New Formula for Red PZ

Problems with current formula

- The formula doesn't work well for irregular shapes or dome. In irregular shapes it is difficult to define the maximum distance.
- The relative approach (the penalty points are calculated relative to the total possible infringement) is not working for big PZs. In these cases (e.g. full CTR as PZ) an infringement of several hundred meters result in very small penalty points
- The formula only considers the entry and exit point, but not the track inside the PZ. In extreme cases (when the balloon enters and exits at the same point) it is possible to infringe the PZ severely without any or very little penalty points.
- The formula also doesn't take the duration of the infringement into account.

New approach

The approach described in this memo is based on the same calculation as a blue PZ. The advantages are:

- Full track is considered
- Time of infringement is considered
- The formula works for any shape of PZ
- It rather considers the severity of the infringement in meters than a relative value
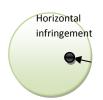- Because blue PZ is already included in most scoring software, implementation is easy.

The formula calculates:

$$penalty = \sum_{time} \frac{total\ infringement[m]}{scale} \Delta t$$

Thus as with the blue PZ for every second the infringement (in meter) is calculated and scaled with a constant value. (To compare the blue PZ takes the infringement in ft divided by 100, thus meter divided by approx. 30)

The main work to be done is to tune the formula. For a red PZ, the infringement can be divided into vertical and horizontal infringement.

The formula can thus be tuned on how the total infringement is calculated and how it is scaled. Possible total infringements are the sum, the diagonal (Pythagoras), minimum or maximum of the horizontal/vertical infringement.

Horizontal infringement

Vertical infringement

Tuning

A simulation was created that simulates several theoretical flights in different PZs. Several methods for calculating the total infringement and scale were used. Different scales can easily be assessed because the operation is linear. Just scale the total points manually.

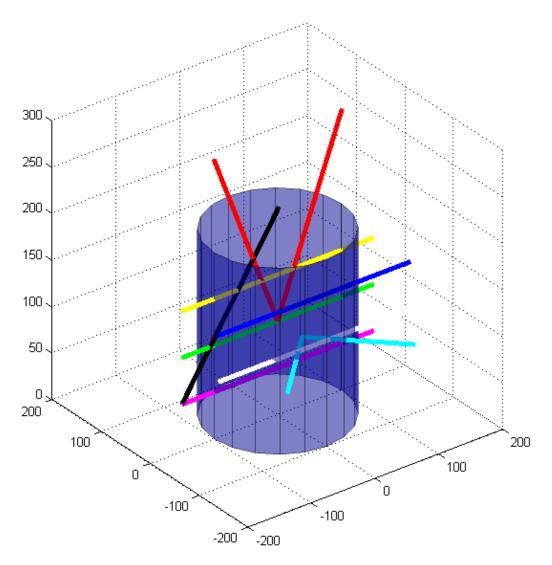|	Total infringement	scale
(1)	Sum of horizontal and vertical infringement	10
(2)	Minimum of horizontal and vertical infringement	4
(3)	Maximum of horizontal and vertical infringement	8
(4)	Diagonal (Pythagoras)	8

So far scale is tuned for having approx 600-700 penalty points when crossing a 100m radius PZ @ 100m altitude with 15km/h.

Arguments for the different methods:

(1) The sum is similar to the current method.
(2) Minimum considers the closest distance between the PZ border and balloon. Especially PZ3 shows that this approach results in less penalty in case of severe infringements.
(3) Only consider the maximum infringement

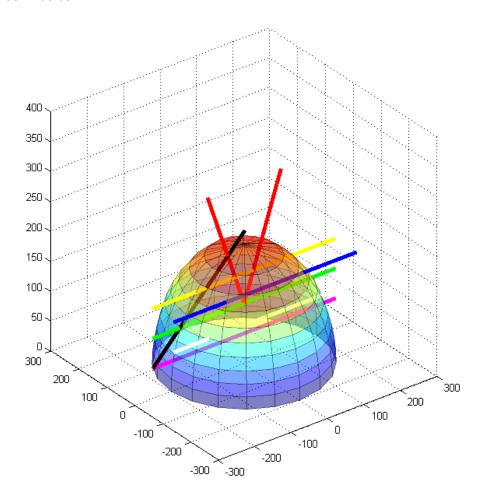In any cases the duration of the infringement is shown. This also helps assessing the infringement.
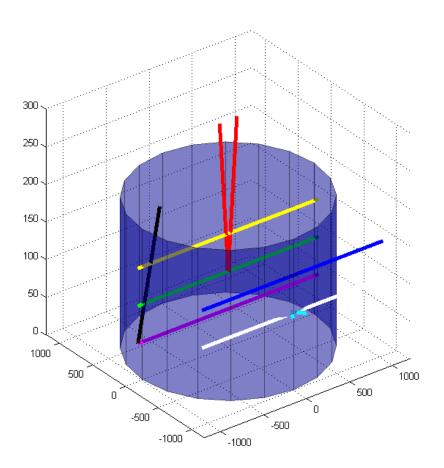
PZ1

100m radius (200m) diameter and 200m height.

Track		Duration	(1)	(2)	(3)	(4)	Old
green	Longest track through, 100m alt, 30km/h	23s	350	300	288	332	365
green	Longest track through, 100m alt, 15km/h	47s	710	600	588	676	370
green	Longest track through, 100m alt, 5km/h	143s	2150	1800	1788	2054	373
magenta	Longest track through, 50m alt, 15km/h	47s	945	600	881	944	432
yellow	Longest track through, 150m alt, 15km/h	47s	475	450	369	438	307
white	Flight at edge, 100m alt, 15km/h	31s	361	128	388	394	286
blue	Flight at edge, 150m alt, 15km/h	31s	206	128	194	206	224
black	Climb @3m/s from 50m alt, 15km/h	30s	263	163	247	267	158
red	Decend into PZ and exit again	55s	698	704	520	640	125
cyan	Horizontal enter and exit, alt 100m, 10km/h	43s	544	286	538	562	228

PZ2

Dome with 200m radius

Track		Duration	(1)	(2)	(3)	(4)	Old
green	Longest track through, 100m alt, 30km/h	41s	765	737	588	695	N/A
green	Longest track through, 100m alt, 15km/h	83s	1532	1474	1178	1393	N/A
green	Longest track through, 100m alt, 5km/h	249s	4596	4422	3534	4178	N/A
magenta	Longest track through, 50m alt, 15km/h	93s	1992	2231	1375	1775	N/A
yellow	Longest track through, 150m alt, 15km/h	63s	1064	544	1058	1094	N/A
white	Flight at edge, 100m alt, 15km/h	75s	1102	1128	813	991	N/A
blue	Flight at edge, 150m alt, 15km/h	53s	673	315	684	703	N/A
black	Climb @3m/s from 50m alt, 15km/h	40s	444	147	482	490	N/A
red	Decend into PZ and exit again	52s	1192	679	1150	1210	N/A

PZ3

1000m radius (2000m diameter) and 200 height.

Track		Duration	(1)	(2)	(3)	(4)	Old
green	Longest track through, 100m alt, 30km/h	239s	14390	5700	15138	15512	374
green	Longest track through, 100m alt, 15km/h	479s	28790	11400	30288	31037	374
green	Longest track through, 100m alt, 5km/h	1439s	86390	34200	90888	93135	375
magenta	Longest track through, 50m alt, 15km/h	479s	31185	16650	30656	32069	437
yellow	Longest track through, 150m alt, 15km/h	479s	26395	5850	30069	30308	312
white	Flight at edge, 100m alt, 15km/h	107s	1247	443	1338	1359	181
blue	Flight at edge, 150m alt, 15km/h	107s	712	443	669	711	118
black	Climb @3m/s from 50m alt, 15km/h	50s	718	427	684	735	92
red	Decend into PZ and exit again	55s	5648	705	6707	6719	13
cyan	Horizontal enter and exit, alt 100m, 10km/h	46s	578	295	575	599	134

Note: The points are extremely high but the infringement is also severe. If you take a look at the
duration it is mostly around 5-10minutes!