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Are *The A-Team* A-Okay?

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Abstract
This paper will look at the scene in the movie *The A-Team* when a tank parachutes its way to the ground with the team inside. The terminal velocity of the tank, with three parachutes and then one parachute will be calculated as per the film. The terminal velocity of the tank with three parachutes was found to reach 20.3 ms^{-1}, and 35.1 ms^{-1} with only one of the parachutes. The probability of survival at these speeds was then explored, based on the amount of G-force that a person can experience before becoming fatal. The terminal velocities that were calculated were found to be 2.1 and 3.6 times larger than the fatal velocity of an impact, for three and one parachutes respectively. Therefore, it was concluded that *The A-Team* would not have survived the fall, as is shown in the movie.

Introduction
In the movie, *The A-team*, there is a scene where the team escape an exploding plane by parachuting to the ground in a tank [1]. In the scene, three parachutes are initially attached to the tank and appear to slow the tank down considerably.

This paper will look at how much the parachutes would have slowed the tank down, and so will find out how fast the tank would have been travelling. The paper will then look at how fast the tank was travelling when two of the three parachutes were taken out, so that there was only one parachute taking the weight of tank, figure 1. The paper also considered the likelihood of survival at these speeds.

Figure 1 – The tank that the A-Team use to escape the exploding plane; the single parachute that remains at the end of the scene can be seen [2].

Theory
When an object falls through the air, gravity is the force that pulls said object to the ground. If a feather and a brick were to fall in a vacuum both would hit the ground simultaneously. However, in practise this does not occur due to the gas molecules in the atmosphere. The gas molecules create an air resistance, or drag force which slows objects down. When the force of drag is equal to the force of gravity, an object has reached its terminal velocity, the point at which no more acceleration occurs. A parachute takes advantage of drag, increasing as it falls, to reduce the terminal velocity, allowing a safe landing [3].

Calculations
In order to work out what speed the tank would have been travelling at in the *A-Team,* the equation for drag force, equation 1 [4], will be made equal to the weight of the tank under gravity, equation 2.

$$F_D = \frac{C_d \rho v^2 A}{2}. \quad (1)$$

Where F_D is the drag force, C_d is the drag coefficient, ρ is the air density, v is the velocity and A is the area of the parachute.

$$F = mg. \quad (2)$$

Where F is the weight of the tank, m is the mass of the tank and g is the gravitational constant.

Since there are three parachutes supporting the tank, the surface area in the drag equation (equation 1) will be multiplied by 3. Making the two equations equal, and rearranging to find the velocity gives equation 3.

$$v = \sqrt{\frac{2mg}{C_d \rho 3A}}. \quad (3)$$

The drag coefficient for a typical parachute is 1.75 [4], the gravitational constant being used is 9.81 ms^{-2} and air density is approximately equal to 1.229 kgm^{-3} [5].

The mass of the tank, the parachutes and the people inside will be considered for the total mass. The tank used in the movie is a M8 Armoured Gun System/Buford, which is a light tank [1]. The weight of the tank is 23,580 kg [6]. There are 4 members of *The A-Team*, all of which are present in the tank, so these men will be assumed to have the average weight of an American, 88.77 kg [7].

Parachutes used by the military in planes similar to the one that *The A-Team* use are G-11 cargo parachutes, which have a weight of 113.4 kg each [8]. All these masses added together, accounting for the multiple parachutes and people within the tank generates a total mass of 24,275.3 kg. Despite the maximum payload capacity for 3 G-11 parachutes being 6,003 kg, it will be assumed that the parachute will not break under the weight of the tank [8].

The surface area of the parachute will be worked out by using equation 4, as the parachute will be modelled as half a sphere. The radius of the G-11 cargo parachute mentioned earlier is 5.35 m [8].

$$A = 2\pi r^2. \quad (4)$$

The surface area of the parachute is therefore equal to 179.8 m^2. If all of these values are substituted into equation 3, the terminal velocity of the tank can be calculated to equal 20.3 ms^{-1}, or 45.4 mph.

According to the U.S. National Highway Traffic Safety Administration, the fatal amount of G-force a person can sustain is found to be 65 g's and the average impact event on a human has a duration of 15 milliseconds [9]. Using this information, an estimate for the speed at which the tank would have to be travelling in order for the fall to be fatal can be calculated using equation 5.

$$v = at. \quad (5)$$

Where a is the acceleration due to gravity and t is the time. Assuming a collision time of 15 milliseconds, the speed at which a collision would be fatal is approximately 9.6 ms^{-1}, using Equation 5. The terminal velocity calculated for the three parachutes is 2.1 times larger than the minimum speed of collision that would be fatal. Therefore, the parachutes would not sufficiently slow the tank down in order for *The A-Team* to land safely.

However, it gets worse for the team, as two of the three parachutes get destroyed, leaving only one parachute to support the falling tank. Therefore, Equation 3 must be modified for only one parachute, Equation 6.

$$v = \sqrt{\frac{2mg}{C_d \rho A}}. \quad (6)$$

Substituting the same values that were used before generates a terminal velocity of 35.1 ms^{-1} or 78.5 mph. This terminal velocity value is 3.6 times the estimated fatal velocity. This result means that *The A-team* would be even more unlikely to survive the fall in the tank, and this plan certainly didn't come together.

Conclusion

In conclusion, the tank that *The A-Team* fall in would have a terminal velocity of 20.3 ms^{-1} when three G-11 cargo parachutes are supporting its weight and 35.1 ms^{-1} with only one. Both of these terminal velocities were found to be fatal to the team inside, based upon the estimated fatal collision speed calculated to be 9.6 ms^{-1}. Therefore, even if the parachutes wouldn't break under the gargantuan weight of the tank, the collision with the ground would almost certainly be fatal for anyone inside.

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