Concept of Tail Volumes to size Horizontal and Vertical tails:

The primary purpose of a tail is to counter the moments produced by the wing. Thus, it would be expected that the tail size would be in some way related to the wing size. The force due to tail lift is proportional to the tail area. Thus, the tail effectiveness is proportional to the tail area times the tail moment arm. This product has units of volume, which leads to the "tail volume coefficient" method for initial estimation of tail size.

Rendering this parameter nondimensional requires dividing by some quantity with units of length. For a vertical tail, the wing yawing moments which must be countered are most directly related to the wing span *bw*. This leads to the "vertical tail volume coefficient," as defined by Eq. (6.26). For a horizontal tail or canard, the pitching moments which must be countered are most directly related to the wing mean chord (Cw). This leads to the "horizontal tail volume coefficient," as shown by Eq. (6.27).

$$c_{VT} = \frac{L_{VT} S_{VT}}{b_W S_W} \qquad (6.26)$$

$$c_{HT} = \frac{L_{HT} S_{HT}}{\overline{C}_W S_W} \qquad (6.27)$$

Note that the moment arm *(L)* is commonly approximated as the distance from the tail quarter-chord (Le., 25070 of the mean chord length measured back from the leading edge of the mean chord) to the wing quarter-chord.

Table 6.4 Tail volume coefficient

	Typical values	
	Horizontal c_{HT}	Vertical c_{VT}
Sailplane	0.50	0.02
Homebuilt	0.50	0.04
General aviation—single engine	0.70	0.04
General aviation—twin engine	0.80	0.07
Agricultural	0.50	0.04
Twin turboprop	0.90	0.08
Flying boat	0.70	0.06
Jet trainer	0.70	0.06
Jet fighter	0.40	0.07
Military cargo/bomber	1.00	0.08
Jet transport	1.00	0.09

These values are used in Eqs. (6.28) or (6.29) to calculate tail area.

$$S_{VT} = c_{VT} b_W S_W / L_{VT} \qquad (6.28)$$

$$S_{HT} = c_{HT} \overline{C}_W S_W / L_{HT} \qquad (6.29)$$

To calculate tail size, the moment arm must be estimated. This can be approximated at this stage of design by a percent of the fuselage length as previously estimated.

For an aircraft with a front-mounted propeller engine, the tail arm is about 60 % of the fuselage length.

For an aircraft with the engines on the wings, the tail arm is about 50-55 % of the fuselage length.

For aft-mounted engines the tail arm is about 45-50% of the fuselage length.

For a sailplane has a tail moment arm of about 65% of the fuselage length.

For the horizontal tail design process, longitudinal trim equations will be used given by:

$$C_{m_{owf}} + C_L(h - h_o) - \frac{l}{\bar{C}}\frac{S_h}{S}C_{L_h} = 0$$

Where $l\ S_h$ is called horizontal tail volume. This non-dimensional longitudinal trim equation provides a critical tool in the design of the horizontal tail.

The combination $l\ S_h / C\ S = V_h$ in above equation is an important non-dimensional parameter in the horizontal tail design, and is referred to as the "*Horizontal tail Volume Coefficient*" V_h.

The tail volume coefficient is an indication of handling quality in longitudinal stability and longitudinal control. As V_h increases, the aircraft tends to be more longitudinally stable, and less longitudinally controllable. The fighter aircraft that are highly maneuverable tend to have a very low tail volume coefficient, namely about 0.2. On the other hand, the jet transport aircraft which must be highly safe and stable tend to have a high tail volume coefficient, namely about 1.1. This parameter is a crucial variable in horizontal tail design and must be selected at the early stages of tail plane design. Although the primary function of the horizontal tail is the longitudinal stability, but the tail volume coefficient serves as a significant parameter both in the longitudinal stability and longitudinal trim issues.