

SUPPLEMENTARY DATA INFORMATION

SAMARA GEOMETRY

The free-fall dynamics of the artificial (Acer) Samara seed were simulated numerically, solving the 3D fluid mechanics problem, coupled with the rigid body motion equations. To this end, the Ansys FLUENT software was employed. Results of the simulation are given in Figure 1 of the data document, reporting the components of velocity vector (upper left), components of the angular velocity vector (lower left), and orientation (right) over time for a free-fall motion in air, with the seed initially at rest.

The simulations highlight the aerodynamic features of the Samara that make it suitable for the current work: after an initial period of acceleration, an autorotation is triggered, resulting in a sudden and sharp decrease in the falling velocity. The trajectory is also stable and close to the vertical.

The same problem was investigated for the case of a 2x scaled Samara: we find that the desirable aerodynamic properties of the seed, namely reduction in descent speed and trajectory stabilisation, are retained for this geometry. Results are given in Fig. 2, and a quantitative comparison between the two cases (1x and 2x) is given in Tables 1 and 2.

Having a larger surface area due to the scaling is crucial to “make room” for the payloads that are instrumental for the objectives of the project (photo and chemically reactive materials).

The 2x scaled Samara is thus selected as a basic building block for the more complex geometries employed in the further work.

CHIMERA GEOMETRY

We investigated numerically the free-fall dynamics of the chimera geometry, consisting of 3 wings (each a 2x Samara, denote also as I-SeedChim 2X) and a central disc. We also tested the possible effects of geometry optimisation on the stability of the motion. Results and qualitative comparisons are given in Figure 3, and trajectories of the falling motion are represented in Figure 4. We find that, acting on the geometry, one can achieve significant stabilisation. A more slender shape for the payload area prevents the oscillations during the falling motion that are typical of the motion of full discs.

EFFECT OF THE PAYLOAD/STEM ADDITION

The addition of a stem-like appendix to the chimera is needed in order to achieve penetration in soil at the end of the fall. We tested numerically the effects on the aerodynamics, as shown in Figure 5 and 6. Figure 5 shows the evolution of the Euler angles during the first 4 seconds of falling. The higher stability of the I-SeedChim (2X) with cone is highlighted by the fact that it reaches more quickly the terminal limit cycle, i.e. the state in which the configuration does not change its dynamical properties (velocities, attitude) in time. In Figure 6 we report a portion of the 3D trajectories of the two prototypes (Chimera with and without conical stem). It is evident that the red line, which tracks the I-SeedChim (2X) with the conical beak, is much closer to vertical through the release point (0,0,0). Thus, the presence of the conical beak leads to a straighter trajectory, with less lateral dispersion, allowing the seed to touch down at a site on the soil surface closer to the vertical through the release point. A quantitative comparison is given in Table 3.