Slingatron Projectiles of Large Mass and (Length/Diameter) Ratio for Atmospheric Traversal to Space or Global Destinations (Tidman, Sec 1.16, Ch 1)

Projectiles that have both a large (Length/Diameter) ratio, e.g., ~ 50, as well as a large mass, e.g., ~ 1 ton, can be accelerated in a slingatron. These projectiles would be capable of traversing the earth's atmosphere with negligible velocity loss from atmospheric drag. Slingatrons thus have the potential to launch hypervelocity streams of projectiles carrying materials to remote places around the globe or into space. This potential exists due to the favorable scaling of the mechanics of slingatrons to large size.

Figure 1 shows a projectile design concept in which an elongated projectile consists of segments that allow it to conform to the changing curvature of the slingatron tube along its path through the accelerator. On approach to the exit the projectile passes through a short straight section that causes alignment of the segments, and this in turn allows spring-loaded locking rods to be driven into their neighboring segments so that the projectile becomes locked into a rigid straight condition. Tail fins would also be deployed for flight through the atmosphere. Elongated projectiles could be stored in some inner turns that function as a storage magazine that is a part of the gyrating platform as discussed in Chapter 5.

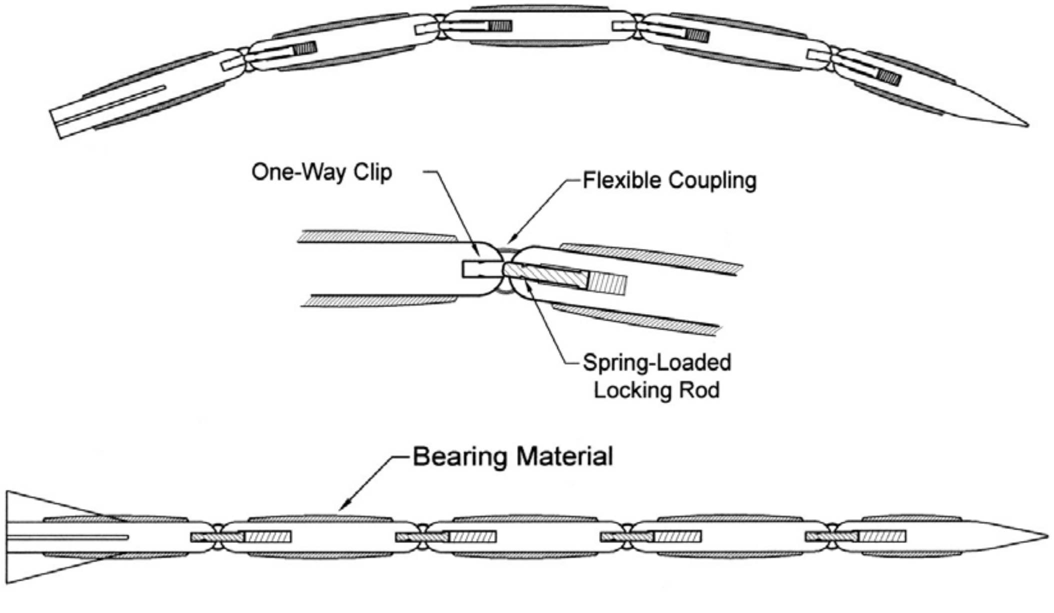

Figure 1. Large L/D projectiles with rigid segments and flexible connections can conform to a curved track for acceleration in a spiral slingatron. At exit the projectile traverses a straight section of tube in which alignment of the segments allows spring-loaded locking rods to be driven into neighboring segments to lock the projectile into a straight condition.

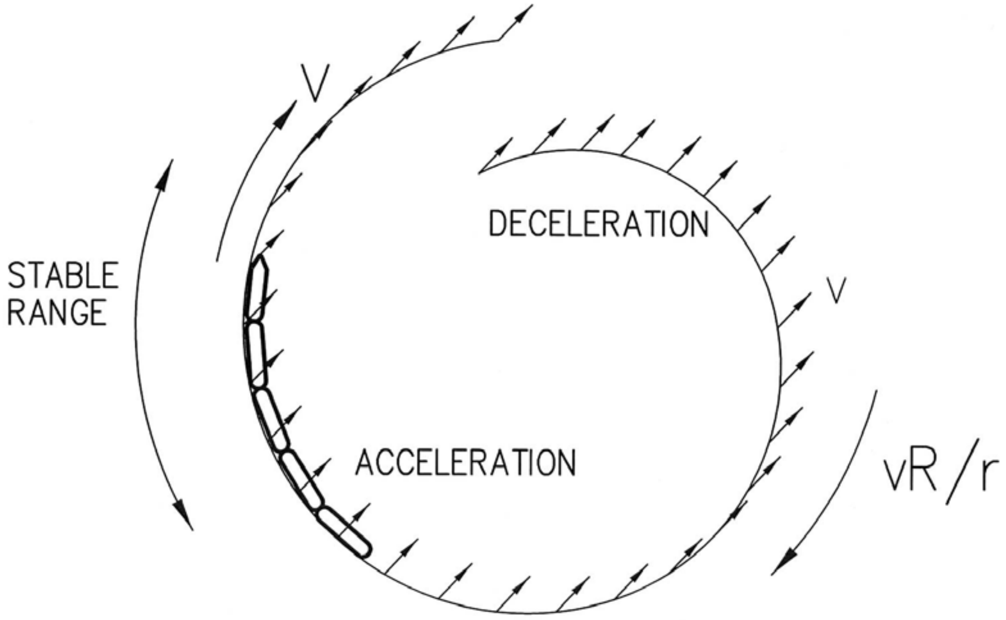

Figure 2. A large L/D projectile shown in an inner turn of a spiral slingatron when the gyration velocity v of the spiral assembly is as shown by the small arrows. The projectile is trapped in the accelerating wave that advances with speed vR/*r* as the gyration velocity vector rotates.

Figure 2 shows a projectile that gains energy as the track swings inward with a velocity component in the direction of the centripetal force acting on the projectile. The accelerating force is distributed along the projectile length and is proportional to the distributed projectile mass. An imaginary observer riding on the projectile would experience the trip as sliding downhill in a gravitational field, with the field strength increasing as the projectile speed increases.

Consider a simple idealized example in which such a projectile is launched from sea level with velocity V_o and an elevation angle ϕ with the horizontal. For estimates we neglect loss due to earth's gravity and estimate only the velocity loss due to air drag in traversing the earth's atmosphere. We assume an exponential atmosphere of scale height *h* =8 km and a sea-level density $\rho_{air} = 1.2\times10^{-3}\,gm/cc$. After obliquely traversing the entire atmosphere at an elevation angle ϕ, the projectile velocity loss ΔV due to atmospheric drag would then be given by

$$\frac{\Delta V}{V(0)} = \frac{V(0)-V(\infty)}{V(0)} = \left\{1-\exp\left(-\frac{C_D\rho_{air}h}{2L\rho_{proj}\sin\phi}\right)\right\}$$

We assume that the projectile approximates a cylinder of length *L*, diameter *d*, and density ρ_{proj}, so that its mass m_{proj} is

$$m_{proj} \cong \frac{\pi}{4} d^3 \left(\frac{L}{d}\right) \rho_{proj}$$

For example, choosing $m_{proj} = 10^6$ gm = 1 ton, *L/d* = 50, $\rho_{proj} = 4 gm/cc$, the projectile diameter follows as *d* = 18.5 cm and length *L* = 927 cm. Assuming the projectile drag coefficient is $C_D = 0.1$, and the launch elevation angle $\phi = 30^o$, the percentage velocity loss of the projectile due to air drag for this oblique pass through the atmosphere would be $\cong 2.6\%$.

We see that such projectiles would experience only a small velocity loss due to atmospheric drag, and could be launched obliquely through the atmosphere and re-enter at various locations around the globe. Such projectiles would traverse the atmosphere in a brief few seconds at the launch and re-entry ends, so that although some ablation would occur, principally in the nose region from the hot air boundary layer, heat would only have time to diffusively advance a short distance into the projectile, i.e., projectiles would arrive at their destinations without major thermal damage. Ablative out-blowing from the hot projectile surface also provides a shielding factor that reduces heat transport into the projectile.

Finally, there are potential commercial applications for slingatron systems located in the CONUS. Smart projectiles with parameters $L/d \cong 50$, mass ≥ 1 ton, and velocity > 6 km/sec could soft-land supplies using a terminal parachute to various global GPS locations.