Chapter 3 Flight Control Systems

3.1 Evolution of Flight Control Systems

- Simple Cable (or Pushrod)
- Hydraulic Boost
- Stability Augmentation System (SAS)
- Control Augmentation System (CAS)
- Fully Powered Controls
- Fly by Wire
Control System

Wing Warp (Twist) System
Flyer by Light Brothers

Aerodynamic Control Surface System
Tab: Small sub-surface to assist the control surface deflection

Trim Tab

Trailing Edge Down

$\delta_t > 0$

Aerodynamic Control Surface

Universal Joint

Balance Tab

Control Stick

Universal Joint

Servo Tab

Control Stick

Trim Wheel

Spring Tab

Control Stick
Chapter I-3 Flight Control Systems

Conventional Mechanical Control System

Control Command Sensor (Transducer)

Motion Sensor

Electric Wire

Electric Unit (Computer)

Servo Valve

Hydraulic Line

Pitch Control

Lateral Control

Control Stick

Aileron Actuator

Elevator Actuator

Advantage of Fly by Wire

- Simple System
- Reduction in Weight
- Volume Efficient
- Higher Reliability
- Good Maintainability
- Integration of Control Augmentation
- Independent of Structure Deformation
- Improved Cockpit Layout
- Flexible in Aerodynamic Shape
- Reduction of Development and Aircraft Cost

Fly-by-Wire Control System
3.2 Automatic Flight Control System

Gyro System

Evolution of Aircraft Automatic Flight Control System
Flight Control Technology

Improvement of Flight Characteristics

- SAS (Stability Augmentation System)
- CAS (Control Augmentation System)
- FBW (Fly by Wire System)*

Reduction of Pilot Work Loads

- FMS (Flight Management System)
- ACT (Active Control Technology)
Active Control Technologies
(FBW : Fly-By-WIRE System)

Relaxed Static Stability
Controllability Reinforcement
Maneuver Load Control
Direct Lift/Side Force Control
Flight Envelope Expansion
Mission Adaptive Wing

Active Control Technologies
Improvement of Aerodynamic Characteristics
Improvement of Structure Characteristics

Load Alleviation
Structure Mode Control
Helicopter: Vibration Control
Maneuver Load Control
Gust Load Control
Work Load Reduction
Ride Control
Flutter Mode Control
Advanced Course of Aerospace Guidance and Control

Chapter I-3 Flight Control Systems

F117 (Nighthawk)
- Length: 38ft (11.6m)
- Span: 22ft (约6.7m)
- Wing Sweep Angle: 72.5deg
- Max. Takeoff Weight: 12,000lb (5,433kg)
- Passenger: 1

B2 (Spirit)
- Length: 21.03m
- Span: 52.43m
- Height: 5.18m
- Max. Speed: 1,000km/h
- Cruise Speed: M0.8
- Empty Weight: 45t
- Max. Takeoff Weight: 170t
- Payload: 18t
- Engine: GE F118-GE-100 Turbo-Fan Engine ×4基
- Thrust: 77.0kN
- Flight Range: 12,000km
- Passenger: 2名

Relaxed Static Stability
Controllability Reinforcement
Relaxed Static Stability (RSS)  Maneuver Load Control (MLC)

Conventional Aircraft

RSS Aircraft

Sub-sonic Speed

Conventional Aircraft

RSS Aircraft

SSS

Conventional Aircraft

RSS Aircraft

Wing Load

Conventional Load

Wing Tip

Maneuver Load Control Surface

Bending Moment

Root

Wing Tip

Maneuver Load Control

Shear

Root

Wing Tip

Basic Wing Lift

Active Control Input

Load Relief from Aileron at Critical Conditions

Added Bending Load

Active Flight control of Lockheed L-1011
Chapter I-3 Flight Control Systems

Flutter Mode Control

Direct Force Control