3590	3671	307	312	3.42	3.34
	12	11,697	3165	3005	295	343	3.70	3.89
	13	12,729	3684	3572	308	308	3.46	3.56
	14	12,768	3742	3646	327	341	3.41	3.50
	15	12,483	3572	3839	364	343	3.49	3.25
	16	12,645	3327	3475	300	276	3.80	3.64
	17	12,874	3456	3213	304	284	3.73	4.01
	18	12,326	3444	3405	298	310	3.58	3.62
	19	13,767	4002	3865	336	376	3.44	3.56
Advanced	20	14,337	3157	3327	285	346	4.54	4.31
	21	13,834	3208	3412	276	315	4.31	4.05
	22	14,778	3234	3318	258	347	4.57	4.45
	23	13,243	2991	3077	278	302	4.43	4.30
	24	13,056	2635	2794	246	295	4.95	4.67
	25	14,763	3349	3502	225	284	4.41	4.22
	26	12,077	2809	2918	256	311	4.30	4.14

Table 3 Comparison of route metrics derived from GPS tracklogs and helmet-cam recordings

Distance (in metres) of each route is based on the measured distance using the network dataset created as an interim step in the creation of the schematic map. Total route time (in seconds) was calculated using the participant's GPS data. The time spent stopping to consult the map (in seconds) was calculated by reviewing the helmet-cam recordings and the average route speed was derived from the GPS data.

A beginner can be expected to travel at approximately 4.5 metres per second, at intermediate level this increases to 8 metres per second and then 12 metres per second (and higher) for advanced levels. These average speeds are much lower in this analysis due to the lack of familiarity of the resort but also because it includes the slower lift journeys and time spent map reading or stopping to gain visual cues. The average route speed (3 ascents on a lift and 3 descents on a trail) increased with skill level which is in part a function of the higher riding speed of these groups but also other characteristics. Advanced skiers and snowboarders tended to spend less time reading the map regardless of it being schematic or panoramic which had the effect of decreasing their route time. Curiously the advanced participants generally spent longer reading the panoramic map and less the schematic suggesting that, for them, a simple representation that identifies start and end of the trail and the trail name in between was sufficient. Beginners went at an increased speed and completed the trail exercise in less time when they used the panoramic map. This pattern was reversed for every route for the advanced riders whose speed was quicker and route time less when using the schematic map.

The route metrics go some way to illustrating that differences in the way in which people navigate on mountain are in part a function of the map they have available. It is also clear that a one-size-fits-all map is probably not suitable for all types of skier or snowboarder who use the mountain in different ways and for whom different navigational aids give more immediate information. There is certainly evidence that for advanced skiers and boarders at least, a schematic map provides the right type of information in an efficient form to support their mountain enjoyment.

5. CONCLUSIONS

The Breckenridge schematic map is an innovative and, perhaps, provocative, attempt to challenge the de facto panoramic method of representing trail networks for winter sports. The map displays in profile all trails on a single, uniform image without the need for insets.

User testing of the schematic Breckenridge map showed that it performed well in supporting on-mountain navigation, particularly for advanced skiers and snowboarders. However, the artistic representation of a mountainscape provided by a panorama retains an established familiarity amongst skiers and snowboarders which they would be reluctant to lose and for beginners, provides an important visual guide to familiarize themselves with their topographical surroundings.

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