“Six-flap” Control Systems

In response to requests, here’s an examination of multiple control surface systems. These are commonly called “six-flap systems” in the literature, although, as you’ll see, some may have more than or less than six control surfaces in total.

The usual reason for a multiple control surface system is to more closely approximate the ideal lift distribution for all conditions, including maneuvers. Since a thermal sailplane is very seldom flying straight and level at a moderate speed, maintaining an appropriate lift distribution during other flight regimes has become a very important consideration. With modern computerized radios, it is possible to configure the transmitter such that control surfaces can be automatically adjusted to proper deflection without direct input from the pilot.

To begin, we’ll look at the control system used on the SB13 “Arcus,” the full sized swept wing sailplane built by Akaflieg Braunschweig and detailed in this column. This control system, depicted in Figures 1.1 and 1.2, uses elevator and aileron functions, along with differential rudders. The SB13 follows the Standard Class rules and therefore does not employ flaps.

The elevator function utilizes the outboard surfaces to produce a very strong force at the greatest possible distance from the CG. The movement of the inboard surfaces acts to distribute the aerodynamic load across a larger portion of the wing, thus reducing any stress rise.

As can be seen by Figure 1.2, aileron function involves some complex mixing of the control surface linkages. The aim here is to produce equivalent but opposite roll forces on the two wings, while at the same time reducing adverse yaw. This allows a rolling movement without the influence of either pitch or yaw forces. In a turn, the pilot can induce roll and pitch independently of rudder induced yaw.

The rudders are set up for differential movement. The outer rudder moves inward, albeit a very small amount, thus lifting it forward. The inner rudder, on the other hand, moves toward the center of the turn a great deal, creating a significant drag differential which slows the inner wing. Combined with appropriate pitch and roll inputs, the pilot is thus capable of making very efficient coordinated turns.

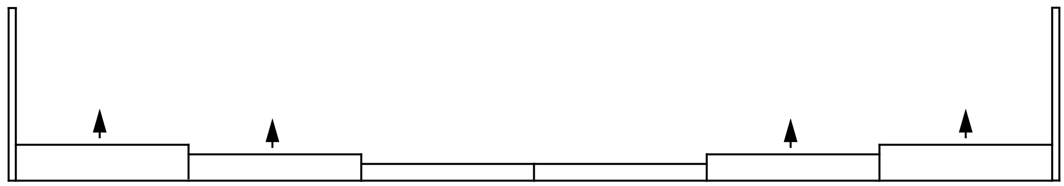

Figure 1.1: up elevator

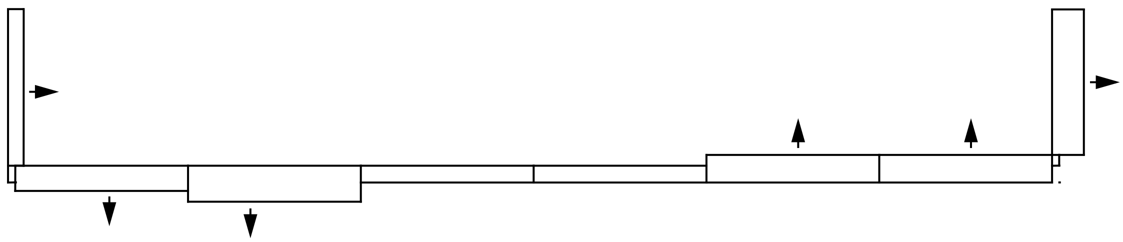

Figure 1.2: right aileron with right rudder

Akaflieg Braunscheig’s SB13 “Arcus”

The next two systems we’ll look at have been used by Dr. Michael Wohlfahrt. Dr. Wohlfahrt is co-author, with Dr. Karl Nickel, of “Schwanzlose Flugzeuge,” a very extensive and complete book on tailless aircraft, with sailplanes the primary focus. The two control systems described here (Figures 2.1- 2.4 and Figures 3.1-3.4) were published about a year apart, with the latter system being the most recent.

These two systems are roughly equivalent, with the exception of aileron function and a small difference in deflection angles in landing mode. It would appear aileron function was changed from a rather complex mixing configuration, similar to that seen on the SB13, to one which is more simple and seems to derive added effectiveness from increased leverage.
We’ve kept the most complicated control system for last. DELTA #4 provided information on Hansjorg Ackerman’s SWALC (Swept Wing Automatic Lift Control). This control system, which uses Multiplex equipment with a “Softmodul,” allows inclusion of some rather unique control functions and is illustrated in Figures 4.1- 4.5.

It is interesting to note the SWALC elevator function, as it is directly opposite to what is seen in the SB13. Mr. Ackerman’s intent is to promote a very specific lift distribution over the outer wing. Since the wing incorporates washout, and produces a “bell shaped” lift distribution when no control surfaces are deflected, elevator function must overcome that initial lift distribution and produce a lift distribution which is most effective at giving

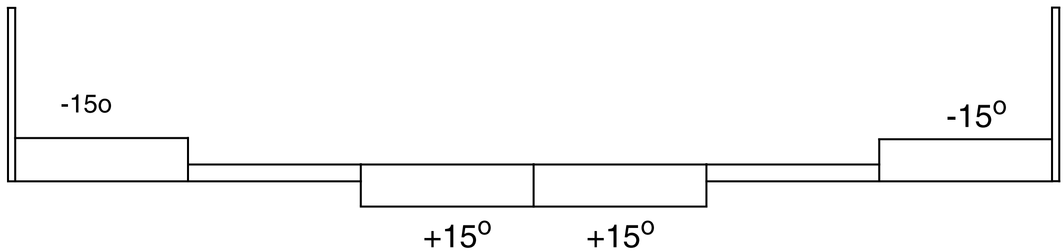

Figure 2.1: up elevator

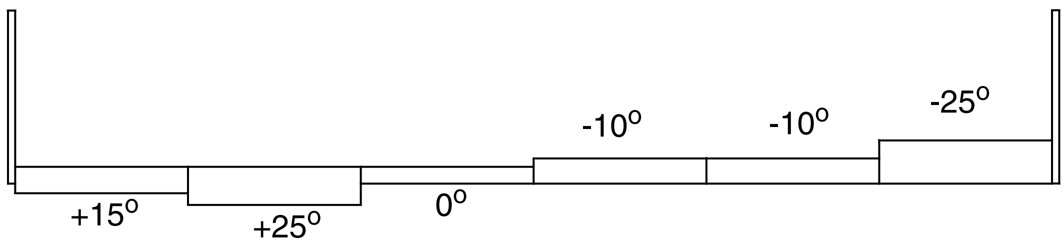

Figure 2.2: right aileron

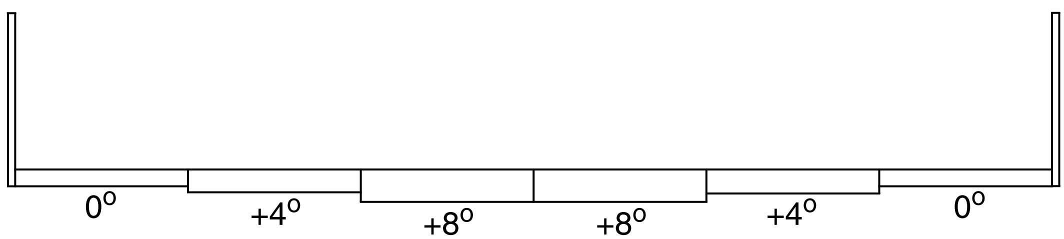

Figure 2.3: positive flap

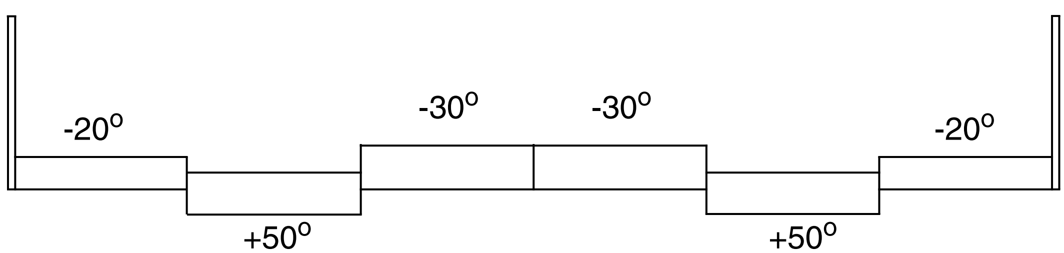

Figure 2.4: landing

Dr. Michael Wohlfahrt, 1989

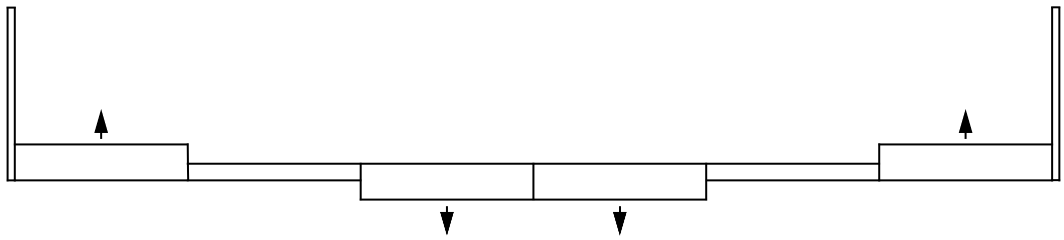

Figure 3.1: up elevator

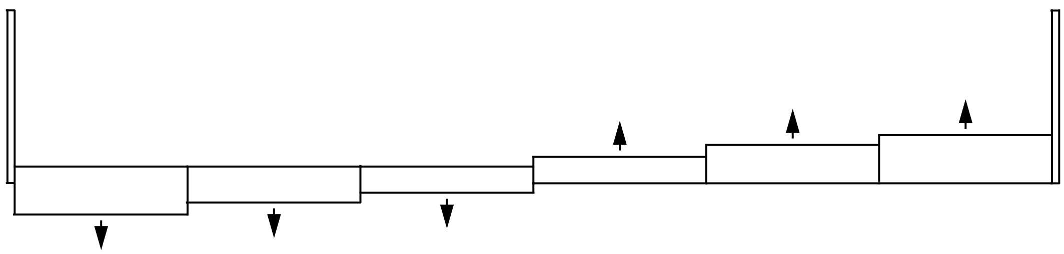

Figure 3.2: right aileron

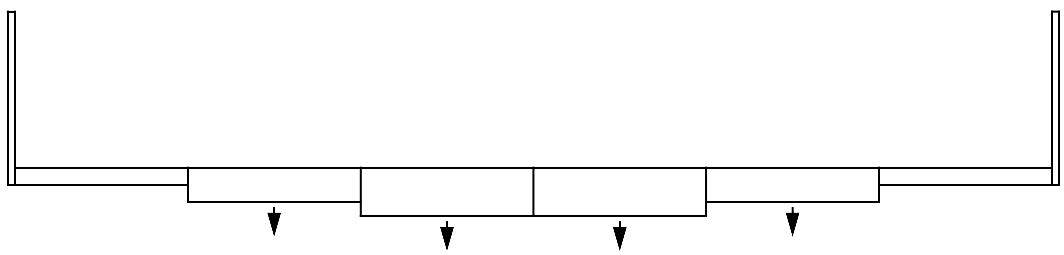

Figure 3.3: positive flap

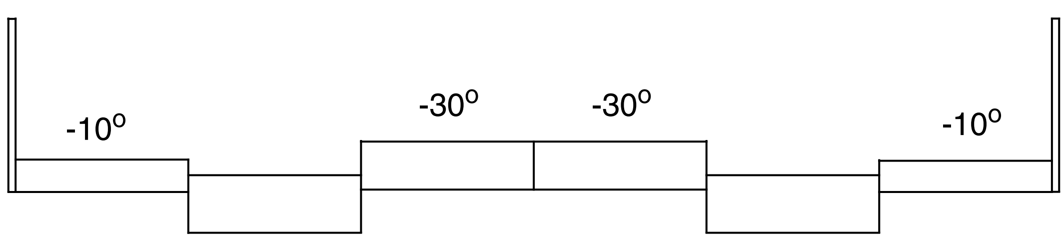

Figure 3.4: landing

Dr. Michael Wohlfahrt, 1990

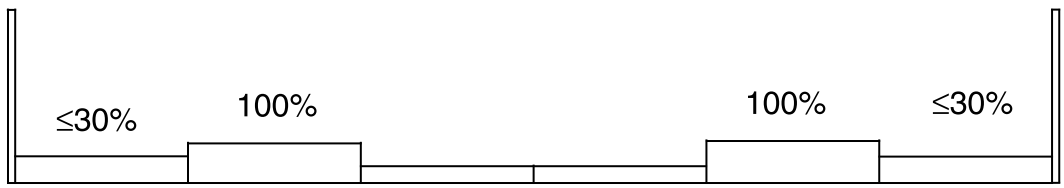

Figure 4.1: up elevator

Figure 4.2: right aileron

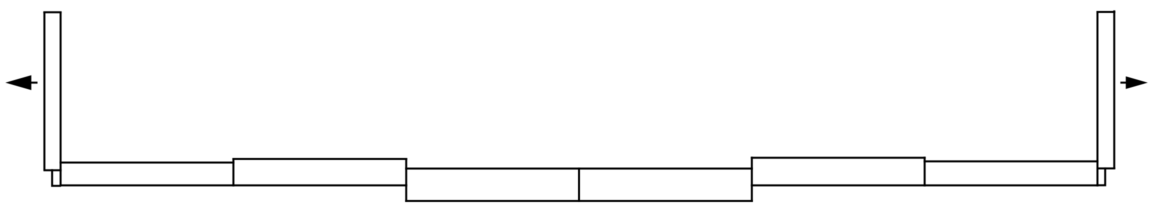

Figure 4.3: thermal

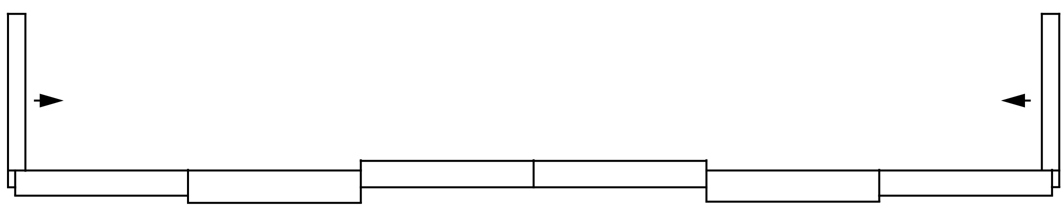

Figure 4.4: speed

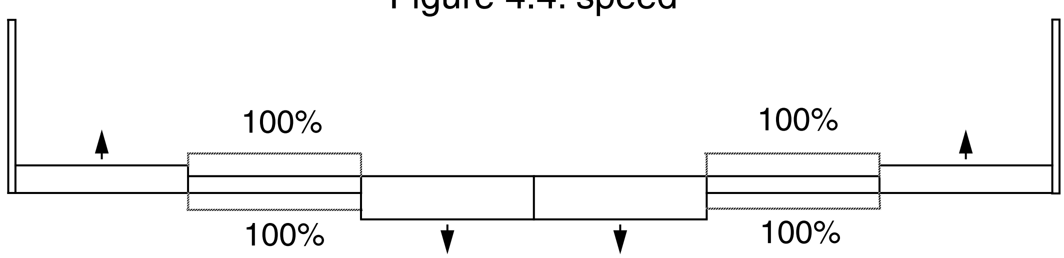

Figure 4.5: landing

Hansjorg Ackerman, S.W.A.L.C.

the pitch authority needed. Aileron function is unique in its own way as well, in that includes absolutely no differential. We have talked about swept wings and aileron differential previously, and Mr. Ackerman's control system adds credence to our contentions.

Rudders, if they can be called that, are not used in turning. However, they play a very important role in thermal and speed modes, where they trim the vertical surface to best advantage for a specific flight regime. In thermal mode, the rudder surfaces move outward, and the vertical fins become pseudo-winglets which contribute to improving lift. In speed mode, the rudder surfaces deflect slightly inward, reducing the drag of these surfaces to a minimum.

In landing mode, flaps go down and outboard control surfaces move up. This is a "butterfly" configuration, and the control surfaces move in relative unison. Pitch control in this configuration is accomplished by deflection of the middle control surfaces and should be very effective.

It should be noted that each of the described control systems is installed in a different wing planform, with sweep angle and taper ratio sometimes varying markedly between designs. Before incorporating any multiple control surface system into a design, great care needs to be taken to assure the lift distribution will be affected in the exact way the designer wishes.

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