

# A Graphical Method of Determining the Neutral Point and Center of Gravity

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The center of gravity (CG) is defined as the center of mass. If suspended by the CG in a gravitational field, an object will remain motionless regardless of orientation. The pitch stability of an aerodyne is directly linked to the location of the CG in relation to the neutral point (NP), the quarter chord point of the mean aerodynamic chord (MAC).

If the CG is ahead of the NP, the aerodyne will be stable in flight, and moving the CG further forward will always make the aircraft more stable. There will invariably be an associated change in decalage or, in the case of swept tailless aircraft, a change in wing twist. As the CG is moved back toward the NP the pitch forces generated by the elevator become more effective.

If the CG is at the NP, the aircraft will be neutrally stable. That is, the pitch attitude of the aircraft will not change if the elevator is not deflected. The term neutral point is derived from this behavior.

If the CG is behind the NP, the aerodyne will be unstable in pitch. While this condition may enhance maneuverability or some other performance factor for a full sized aircraft, it is something to be avoided by modelers. A full sized aircraft in this state may be flyable by an experienced pilot, but a model aircraft in this state may not be flyable at all. If the CG is substantially behind the NP, some sort of active control system will be necessary for sustained flight. Redundant computer systems take care of maintaining pitch stability in the B-2 Stealth bomber and NASA's X-29 research vehicle, both of which are inherently unstable.

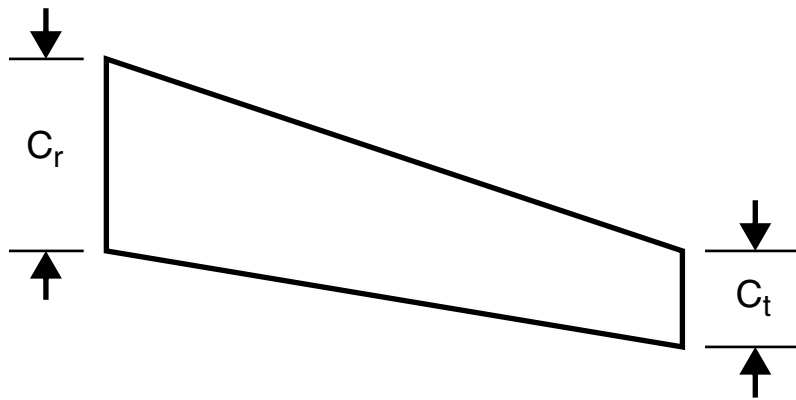
We certainly do not want to winch launch and attempt to fly an unstable aircraft, so there can be no denying the importance of pitch stability. Yet the usual methods for assuring ourselves of a safe balance point — CG ahead of NP — involve quite a bit of relatively complex mathematics. There has to be a better way, and so there is. We'll describe here a graphical method of finding the neutral point which works for any tailless planform.

Before flying your latest tailless creation, make sure the CG is in front of the NP!

To start, draw out one complete wing on a piece of paper. This can be either a full size tracing, or drawn to some scale with which you feel comfortable. By following the simple directions outlined here, you can easily find the NP of either single or multipanel wings without resorting to mathematics of any kind.

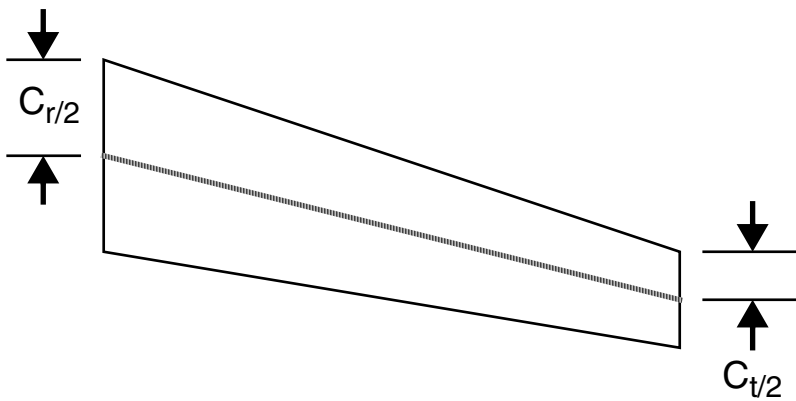
Step 1

- Identify end chords of panel as root chord,  $C_r$ , and tip chord,  $C_t$ .



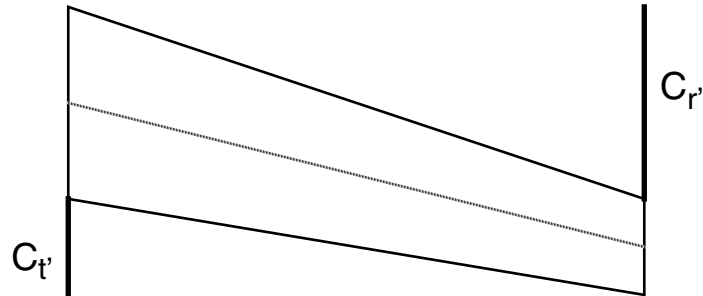
Step 2

- Find and mark midpoints of  $C_r$  and  $C_t$ .
- Connect the two points. This is the half chord line.



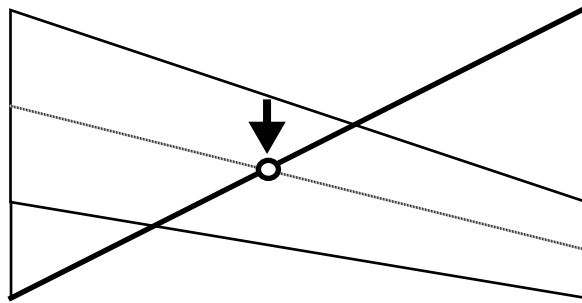
Step 3

- Draw  $C_r$  extending from the leading edge of the wing tip, forming  $C_r'$ .
- Draw  $C_t$  extending from the trailing edge of the root, forming  $C_t'$ .



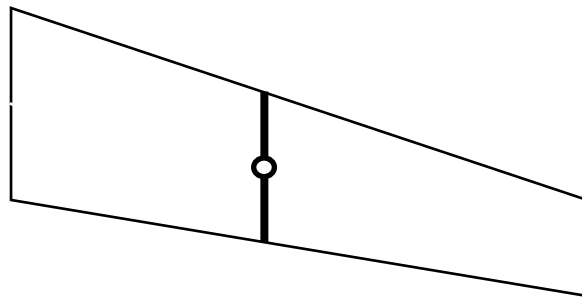
Step 4

- Draw a diagonal line from the end of  $C_r'$  to the end of  $C_t'$ .
- Mark the intersection of this line and the half chord line.



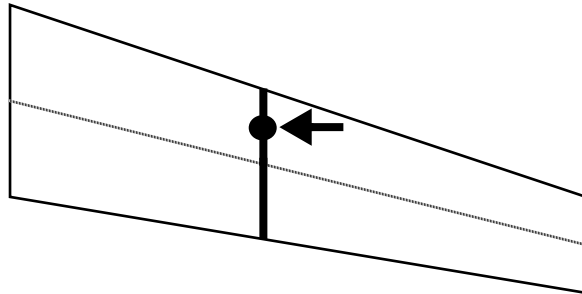
Step 5

- Draw a line through the point drawn in Step 4. This line must be parallel to  $C_r$  and  $C_t$ . This is the geometric mean chord.



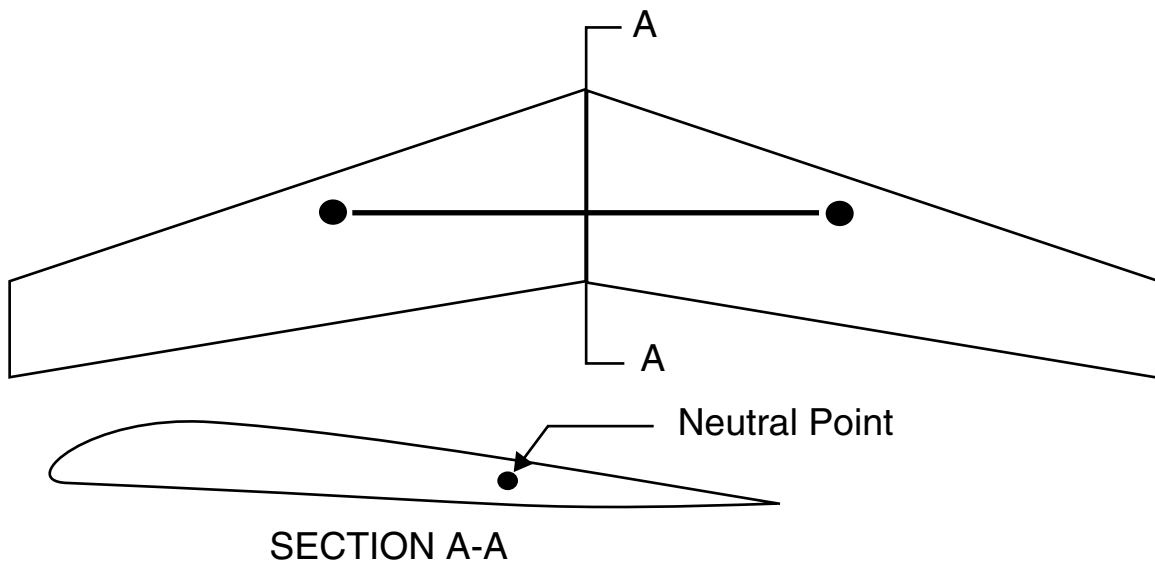
Step 6

- On the geometric mean chord, mark the midpoint between the leading edge and the half chord line. This is the Neutral Point of this wing panel - 25%MAC.



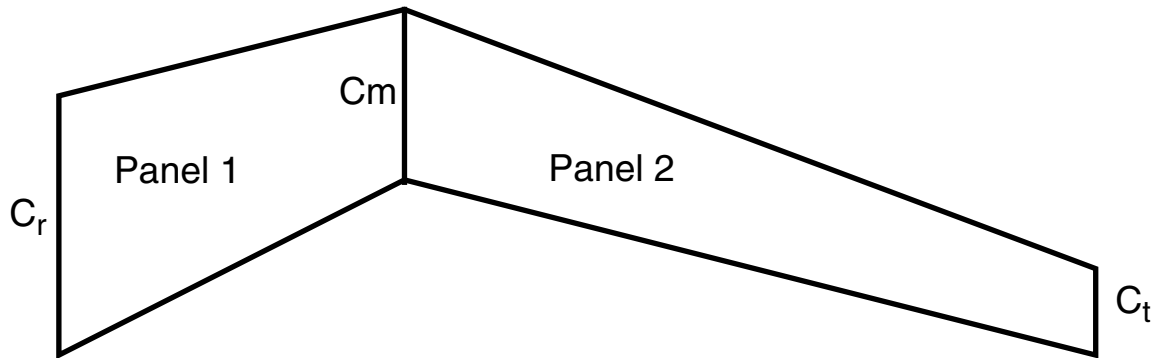
Step 7

- Draw a line connecting the Neutral points of the left and right wing panels. This provides an intersection with the center line.
- The Neutral Point is then easily projected onto a side view of the root chord.

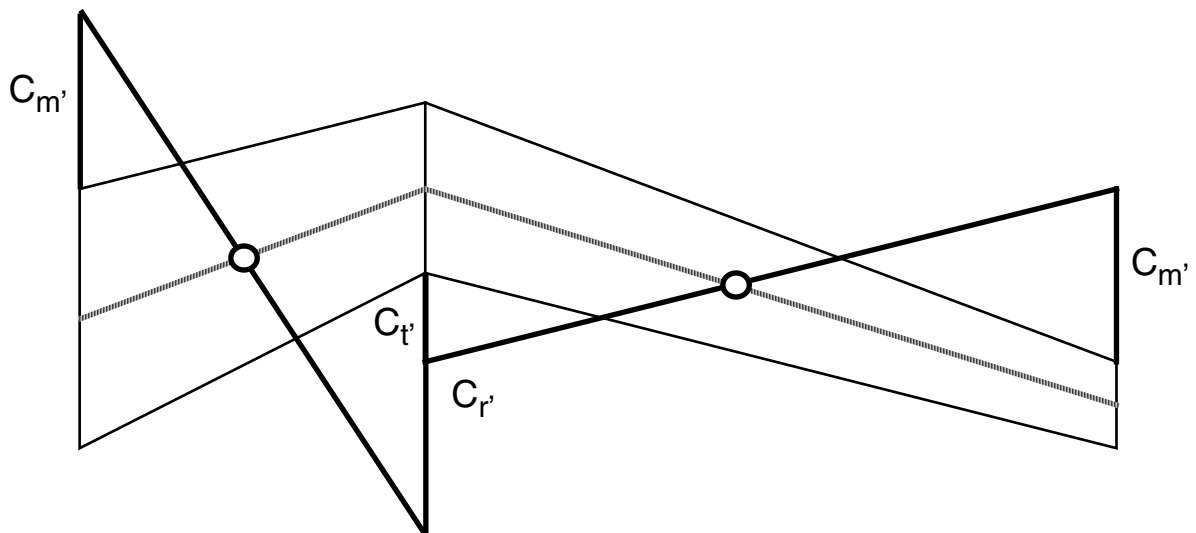


## A Graphical Method of Determining the N.P. and C.G.

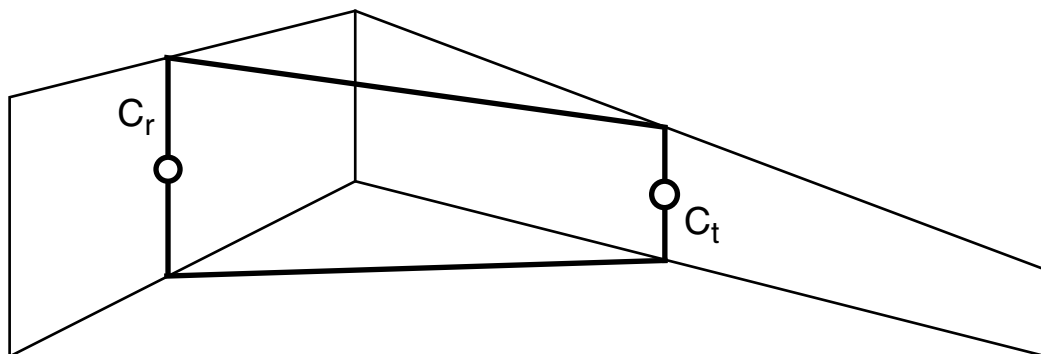
For a multi-panel wing, start with Step 1 and identify all chords which define the entire wing.



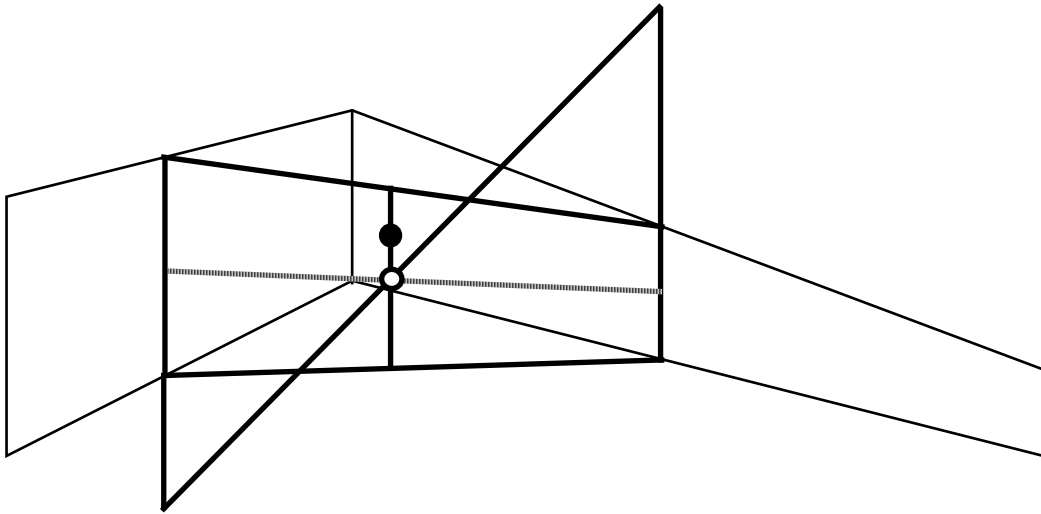
Follow with Steps 2, 3, and 4 for both panels. Since panel 1 sweeps forward,  $C_r'$  and  $C_m'$  are relocated to trailing edge and leading edge, respectively. This brings the intersection closer to a  $90^\circ$  angle. (Pretty tricky, eh?)



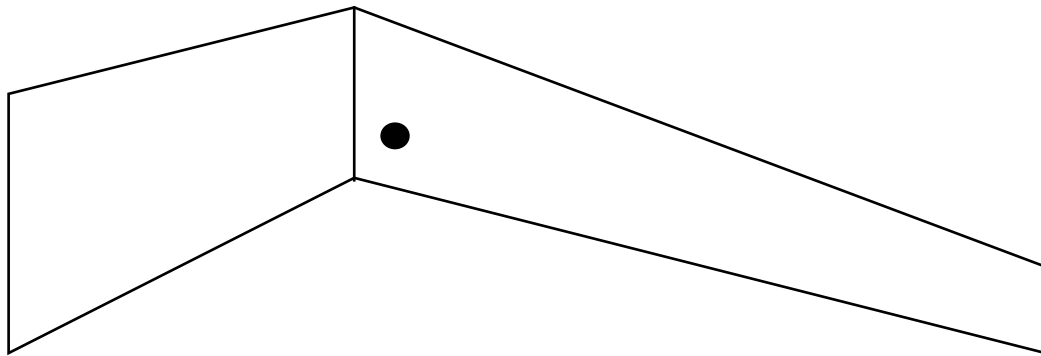
With Step 5, connect the newfound chords with artificial leading and trailing edges.



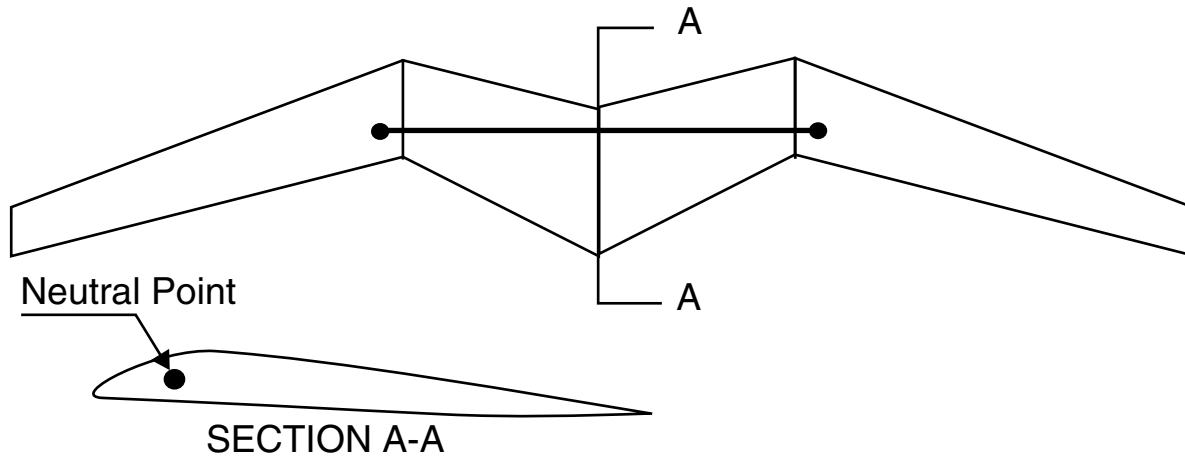
Follow Steps 2, 3, 4, 5 and 6 for this single panel.



This is the Neutral Point of the entire right wing.

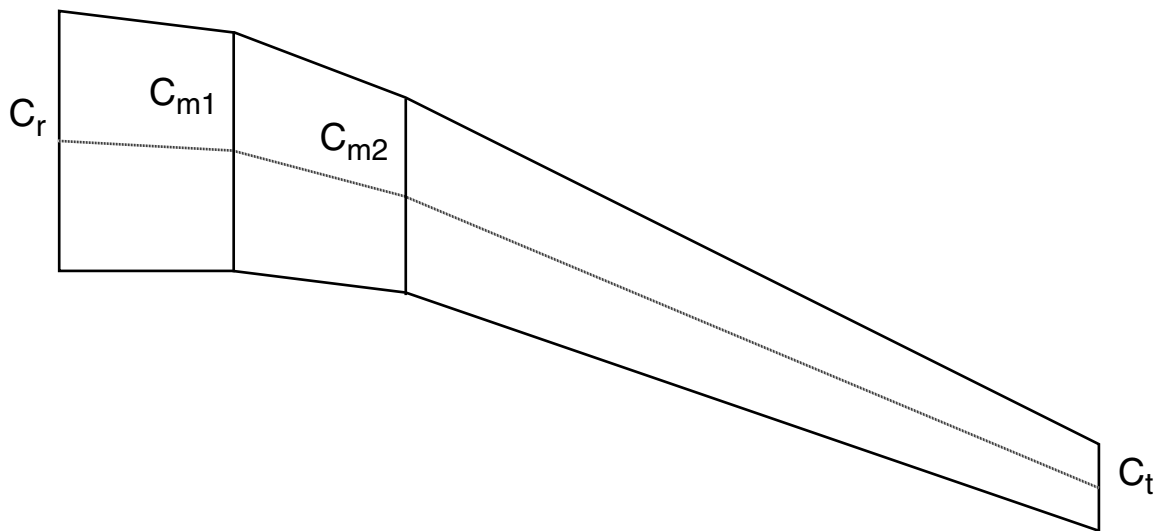


Performing Step 7 gives the Neutral Point for the entire wing and allows for projection onto the side view of the root.

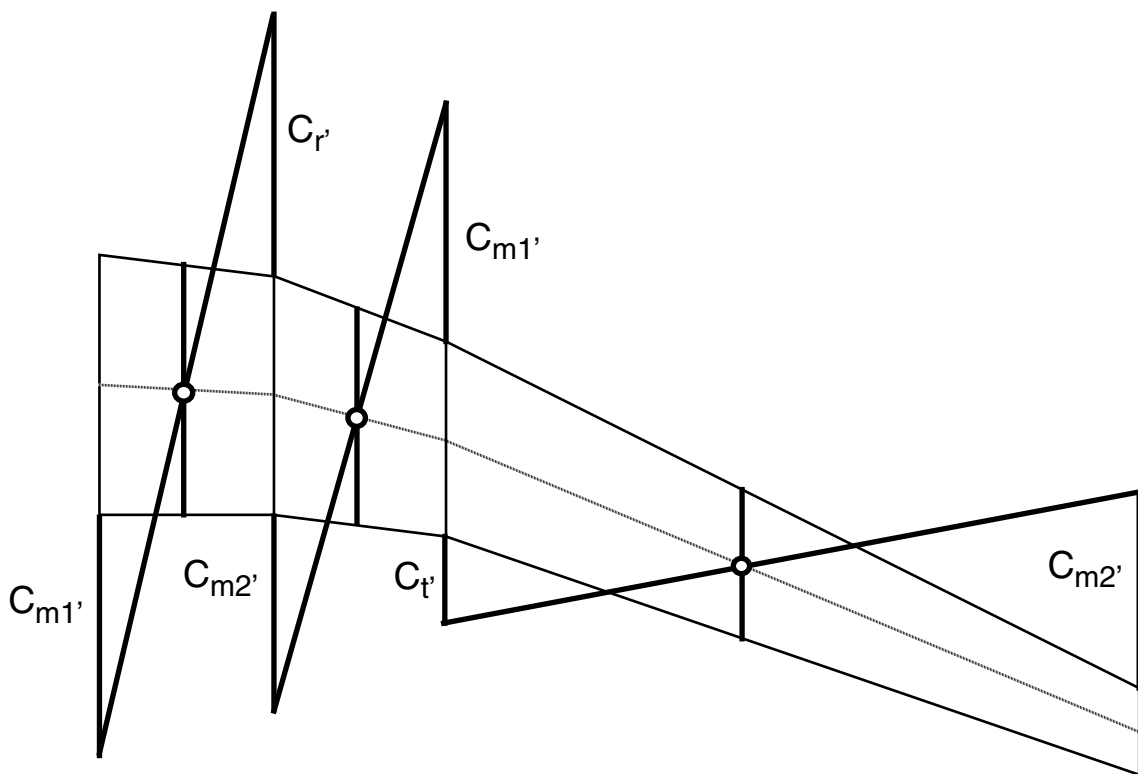


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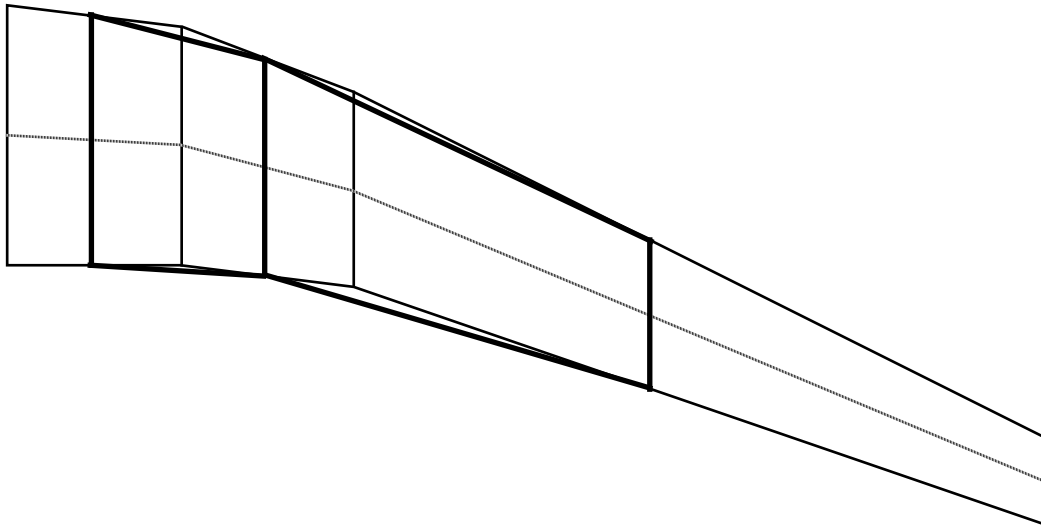
This wing is similar to that of the Akafleig Braunschweig SB-13. Begin with Steps 1 and 2...



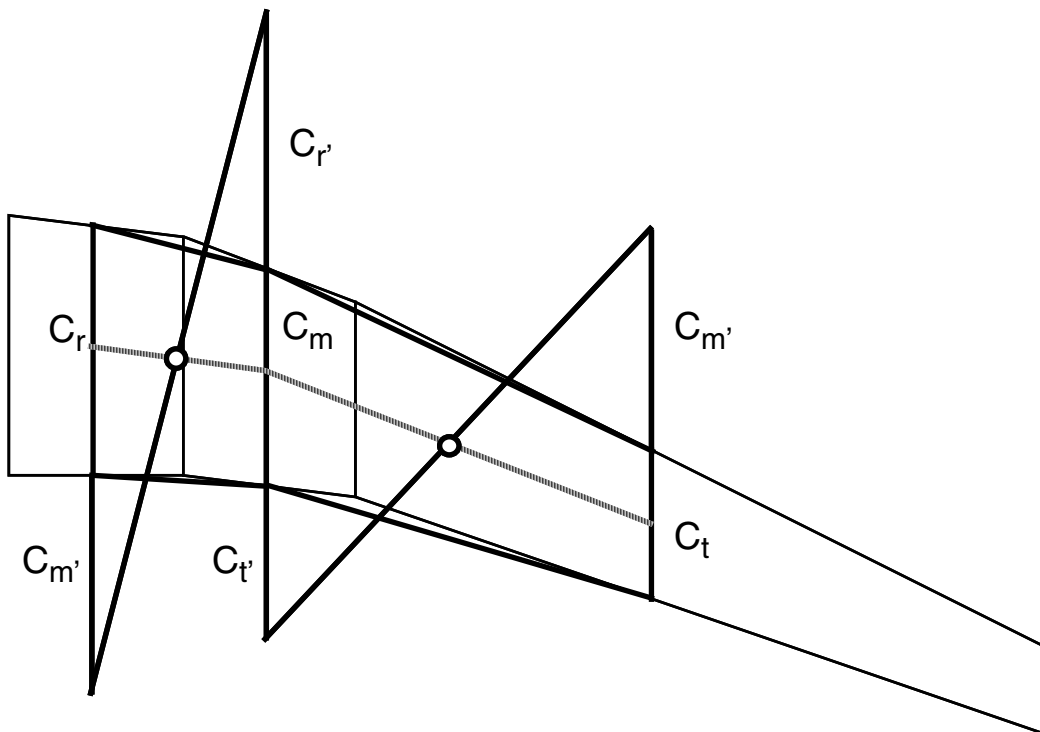
Follow with Steps 3, 4, and 5...



Then connect the new chords with artificial leading and trailing edges, just as before...

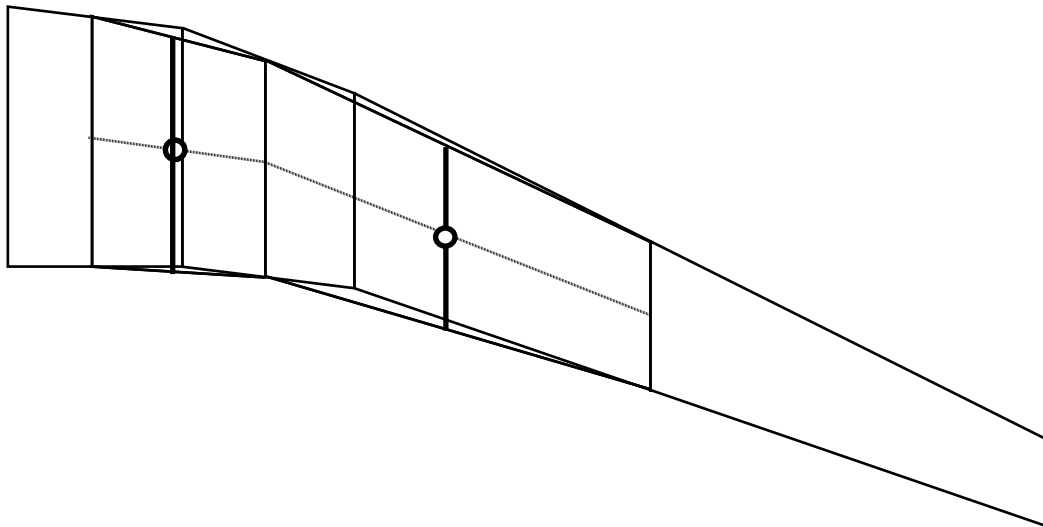


Follow with Steps 1, 2, 3, 4, and 5 using the resulting panels from the previous operations...

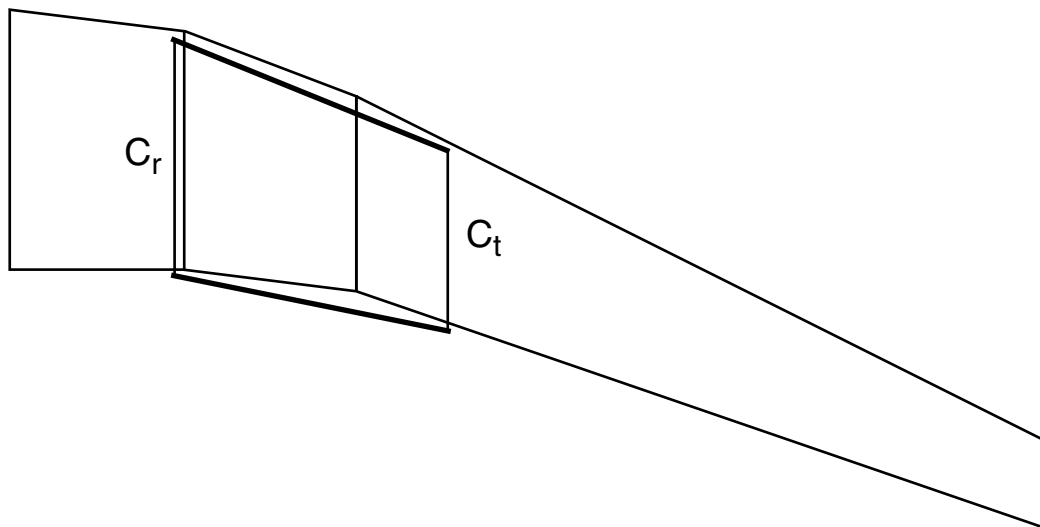




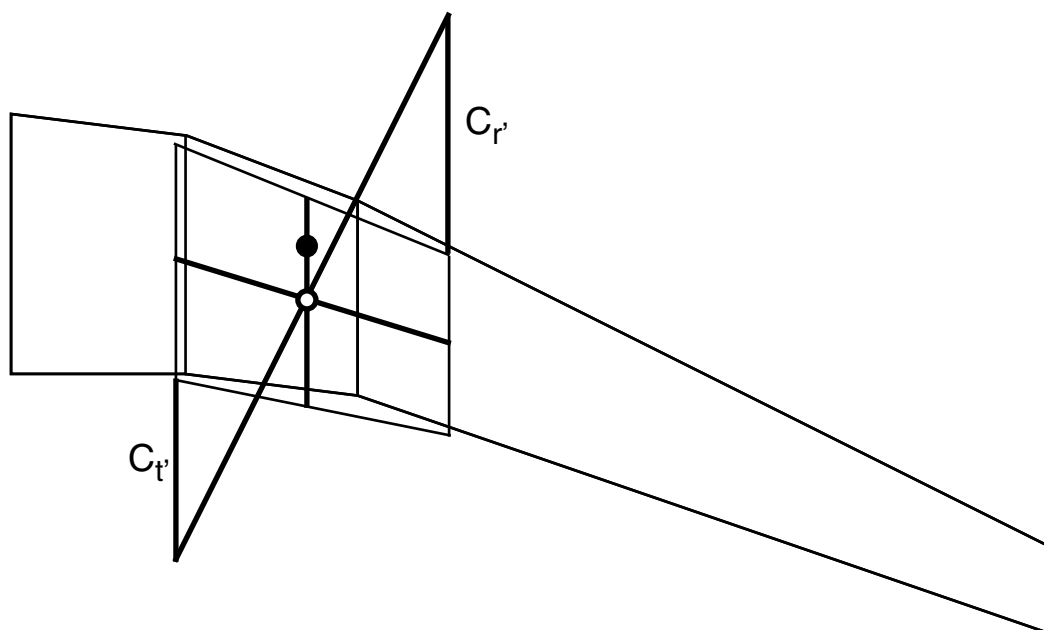
Perform Step 6 for both panels...



And connect the new chord lines with artificial leading and trailing edges.



Perform Steps 1, 2, 3, 4, 5, and 6 on the final panel...



This is the Neutral Point for the right wing panel. Performing Step 7, as before, finishes the process.

