Altitude Loss of Parachute-Load Systems Using Clustered Parachutes

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Theme

FOR a successful recovery of persons or loads with parachutes, a certain minimum altitude is necessary for the deceleration of the parachute-load-system down to the desired landing velocity. This study investigates the changes of the minimum altitude if clustered parachutes are used.

Contents

The study includes experiments[3] as well as a theoretical analysis[1] of the problems. A 130-kg test vehicle was used for drop-tests from a Do-27 aircraft. The cluster consisted of two or three circular flat solid cloth parachutes, each having 28 gores and 28 suspension lines. The total nominal area of the cluster was 58 m^2. The diameter of the parachutes decreased accordingly to the number of canopies in the cluster, e.g. using three canopies the parachutes nominal diameter had to be $D_0 = 4.96$ m. The parachutes were packed in a single bag with three separate compartments. The bag was stored in a cylindrically shaped bay of the test vehicle. Two seconds after dropping the test vehicle from the aircraft the lid of the parachute bay was fired. The lid extracted a 0.8-m-diam circular flat solid cloth pilot chute which then extracted and pulled off the parachute bag.

As minimum altitude loss H^* is investigated which arises between the moment of the opening of the parachute package ($t=0$, Fig. 1) and the time when the landing velocity is reached ($t=t^*$), the landing velocity being defined as 1,2 v_e (with v_e = equilibrium velocity). The recovery in this time interval consists of three phases: deployment, filling, and transition. The altitude loss during deployment depends on the extraction system.

For the computation of the altitude loss during the filling and transition phases the parachute-load-system is supposed to consist of two point masses. The equation of motion in the direction of the connection of the two points for the payload is given[2,4] and is of the form

$$m_L \dot{v}_L = -F - T_L + W_L \sin\gamma_L \qquad (1)$$

and for the canopy is

$$m_s \dot{v}_C + v_C \dot{m}_s = F - T_C + W_C \sin\gamma_C \qquad (2)$$

where m = mass, v = velocity, T = component of the drag force in the direction of the connection, $W\sin\gamma$ = component of the weight force in the direction of the connection, F = resulting suspension line force, and m_s = sum of canopy mass and virtual mass. The subscripts L and C indicate load and canopy, respectively.

It is supposed, that the shape of the canopy is unchanged after the filling.[2] Thus, for the transition phase $m_s = m_C$ and $\dot{m}_s = 0$ in Eq. (2). If in the parachute-load-system the single parachute is replaced by several parallel parachutes that are equally filled, Eq. (2) becomes

$$m_s \dot{v}_C + v_C \dot{m}_s = F/n_k - T_c + W_C \sin\gamma_C \qquad (3)$$

with n_k = number of canopies.

A comparison of the theoretical and experimental time histories of the rate of descent of parachute-load-systems with 1, 2, and 3 canopies is shown in Fig. 1. The following conditions are supposed: total mass m_T of the system = 130 kg, total nominal area S_0 of the canopies = 58 m^2, launch velocity v_a = 55 m/sec. The minimum altitude loss as a function of the

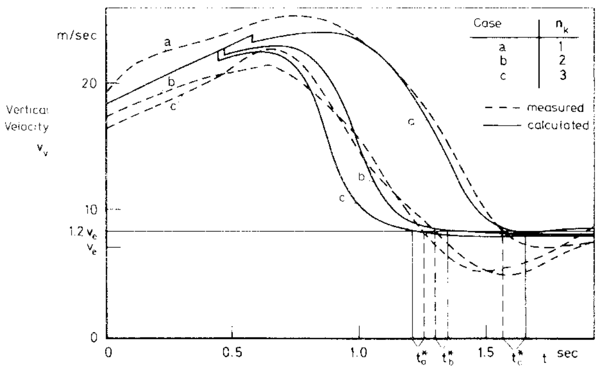

Fig. 1 Comparison of calculated and measured rates of descent.

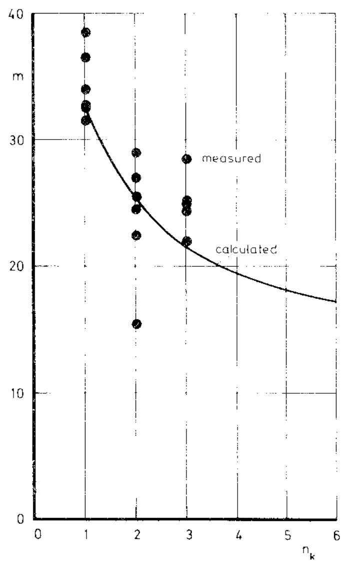

Fig. 2 Altitude loss vs number of canopies.

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Index categories: Launch Vehicle Systems (including Ground Support); Entry Deceleration Systems and Flight Mechanics.

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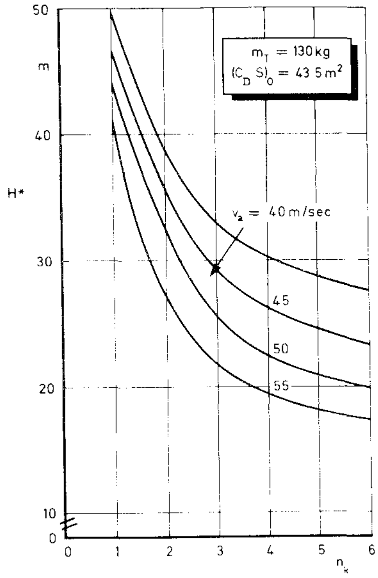

Fig. 3 Calculated altitude loss for various numbers of canopies and launch velocities.

number of canopies is represented in Fig. 2. It is shown that this minimum altitude loss decreases with the number of canopies. If the relatively high scatter of the measured values is taken into account, there exists a satisfactory agreement between theory and measurements. Fig. 3 shows the dependence of the minimum altitude loss on the number of canopies for various launch velocities. If the launch velocity is increased, the minimum altitude loss decreases. Summarizing, to obtain an altitude loss as small as possible (i.e., for a successful recovery from low altitudes) it is useful to use several small parachutes instead of one parachute.

References

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