The difficulty of orienteering

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When preparing an orienteering event, it is of utmost importance to take into account the difficulty. An orienteering event usually consists of several courses of varying difficulty. There may be young participants, adult beginners, adult experts, aged adults, each group demanding its own difficulty level. In addition, there is usually a variation of difficulty within any one course to make it more interesting: some legs are easy and permit fast running, other legs are difficult and demand careful map reading or slow running because of the terrain. (The term “leg” is used to indicate the parts of an orienteering course between two controls.)

Several categories exist, usually in a range of 1 to 6. In this article no attempt has been made to develop a category system, we will just look at difficulty aspects as variables, and varying the difficulty upward or downward so it is appropriate for each category. Also, we can change the difficulty mix: if the terrain is very more complicated or visibility is low because of vegetation, we may reduce other demanding aspects, for example, we can reduce the distance of controls from paths.

This article is directed at course setters. To explain in more detail the ideas set out in this article, various simplifications have been introduced.
1. Sometimes the map is changed in order to explain the idea; in practice we can´t change the map, we would have to vary difficulty by locating other controls.

2. Variables are looked at in isolation, that is, the “other things being equal” approach is followed.
3. Flags can be placed anywhere independently of the availability of controls (like rocks or trees).
4. Runners come in to a control following more or less closely the red line, that is, the straight line from the previous control. In practice, though, they may come in from very different directions.

Difficulty in this context is practically identical with time for a certain person. A course that takes two hours to complete is twice as difficult as a course that takes the same person one hour. The reasons may be physical and/or they may be in the map-reading aspect.

1. A difficulty model

Like cross-country running the sport of orienteering demands physical effort, but it also demands more intellectual efforts, namely map reading and decision making.

The physical difficulty

The physical difficulty has to do with distances, height differences and the difficulty of the terrain. Distances are measured in a straight line between controls (a program like OCAD calculates the total distance automatically). Actual distances may be much longer; there can be a hidden difficulty factor here. We can adjust the OCAD-distance by adding the more or less inevitable detours:

real length = OCAD-distance + detours (in meters)

The height differences are totaled in one direction, summing all the meters going upward. To have a single-value index of physical difficulty we might combine distance and height differences (both in meters) using the formula:

equivalent length
EL= (OCAD-distance + detours) + 20 * height diff (meters)

This formula is based on the experience that vertical speed is approximately one tenth of horizontal speed. The height difference is given in one direction only and that's why 20 is used, because you go up but you have to go down as well. Downward speed may be somewhat greater than upward, top speed is reached at 5% downward slope.

We might quantify further:

The Equivalent Length in this type of Terrain ELT (in meters) is

ELT = terrain factor * ((OCAD-distance + detours) + 20 * height diff)

If a dense forest reduces your speed to 25 % of that on a road, its terrain factor would be 4. (ISOM calls those 25 % "runnability" and couples it only to forests – shades of green – but the term could be applied to any kind of terrain).

The terrain factor is determined by
a. density of vegetation
b. evenness of the ground
c. steepness of slope
d. nature of the surface: steep slope with loose stones or pine cones or a slippery loam surface; loose sand or a wet muddy surface will all slow the runner down.

The physical difficulty has not just to do with effort, everything which causes the runner to slow down is a physical difficulty. A steep slope with loose stones or snow, where the runner follows the contour lines, may slow him down and at the same time it may reduce his physical effort because he has to advance very carefully and slowly.

The time a participant would need for the ELT would be

ELT-time = ELT / speed

Where:
- ELT is expressed in meters (ELT is Equivalent Length in this type of Terrain)
- the speed of the runner in meters per minute on paths or roads for a similar distance
- ELT-time is in minutes.

Because of the differences in legs we would have to calculate this by leg, then add them all together.

ELT-time would be the time he needs to do the course without doing any map reading, that is, when the course is marked by colored tapes.

The map-reading difficulty

The map-reading difficulty can be distinguished in

a. general difficulty of the terrain
This can be a design decision, it refers to the selection of a terrain for the orienteering event. In general we will select a site that has sufficiently difficult zones and at the same time, offers

easier courses. On the other hand, once the site is elected, if the terrain is demanding, this in turn will influence the total distance and height difference that the courses will result in.

b. average difficulty of the whole course
A whole course will consist of segments of varying difficulty, some segments permitting easy map reading so the runner can focus on speed, whereas other segments require precise map reading with a corresponding decrease in speed. Indeed this variability in difficulty is a design consideration to make the whole course interesting. The spread in difficulty of course will depend on the age or proficiency category. On a 6-point scale, beginners might have segments with a difficulty of 1 to 3, with an average of 2, while experts might have segments with difficulty spreading between 3 and 6.

c. difficulty of the course segments
Can we quantify the map-reading difficulty, like we quantified the physical difficulty in the previous paragraph by taking the ELT-time? The difference between ELT-time and the real time of a runner would give an indication of the map reading difficulty, i.e. the time the runner needed to read the map. Dividing the time for map reading by the ELT-time gives us a measure that is less dependent on the length of the course (MRD is Map-Reading Difficulty):

MRD = (time – ELTtime) / ELTtime

When the time of the runner is equal to ELTtime, his MRD would be 0, when he needs twice the ELTtime, his MRD would be 1. A training event was set up in order to get a quantitative idea of the map-reading difficulty. At the end of the course the participants handed in their maps and had to return passing through the same controls. The return route had been marked with tape on one side of the trees, so that they could only see it on their way back. These markings were very easy to follow. The experiment gave a rough idea of subjective difficulty: participants needed between 11 and 76% more time when reading a map compared to the situation where they just followed the tapes.

Besides for comparing individuals, the MRD can be used to compare courses, but then we need some average for a group of runners (only valid for this group). The usual way to indicate the difficulty of a course is to specify the time of the winner, but that is very dependent on the presence or absence of a very fast participant (Silvestre, p.242). The average (or arithmetic mean) again is very dependent on the presence or absence of a very slow participant. Instead of taking the time of an individual runner it will be more significant to take the median time of a group of runners for this kind of analysis.

1	45	1	62
2	49	2	67
3	52	3	68
4	58	4	72
5	59	5	73
		6	77

Figure 1 Two results lists

For those not familiar with the concept “median” a short explanation follows.
Suppose there are 5 participants in a certain course with times in minutes (ordered) as in the first list of figure 1:

The median would be the time of the middle participant, that is 5 / 2 or 2,5, round up, gives 3. The median time of this course, for these participants, is 52 minutes. In case there is an even number of participants, (figure 1 second list) say 6, we divide by 2, gives 3, and we take the time of the 3d participant: 68. (This is a little simplification for doing it by hand: officially we would have to take the average of participant 3 and 4. Excel does it that way. That would make 70.) An ordered list of participants is an automatic byproduct of an orienteering event.

Relation between techniques and difficulty

To make a course segment difficult, popular techniques can either be made impossible to use or their application can be penalized. An example: a beginners´ technique is "running on the needle", following the straight lines between controls. If the controls are placed so that there is an impassable obstacle like a steep cliff in the straight line, participants will have to look for other methods. If there is a grove of dense vegetation on the straight line, they may traverse it but at a heavy penalty.

There is a relation between difficulty and the techniques participants can use. Young runners and beginners may not be able to use contour lines, but expert runners may use the technique "follow the contour line". A course segment that makes an angle of 45 degrees with the contour lines is more difficult because they can no longer apply the popular technique of following the contour line.

Thus, in order to know how to vary difficulty, it is necessary to know what techniques can be used by the participants. This also means that, to be a successful course setter, you will need extensive knowledge about available techniques, which is almost equivalent of saying that you have to be a reasonably successful orienteerer, successful more in your map reading than in your fast running.

2. The psychology of problem solving

Orienteering is about problem solving, and that is the principal difference with its sister sport athletics, which is just running. The difference can be quantified in the concept MRD, as described previously.

The banana problem

In a psychological experiment a monkey was shown a banana, but in between them was a fence, some 20 meters long (figure 2a). The monkey was hungry and wanted to get that banana. If both the monkey and the banana were close to the fence, the monkey had a big dilemma as to how to get at the banana. It was less of a problem for the monkey to walk around the fence and get the banana when the banana was farther from the fence (figure 2b). In the case when the banana was close, the monkey had to move away from the banana to get it. It was easier still for the monkey when both he and the banana were farther away from the fence (figure 2c, at a smaller scale).

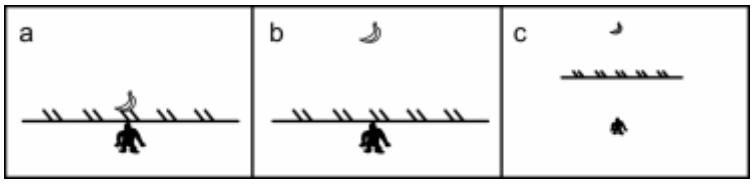

Figure 2 The banana problem

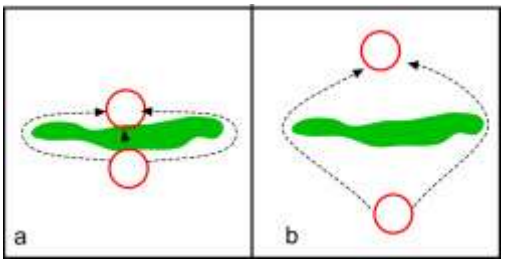

Figure 3 An orienteerer´s banana problem

We can apply this psychological principle in the design of orienteering courses. If there is a long obstacle (narrow long hill, stream with very dense vegetation) and the previous control is just before the obstacle and the next control is just on the other side of the obstacle, the runner will

experience the frustration of having to move away from the control he is going to in order to get there (figure 3a). Or, probably, he will try to move over or through the obstacle, which may cost him a lot of time and energy. It should not be immediately clear that the obstacle is impassable. The farther we move both controls away from the obstacle, the easier it will be for the runner to plan a route around the obstacle (figure 3b).

Generating neurotics

Neuroticism has to do with indecisiveness, the runner can't decide what to do. Before a dense forest, the runner can't decide whether to move through it or around it to the left or to the right, hopping from his left foot on his right and vice versa! For this to occur, we have to design a course segment where several solutions are, on first impressions, equally feasible. In general there will be three solutions:

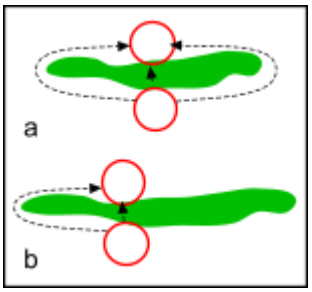

Figure 4 Two or three alternatives

1. going around to the left
2. passing through the difficult terrain
3. passing around to the right.

In general, the more alternatives there are, the more the runner will have to think and will lose time. Considered this way, figure 4a is more difficult than 4b, because it offers three alternatives, whereas 4b only offers 2 reasonable alternatives.

Difficulty will vary with the number of alternatives – more alternative routes increase decision time – and with the number and kind of attributes of each route, for example, vegetation, detours, clear intermediate reference points, etc.

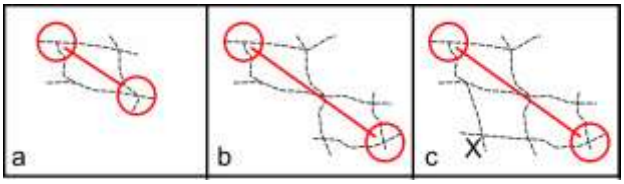

Figure 5 Serial decisions

Serial decisions also increase the number of alternative routes: in figure 5a there are only two alternative routes, but in figure 5b there are four! Probably there is a tendency to stay close to the red line, so in figure 5c the short route through point X might be overseen. The runner may decide the whole route at the first control or he may go for "serial decisions", making first a rapid decision to go to the crossing halfway the second control, and then decide on the second half walking or after arriving at the crossroad.

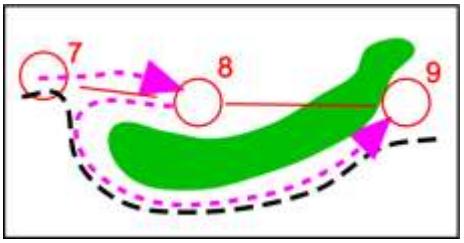

Figure 6 Retracing steps

The best thing for the runner to do is not to waste his time. After a quick look at the alternatives, he should choose one and off he goes. A minute of deliberation means that the chosen route has to be a minute or more faster! But as designers of orienteering events we aim to make life difficult for indecisive people.

Moving away from the next control is even more arduous when this means one has to retrace one´s steps (figure 6). There is a double motivational difficulty here:

1. Moving back over the same trail, thus losing one´s investment of time and energy, and
2. Moving away from the goal even more than in figure 3. Thus there will be a strong motivation to go straight on toward the control number 9.

Design for decision making

To make a leg more difficult , we can offer choices! A leg that has somewhat equally attractive choices instead of having just one solution is more difficult. Example (figure 7): in the first map the runner will immediately choose the road going West, in the second map the runner is more likely to ponder over which of the two roads he will take, thus loosing precious seconds.

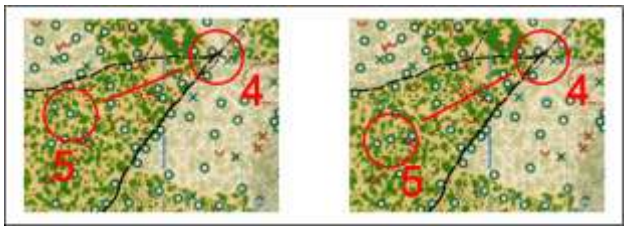

Figure 7 Design for decision making

Longer legs in general offer more alternative routes, but even here it is worthwhile paying attention and place controls in such a manner that several equally attractive alternative routes result in a more difficult course; on the other hand for a lower category the best route may be immediately obvious, even for longer legs.

3. Linear features

Types of linear features

Linear features in increasing order of difficulty may be classified as follows (see figure 8):
- paths and roads or tracks – fast running
- other linear features not paths, e.g. power lines, streams – easy map reading, but less fast running
- pseudo linear features, visible on the map but not in the terrain, e.g. contour lines. They are special in that you can´t see them when you cross them.
- pseudo linear features not directly visible in neither terrain nor map, e.g. valley or draw, ridge or spur, sharp change in steepness of slope, the edge of a plateau, a linear group of rocks. These lines only exist in the minds of the runners.

Linear features in the line of running are also called "hand rails", you may either follow them or move parallel to them at a certain distance, while keeping an eye on them.

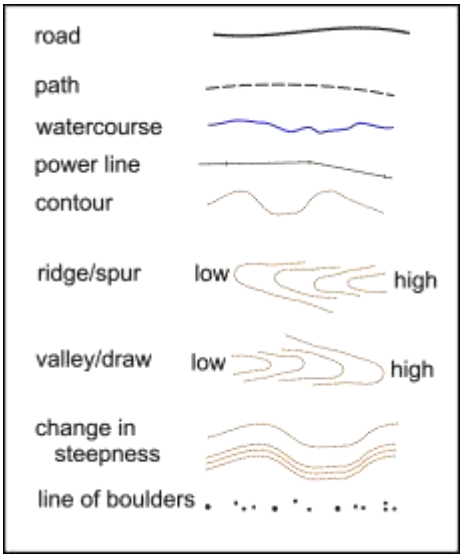

Figure 8 Linear features

Paths and roads

Paths and roads are a special kind of linear features in that they make map reading easy and that they allow fast running. A basic concern in the design of orienteering events is to vary the attractiveness of paths for following them. Variations are:
- force use of paths for beginners´ categories

- permit use of paths, but leave other options open
- Discourage use of paths (no paths between two controls or paths with a long detour) for advanced categories.

For the easy categories we will place controls so that the interconnecting lines between them coincide with or are very close to paths, so that runners are not tempted to go cross-country. Example (figure 9): whereas for a more advanced category we might use only control 51 and 53 and we expect runners to make a detour sticking to the path instead of going through the difficult terrain, for beginners we would place an additional control 52 so they wouldn´t even think about passing through the terrain.

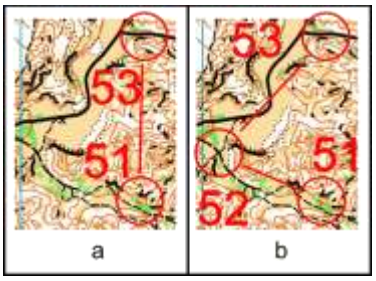

Figure 9 Stick to paths

Linear feature in the direction of running

For the easier categories variations in difficulty could be:
a. control/flag directly on the linear feature (the runner will stumble over the control or flag) vs. a certain distance away from it
b. the control/flag is clearly visible from the linear feature or not (the runner can see it without leaving the path vs. he must leave the path before he can see it.
c. when there are clear reference points on the linear feature, like curves or rocks or junctions, the runner can use them to decide when to leave the linear feature, but when runners have to pace a longer distance from an attack point farther away on the line it will cost more time and result in lower precision.

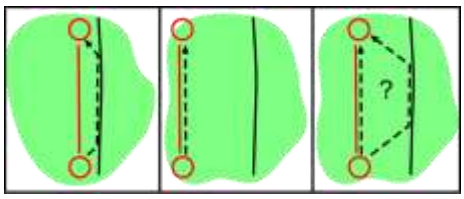

Figure 10 Linear feature or on the needle?

Placing the controls farther away from the path will increase the difficulty, but it will also make it easier for the runner to decide to "run on the needle". So, if you want him to hesitate, put the controls away from the path but at such a distance that the runner is hesitant whether to go out of his way or not to take the path or to go straight through. Well, runners don´t have the same need for security.

Also a mix of linear features is possible: close to the straight line segment is a difficult linear feature, e.g. a power line or a wall, and parallel to the segment but at a certain distance is an easy linear feature, like a path (figure 11).

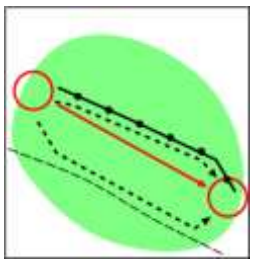

Figure 11 Alternative linear features

Angles of a linear feature and the leg

The leg may cut a linear feature at different angles:

- linear feature perpendicular to the segment. This permits the runner to adjust the distance and, when the path has clear reference points (e.g. bends), it also permits repositioning for the next part of the leg (fig. 12a).
- linear feature coinciding more or less with the leg (figure 12d). This will make it attractive for everybody to follow the linear feature.
- linear feature not perpendicular with the segment will avoid this possibility of adjusting distance and repositioning, thus it will enhance difficulty (fig. 12b and 12c).

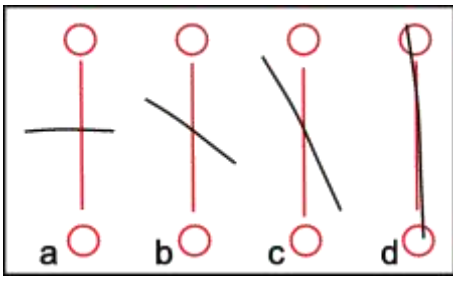

Figure 12 Path angles

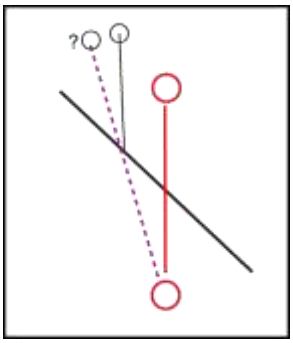

Figure 13 Direction error results in distance error

Well, the greatest difficulty will occur with no linear features at all. But if they are part of the terrain, the biggest problem will arise when segments cut a linear feature at angles of between 30 and 60 degrees. An error in direction will also result in a distance error (figure 13): when the runner has estimated he has to run 150 meters after crossing the road, he will run too far if he has deviated to the left, even if he follows the (originally) correct compass course.

Linear feature perpendicular to the leg

The easiest case is when the control is directly on the linear feature: the linear feature will stop the runner who then starts looking for the control. The runner can use the "aiming-off" technique, if he knows how to use it. Expecting more techniques of the runner is concomitant to saying that it is more difficult.

With a linear feature more or less perpendicular to the segment before the control it will be easier to find the control when the control is closer to the linear feature (figure 14b vs. 14c).

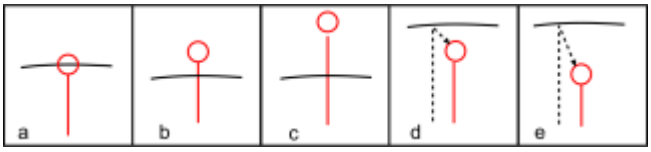

Figure 14 Linear feature perpendicular to leg

When the linear feature is after the control at first sight a runner doesn´t benefit from it, but when the control is close to the linear feature, the runner might run full speed till the linear feature stops him and then go back to find the control (figure 14c), whereas a less experienced runner might slow down well before the control and start looking for it. The farther the control before the linear feature, the less likely the runner is to go to the linear feature first, but he will start seeking the control first (figure 14e).

Ends of linear features

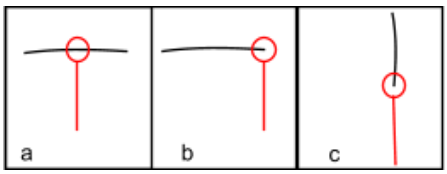

Figure 15 End effects

When the control is on a linear feature perpendicular to the leg, the runner will stop on reaching the linear feature and will start looking for the control (figure 15a). This is independent of whether he knows the aiming-off technique. When the control is at the end of the linear feature (figure 15b), half of those not knowing the aiming-off technique will miss the control, so this is (statistically speaking) more difficult. Even more difficult is the situation in figure 15 c: if visibility is limited, most runners will miss the control, so they have to pay attention to the distance. A secure technique would be "double-aim off": aim off to the left, aim off with the distance, in this case running 25% more than the calculated distance, turn right till the linear feature, turn right towards the end of the linear feature. Requiring a more advanced technique is equivalent to being more difficult.

Parallel errors

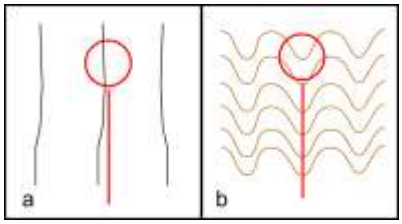

Figure 16 Parallel errors

The course setter can design for parallel errors; first of all he should seek a zone with parallel linear features. The linear features may be gullies, streams (figure 16a) or re-entrants or spurs (figure 16b). Runners should approach the end of the linear feature in the direction of the linear feature (figure 16a), coming from an area without clear reference points and from a sufficient distance.

Real vs. measured attack point on a linear feature

In figure 17a there is a small rock near the path, which can serve as attack point. In figure 17b there is no rock near the path (or, if the rock is not big, it could be taken off the map - rocks are a very subjective feature in cartography). Now the nearest attack point is the road-path junction and the point where the path has to be left can be measured or estimated from the junction, thus decreasing the accuracy and increasing the difficulty. In figure 17c the control is farther from the path, thus increasing the difficulty after leaving the path, in figure 17d the control is as close to the path as in figure 17b but the distance to be measured along the path is much longer, thus decreasing precision.

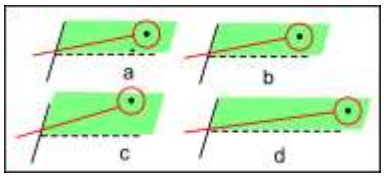

Figure 17. Measured attack point

Flag on a linear feature

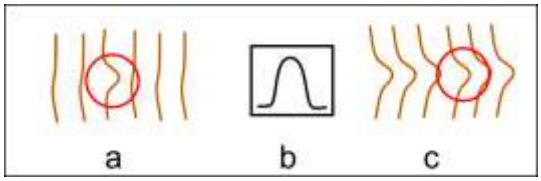

Figure 18 Re-entrant: point vs. line

In theory we might place a flag without there being a control point visible on the map (e.g. a rock, a tree stump), but that is something "not done" in official orienteering events (it might be done in training events). The exceptions I have seen in practice are a ridge or spur and re-entrant(figure 18). The reason probably is that there are no separate control

descriptions for a single contour line that shows as a re-entrant and a series of contour lines forming re-entrants and thus a valley. Thus we can place a flag somewhere on a draw and give it the control description of re-entrant (figure 18b). In practice the same thing occurs, though, when the control is very small and nearly invisible, such as a small rock or a small hole, which can be really in the middle of nowhere and practically invisible from more than five meters away because of dense vegetation. If re-entrants are line features we can have a junction of two re-entrants.

Valley or ridge

A rock or tree in the middle of a valley (also called "draw" when it is small; when it is even smaller it would be a "gully") or ridge (also called "spur" when it is small) is easier to find than an object to one side, especially if there are more of these objects (figure 19b). The experienced orienteer would immediately draw the line A-B where the water would go (the deepest part of the little valley) and follow that line (figure 19c), thus making it as easy as in figure 19a where, instead of a series of reentrants there is a path through the group of rocks. As in figure 19a, where control 45 is more difficult than control 36 because it is farther away from the path, in figure 19b and 19c the control 58 is more difficult than control 67. And, of course, because of the necessary perception of contours, control 58 in figure 19c is more difficult than control 45 in figure 19a.

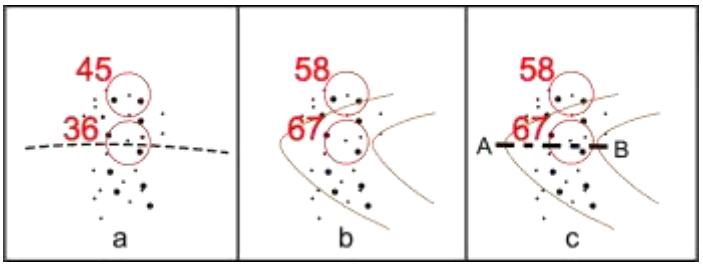

Figure 19. Distance from linear feature

4. Visibility

Visibility plays a big role in orienteering, be it visibility in the terrain or visibility on the map.

Visibility of the control and/or flag

According to IOF-rules, a control flag should be placed in such a manner that competitors see it only when they have reached the described control feature. The visibility of the control should be the same whether or not there is a competitor at the control site. The control flag should not be hidden, once a competitor reaches the control he should not have to search for the flag.

Visibility is coupled to distance, that is, low visibility means you can only see the control and/or the flag from a short distance, perhaps because of dense vegetation. It is also coupled to direction, the control and/or flag may be clearly visible from some directions whereas from other directions they are invisible.

The flag may be positioned in order of increasing difficulty:
a. So it can be seen from a considerable distance from all directions
b. So it can be seen from a considerable distance from the direction where the runners are coming from
c. So it can be seen from a short distance from where the runners are coming from
d. So it can't be seen from where the runners are coming from, but it is visible at angles of 90

degrees from the runners´ directions, behind a rock, for example.
e. So it can be seen only when the runner is looking backward
f. So it cannot be seen from anywhere, e.g. inside a bush or a hole or a cave (of course the control should be visible).

Other variations in visibility:
- On a knoll vs. in a pit or gully
- Inside a thicket or on the edge

Control on a slope

If the slope is part of a valley and the leg cuts the valley more or less perpendicularly, the control can be placed on the first, descending, slope or on the second, ascending, slope (figure 20). The descending slope provides a reduced visibility, perhaps reduced even more by vegetation, and even more so for convex slopes. When the control is placed on the other side of the valley visibility from the opposing slope will be higher. The runner can either view the flag directly or see other runners in the vicinity of the flag. The difficulty increases when the line of approach is not perpendicular to the contour lines.

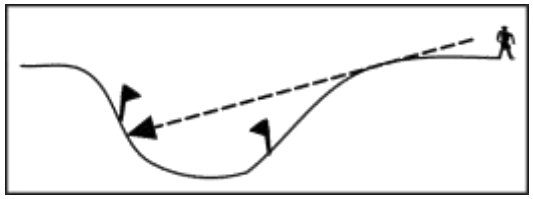

Figure 20 Control on a slope

Put a control where the runner can´t see the terrain

In a dense forest the surrounding terrain is invisible; this deprives the runner of information he would have in an open terrain, he must rely completely on the map. Figure 21 control 2b shows a control in a depression below a high cliff. If the runner didn´t look at the cliff before arriving at the control, he has missed valuable information for the next leg to control 3. In that case he will have to rely entirely on map reading for his route choice. If the control were at 2a the runner could still oversee the slope and perhaps see the path to the south that climbs the slope (under the power line).

A control in a dense forest offers two difficulties: the control itself will be difficult to find, but also there is no visual information from the terrain to go to the next control.

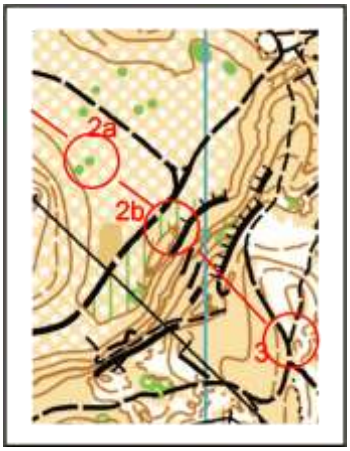

Figure 21 Invisible terrain

Prolong distant visible lines

A linear feature on the other side of the valley or on flat land below a slope, perpendicular to the stream and clearly visible from where the runner comes from, can help him to find his position. To increase difficulty put the control away from that line, to decrease difficulty keep the control close to that line. In figure 22 the fence may be well visible from the other slope, so that control b is rather easy to find, whereas controls a and c are more difficult.

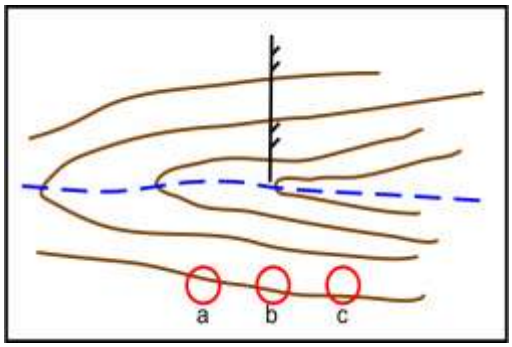

Figure 23 Prolong distant line

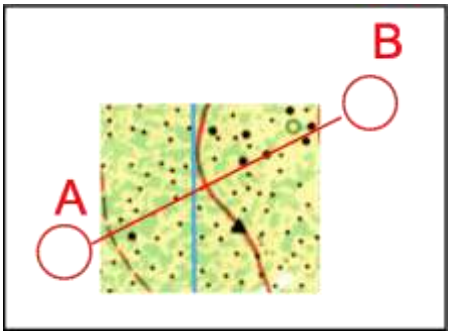

Figure 22 Tree as distant landmark

Transfer of compass directions to the terrain

If a runner can transfer his compass direction to some visible object 100 or 200 meters away, it will be easier than if there are no such objects, because of dense vegetation which limits his viewing distance or because his "horizon" is a formless mass of bushes. Such a situation will force him to "run on the needle", constantly looking at his compass. This again will be made difficult if he has to change directions all the time, for example, in a forest consisting of small groves, forcing him to zigzag around them.

Another way to transfer a compass direction to the terrain, is to transfer it to something very distant, for example a mountain top at 2 kilometers distance. This can be thwarted by having the segment not pointing toward such a horizon.

In figure 23, when going from control A to B, a large tree (little green circle) may be visible from a distance and may serve as a beacon for maintaining the compass course. When going from B to A there is no such visible point on this map segment.

Visibility of the map

When the map is full of fine details, difficulty is enhanced. Not just the density of the contour lines, but more so their intricate forms contribute to this type of difficulty, together with intricate forms of streams, further complicated by the presence of rocks, cliffs, boulders, trees, groves, etc. In figure 24c a control on a rock in the green area would be difficult to find because the contour lines are poorly visible. This is the situation where a magnifying glass becomes very useful.

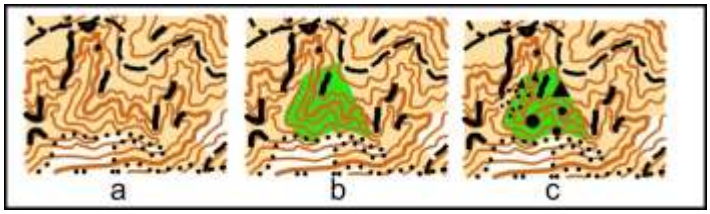

Figure 24 Density of the map

An increased number of features will make map reading more difficult, even more so when this is coupled to colors like dark green. Perhaps this situation should be avoided for the older categories as it demands high visual acuity or the use a magnifying glass.

5. More difficulty variables

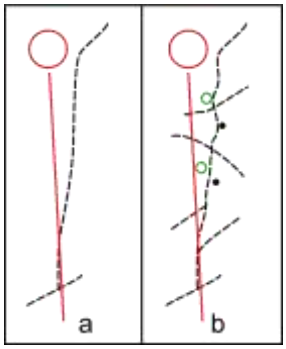

Figure 25. Need to consult the map

Need to consult the map

Consulting the map costs time. Compare the situation that the runner has to follow a path for 500 meters, and that this path has a clear sharp bend at 500 meters, versus the situation of a path which has many weak bends and several crossroads, boulders and trees (figure 25). In the first case the runner will not have to look at his map until he arrives at the sharp bend and that saves him time. So, to avoid remembering, avoid conspicuous objects which seldom occur in this terrain. A route that passes through many intermediate points is also more difficult to remember.

Many similar features

In the previous paragraph we talked about many features, but things get worse when there are many similar features, like many boulders. If a path, a stream or a contour line has many weak bends, it will be difficult to follow up to a desired point (figure 26). A route through a field with many boulders is more difficult than a route where there are only a few.

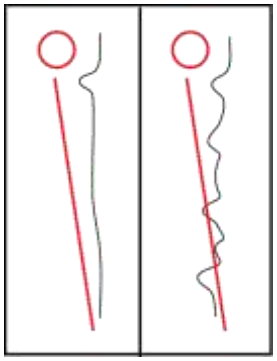

Figure 26 Many similar features

Different cartographers produce different maps and even the same cartographer may use different standards for different pieces of terrain. This is most evident when there are many similar features, like boulders or trees. A boulder of one meter high will be shown if there are no other ones around, but if the area is full of boulders of bigger sizes then it may be omitted or the whole area may be shown as a boulder field. One cartographer may represent a terrain as open land with a precise mapping of individual thickets and trees, another cartographer may represent the same area as open land with scattered trees. There is no precise rule for this, so the runner must allow for these differences in maps. (Runners may also change their perception of an area if there are too many small and similar details: although the cartographer put individual boulders on the map, the runner may see it as a boulder field and switch to compass direction and distance estimation.) Placing a control in such an area with many similar features, some of them not being on the map, will increase difficulty.

Number of runners passing through a control

There is a standard minimum interval of 2 (or 3) minutes between participants on any one course at the start. Later on in the course this interval will vary, but on the average it will remain 2 minutes. However if several courses use the same controls, this interval diminishes. Placing the controls is a lot of work and there is a logical tendency to combine controls for different courses. If two courses use the same control, the average interval between runners will be one minute, if three courses use the same control the average interval is 0.7 minute. The relation with difficulty lies in the probability of finding a control because the runner sees other people at or leaving the control. The more people visit a control per minute, the faster a runner will locate the control. There is a relationship with visibility here: in dense vegetation or very uneven terrain the runner

can´t see far and so he will not see from far away people leaving a control. In high-visibility terrain there should be less combining of controls. Instead we could use several controls for different courses close together.

Dog legs

The term “dog leg” (also called “acute angle” effect) is used to indicate the situation in figure 27a: runners leave the control in almost the same direction they came from, thus it will be easier for arriving runners to find the control, because they can see runners leaving the control. The same applies when two or more courses use the same control but pass it in opposite directions (fig.27b). Of course visibility plays a role: in dense vegetation dog legs have little importance. We will not actively plan in dog legs in easier categories, but we would pay more attention to this phenomenon with the higher categories. This means: in an easier category we will not actively use it, but we might leave it in if it somehow got into the course (perhaps as a result of trying to economize on flags).

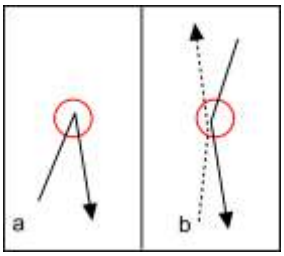

Figure 27. Dog leg

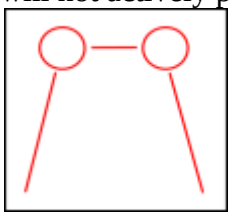
Figure 28. Avoiding dog legs

The classical solution to avoid dog legs is to add another control so the runners leave the control more or less perpendicular to the direction they came from (figure 28).

Controls of other courses nearby

They function as distracters and often induce runners to have a look at the control´s code number, even though they know that it can´t be the control they are looking for, thus losing their time. Controls of the same type of different courses should not be closer than 60 meters (that is, their circles should not overlap). Anyway, putting controls of different courses close together with sufficient visibility for the distracter will augment the difficulty. The distracter might be a control for an easier category, the control sought might be much less visible than the distracter. Also putting controls of different courses close together will counteract the dog-leg effect: other runners coming from a control may not come from the control the runner is looking for.

The attack point and the control

From the attack point there is nothing but direction with the compass and distance. The greater the distance of the control from the attack point the more difficult the course segment.

Another aspect is the position of the attack point with respect to the control. An attack point before the control (figure 29c) will be more readily used than an attack point behind the control (figure 29a). It is like the "banana problem", there is a resistance against moving away from the control. So if there is a clear attack point in an otherwise unclear terrain, to increase the difficulty put the control before the attack point. Having the attack point sideways away from the control is in between the two other cases. The choice in general is between running on the needle from a point much farther away vs. passing

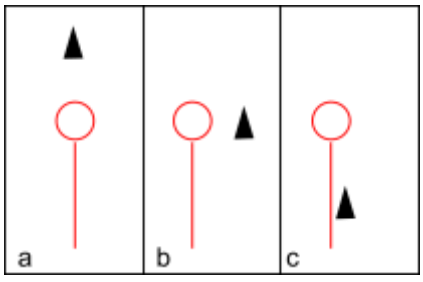

Figure 29 Position of attack point

through the attack point, which means a detour but offers more security, so it may save time in the end.

Leg distances

Firstly distance refers to the distance of the whole course: a course of 11 km will take more time than one of 5 km. This is an indication of the physical difficulty.

Secondly, there is the length of each leg: very short legs, 100 meters or less, put the emphasis on fast map and compass use and will seldom have intermediate points. On longer legs relatively more time will be spent on running and less on map reading, perhaps more on route choice. A relation exists with the number of controls: the more controls there are in a course, the shorter will be the average leg length.

Thirdly, with more impact on the map-reading difficulty, there is the distance to attack points and other intermediate points. In general, a leg will be more difficult with a greater distance from the attack point in terrain with limited visibility. On very short legs the previous control is acting like an attack point. Actually, the most elementary method of varying the difficulty of a leg is to vary the distance of the leg from attack points, including those measured on or from linear features.

Distance measuring

The terrain has an impact on the physical difficulty, but it also influences the map reading difficulty, because distance measuring can be less precise. A rocky area, bushes, dense vegetation, uneven ground, will make the runner´s distance measuring (usually pace counting) more difficult when he can go in a straight line, and even more so when he must run around obstacles like rocks, groves, trees, bushes, etc. Measuring distance up or down a slope will be less precise than measuring along a contour line.

Near the control

How easy it is to find the flag will depend on the size of the control (a rock of 4 meters versus one of 1 meter in an area with bushes of 1 meter high). It also depends on which side of the control the flag is located, with respect to where the runners are coming from. The same control might be used for two different categories, one coming from where they cannot see the flag and the other coming from the opposite direction where they can see the flag from a certain distance. There is a tendency to place the flag in lower places (re-entrant, hole, ditch) because that limits their visibility. This is in conflict with the rule that it should not be easier to find a control when there is another runner at the control. Yet another rule states that the runner should look for and find the control, not the flag; the runner looks for the flag once he has found the control.

Distance orienteering vs. finding the control

We can distinguish between the difficulty of the route to the next control and actually finding the next control. There may be a clear path to the next control, but near the control the runner will have to leave the path and seek the control among a multitude of rocks. Or the reverse, the route to the control is vague, there are no recognizable features, but the control itself is a path junction which can be easily found once the runner is sufficiently near it. Of course, we can combine both difficulties: both the route to the control and the exact location of the control are difficult. In

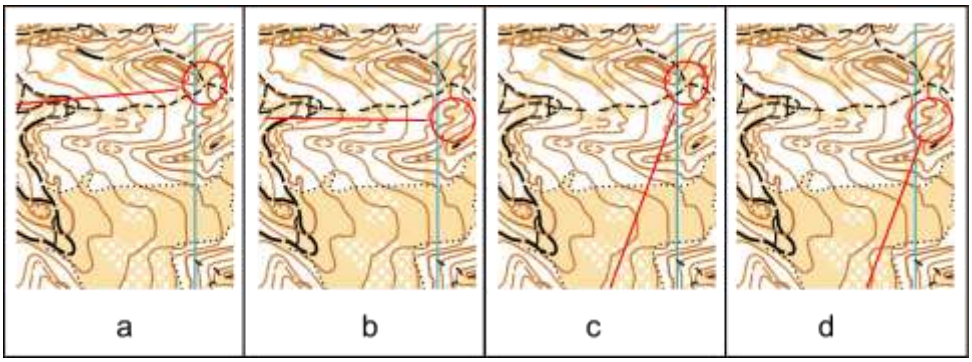

Figure 30 Distance orienteering and fine orienteering

figure 30a both distance and fine orienteering are easy: follow the path and the runner will stumble over the flag at the path junction. In figure 30b distance orienteering is easy: follow the path, but near the control the runner will have to pay attention. In figure 30c distance orienteering is much more difficult: the runner will have to pay attention to contours to get near the control, but once the runner is there, the runner can´t miss the path junction on the saddle. Figure 30d shows the most difficult situation: both distance and fine orienteering require reading contour lines.

Less obvious control descriptions

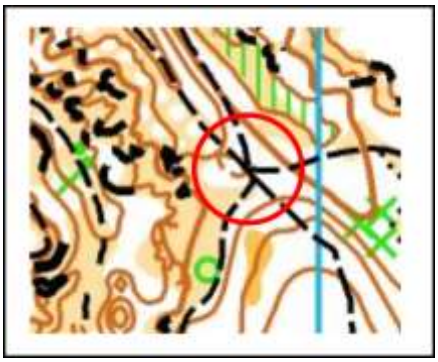

Figure 31 Other description

In figure 31 the most obvious control description would be "crossing" but it is also a "saddle". We might even use different descriptions for different categories for the same control (this would be difficult in OCAD). For beginners we would not use contour line aspects, so the control would be described as "crossing", whereas for higher categories it could be described as "saddle".

A "thicket" near the road under a power line can also be described as "crossing of power line and road". A crossing of two power lines is an easy landmark, but it is not a very usual description. Control descriptions can be varied from an instructional viewpoint, in order to draw attention to other aspects of the landscape. Unusual control descriptions make the runner think, thus making him loose some seconds again.

Number of controls

The number of controls also influences the difficulty of a course: a course of 8 kilometers and 2 controls is certainly easier than the same course of 8 kilometers with 14 controls . In other words, it will take less time.

Easy controls for positioning

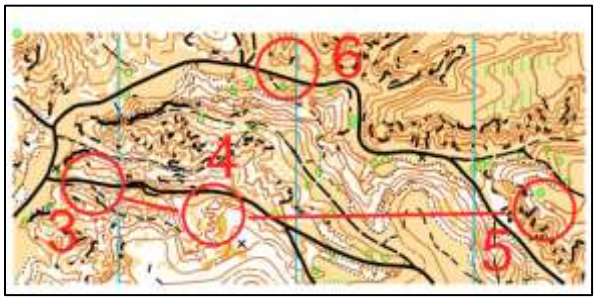

Figure 32 Add a control to increase difficulty

Controls can be inserted just for putting the runners into position for the next leg. In figure 32 the first design was from control 3 to control 5 but then everybody would take the road, so the easy control 4 was inserted to induce runners to consider following more closely the straight line to control 5. For an easier category we might leave out control 4, so the runners would probably follow the road toward 5. For a beginners´ category we might even use control 6 instead of 4, to induce the runners to follow the road. Placing an extra control to avoid dog legs is another example of an easy control just to steer participants.

Change the map or terrain

First of all, we can eliminate certain conspicuous features from the map. Sometimes power lines are eliminated. In one event paths at the border of the map were eliminated in order to avoid runners following the map´s edge and to force them through the rough terrain.

When there is an absolute scarcity of controls, something might be added to the map, e.g. a rock that was not on the map because it was too small according to the topographer. What about changing the terrain (and afterwards the map)? Dig a small gully or pit somewhere, or drop a rock, or a tree stump – and put it on the map.

6. Exercise: change the difficulty of a leg

An exercise for learning how to vary difficulty is to review a course you ran recently, look at each leg and change its difficulty somewhat. Take the first control of each leg as given, but change the next control, so as to make the leg easier and again so as to make it more difficult. Example (figure 33): control 3 is a re-entrant near a path bend, control 4 is between two rock faces not very far from a path bend with a problem of route selection: straight forward or pass along the south side of the valley with steep sides. To make control 3 easier it can be put on the path junction 60 meters to the Northwest, to make it more difficult it can be moved 60 meters to the North, farther away from the path, where there are many re-entrants.

	easier	more difficult
2 - 3	60 m NW, path junction	60 m N, reentrant
3 - 4	50 m W, rock face	100 m SE, rock face

Figure 33 Playing with difficulty

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Table of figures: