be described as a "one-handed aeroplane." All operation from take-off to landing, including violent manœuvres, could be conducted by the pilot with only one hand on the flight controls, leaving the other available for cockpit operation.

The 707's control system was, in Boeing's view, the "ultimate development of a fail-safe and responsive system." All primary controls were operated by control tabs and balanced by unique pressure-plate balances located forward of the surface hinge-lines. The stabilizer was manually adjusted by the pilot except for large trim-changes occasioned by large speed-changes or operation of the wing flaps. In this event, a small electric motor actuated the manual stabilizer trim system for the pilot, if he so desired. The wing-mounted spoilers were the only hydraulically-operated surfaces.

Complete loss of the dual hydraulic systems merely reduced the crosswind landing capability of the 707 from approximately 35 m.p.h. to 10-12 m.p.h. of crosswind component. In this event, of course, both the landing gear and wing flaps must be lowered manually. The pilot control-forces and flight-stability characteristics of the 707 were "deemed superior by the many airline and military pilots who have flown the aircraft, thus indicating that Boeing design objectives have been attained with a fail-safe system."

Structural philosophy.—In the case of the 707, this might be briefly summarized as follows:—

(a) Anticipate that structural integrity will inevitably be compromised by flight or ground damage or collisions, defects in manufacture or faulty maintenance in service.

(b) Select the structural design criteria to control the consequences of such damage. Test and redesign and test again to substantiate the validity of the design criteria. Thus Boeing had provided a fail-safe structure that could absorb damage without sudden or rapid progressive failure, thereby providing ample time for routine inspection to detect any structural damage.

(c) Establish close liaison with each operator to aid in maintaining the original design reliability.

In order to satisfy this design philosophy, many specific design criteria had to be established and confirmed by component and/or full-scale tests. A few general examples could be listed:

(a) Provide multiple load-path structure such that a single component failure will not cause the structure to fail. This could be applied, for example, to the attachment points for the vertical fin, control-surface hinges or the more complex structure around cutouts for windshields, doors and windows.

(b) Provide tear resistance by incorporation of tear-stopping reinforcement material and/or selecting low working stress levels.

(c) Select low working stresses to preclude abnormal fatigue maintenance or inspection requirements.

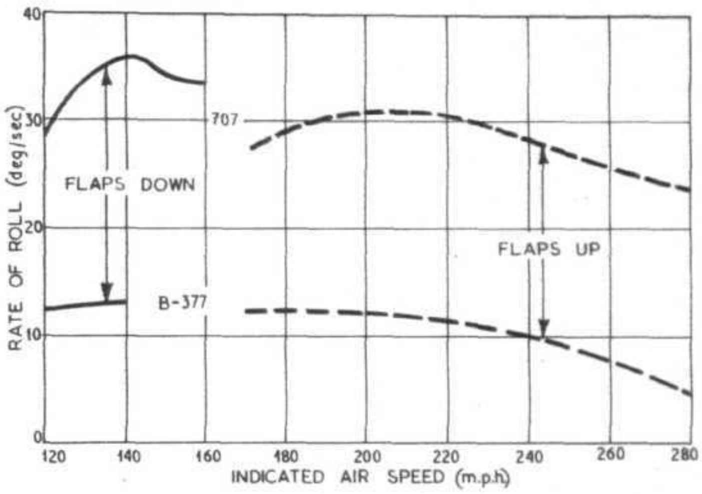
(d) Provide ample fatigue endurance after partial failure to provide adequate time for discovery of any failure.

(e) Use plug-type doors, hatches and windows to eliminate catastrophic failures of latches and hinges.

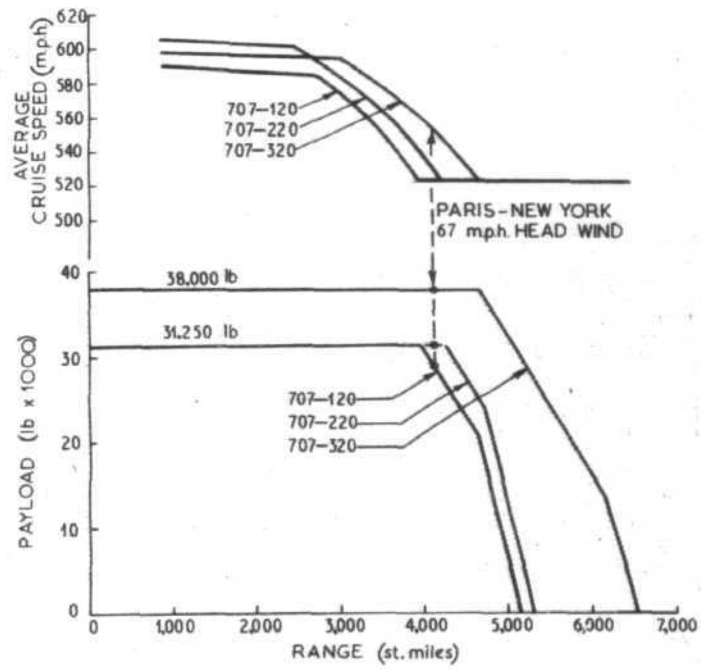
When creating a light and efficient structure, a designer had to rely heavily on past experience. Thus the extensive structural tests completed on the B-47, B-52 and prototype tanker-transport were of great value. The B-47 and B-52 had been static-tested on the ground and flight-tested to establish loads and load distribution under all manœuvres. Flight-load testing had already been accomplished on the prototype 707, as well as flight flutter tests to ensure a flutter-free structure at all speeds up to M=0.95. Fatigue testing of critical wing joints, splices, and structurally complex areas or sections was now being accomplished at Seattle. Additional fatigue tests on fuselage components, body tear-resistance tests, and, later, full-scale body fatigue tests were planned. As this work proceeded and was evaluated, additional testing would be planned as required. [*Continued overleaf*

Subject	No. of models	Type of model
Aerofoils ...	30	Two-dimensional
B-47 wings ...	34	Complete, three-dimensional
B-52 wings ...	68	Complete, three-dimensional
707 wings ...	53	Complete, three-dimensional
Nacelles	308	Pod and strut configurations
Flutter	24	Complete dynamic-response models

Tabulated above are details of wind-tunnel testing carried out by Boeing in the development of their three large multi-jet projects—B-47, B-52 and 707. Aerodynamic tests accounted for 10,093 wind-tunnel hours, and flutter-test time totalled 4,930 hours.



Comparison of rates-of-roll of the Boeing 707 (upper curves) and Stratocruiser.



(Above) Payload and cruising speed (upper graph) are here plotted against range for all three versions of the Boeing 707. Each is assumed to take-off at maximum gross weight, and allowance is made for fuel reserves of 1,600 U.S. gal (707-120) and 1,700 U.S. gal (707-220 and 707-320).

The curves below for the Boeing 707 family show C.A.R. field lengths required for take-off (left) and landing at sea level I.S.A. Though its landing requirements are relatively modest, the 707 will apparently need rather longer take-off distances than are generally available at major airports today if its payload-range capabilities are to be fully exploited.