# Toy Examples outputs

## ToyExample1: ./generator -mode 0 -n 6

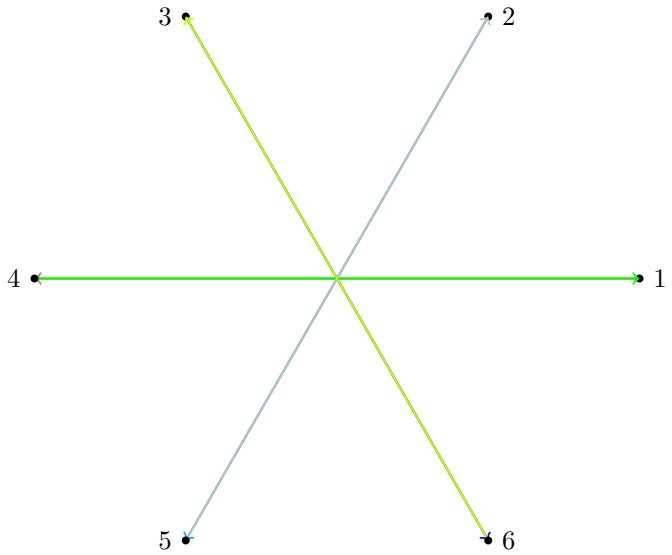


Figure 1: ToyExample1 configuration

```
   Pairs in conflict:
(1, 2) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.025000 hour.
(1, 3) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.014434 hour.
(1, 4) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.012500 hour.
(1, 5) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.014434 hour.
(1, 6) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.025000 hour.
(2, 3) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.025000 hour.
(2, 4) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.014434 hour.
(2, 5) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.012500 hour.
(2, 6) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.014434 hour.
(3, 4) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.025000 hour.
(3, 5) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.014434 hour.
(3, 6) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.012500 hour.
(4, 5) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.025000 hour.
(4, 6) with distance at the time of minimal separation:  0.000000, and duration of conflict:
0.014434 hour.
```

(5, 6) with distance at the time of minimal separation:  0.000000, and duration of conflict: 0.025000 hour.
N° conflicts per aircraft:
5, 5, 5, 5, 5, 5,
Proportion of aircraft with one conflict or more:  1.000000
Total pairs in conflict:  15
Proportion of pairs of conflicts:  1.000000

## ToyExample2: ./generator -mode 0 -n 6 -vmin 380 -vmax 400

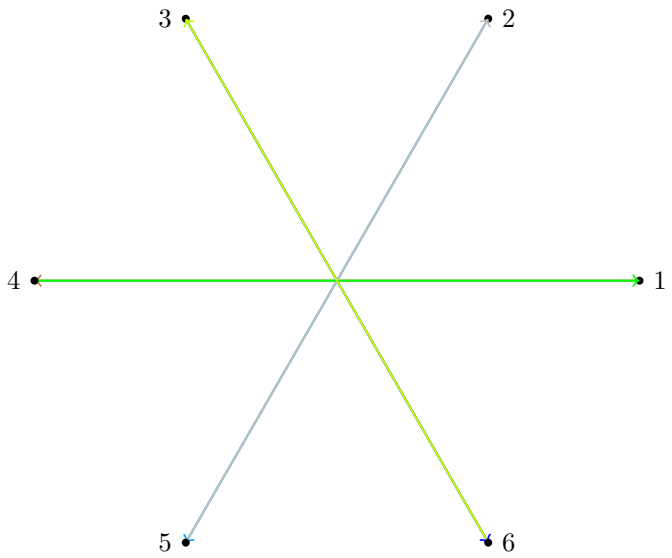


Figure 2: ToyExample2 configuration

Pairs in conflict:
(1, 3) with distance at the time of minimal separation:  2.384979, and duration of conflict: 0.013194 hour.
(1, 4) with distance at the time of minimal separation:  0.000000, and duration of conflict: 0.012934 hour.
(1, 5) with distance at the time of minimal separation:  2.648785, and duration of conflict: 0.012715 hour.
(1, 6) with distance at the time of minimal separation:  3.330271, and duration of conflict: 0.019437 hour.
(2, 3) with distance at the time of minimal separation:  1.062470, and duration of conflict: 0.025031 hour.
(2, 4) with distance at the time of minimal separation:  0.408545, and duration of conflict: 0.014665 hour.
(2, 5) with distance at the time of minimal separation:  0.000015, and duration of conflict: 0.012791 hour.
(2, 6) with distance at the time of minimal separation:  1.075521, and duration of conflict: 0.014477 hour.
(3, 4) with distance at the time of minimal separation:  1.770025, and duration of conflict: 0.023908 hour.
(3, 5) with distance at the time of minimal separation:  0.263842, and duration of conflict: 0.014795 hour.
(3, 6) with distance at the time of minimal separation:  0.000000, and duration of conflict: 0.012877 hour.

```
(4, 5) with distance at the time of minimal separation:  1.313088, and duration of conflict:
0.024634 hour.
(4, 6) with distance at the time of minimal separation:  1.484028, and duration of conflict:
0.014127 hour.
(5, 6) with distance at the time of minimal separation:  1.257345, and duration of conflict:
0.024894 hour.
N° conflicts per aircraft:
4, 4, 5, 5, 5, 5,
Proportion of aircraft with one conflict or more:  1.000000
Total pairs in conflict:  14
Proportion of pairs of conflicts:  0.933333
```

## Explanations

We notice that the two examples input parameters differ only for the feasible range of the aircraft speed, i.e., [`vmin`,`vmax`], which is [400,400] for the first example, and [380,400] for the second. This is enough to generate two different instances: the first one has all the aircraft in conflict, the second one has the pair (1,2) not in conflict. The two graphical representations of the examples in Figure 1 and 2 are exactly the same, since the initial positions of aircraft $\hat{p}_i$ do not change and since we cannot show the speed, but just the velocity direction of the aircraft. In the .dat files, on the contrary, the two instances differ in the values of velocities $\hat{V}_i$. As for the Toy Example 1, all the aircraft have the same speed, thus they all *meet* in the center of the circle, i.e., with a minimal separation of 0 NM. In the Toy Example 2, because of the different speeds of the aircraft, they will reach the minimal distance in different points of the circle. Such minimal distance may be greater than zero and also greater than the safety distance $D$. This is exactly the case for the pair (1,2), the minimal separation of which is 5.2 NM which is greater than 5. The minimal separation is computed in the function `dist_min` of our generator code (for details on the formulas behind, see Cafieri and Durand "*Aircraft deconfliction with speed regulation: new models from mixed-integer optimization*", Journal of Global Optimization 58(4), 2014). Then, in the function `conflict`, this minimal distance is compared to the value of $D$, in order to determine if aircraft $i$ and $j$ are in conflict.

The generator can further compute the duration of the conflict between such pair $(i, j)$ (function `duration`), computing the two roots of the second-order poynomial equation

$$\|(\hat{p}_i + t\hat{V}_i) - (\hat{p}_j + t\hat{V}_j)\|^2 = D^2,$$

which correspond to the instants in which the conflict starts and finishes, respectively.