Integrated Simulation System of Aircraft

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Abstract

Integrated Simulation System of Aircraft is a networked virtual synthetic environment. This paper presents hardware-in-the-loop simulation, man-in-the-loop simulation, computer generated aircraft, virtual prototype of aircraft dynamics, and networked simulation system.

Key Words: Integrated Simulation System, Hardware-in-the-loop Simulation, Man-in-the-loop Simulation, Virtual Prototype

Generally, the simulation of the real world consists of three main parts: Entity/System (aircraft, vehicle, power plant ···), natural environment (terrain, weather, ocean) and human behavior (individual, group, organization), each part has interaction relation to the others(Fig. 1).
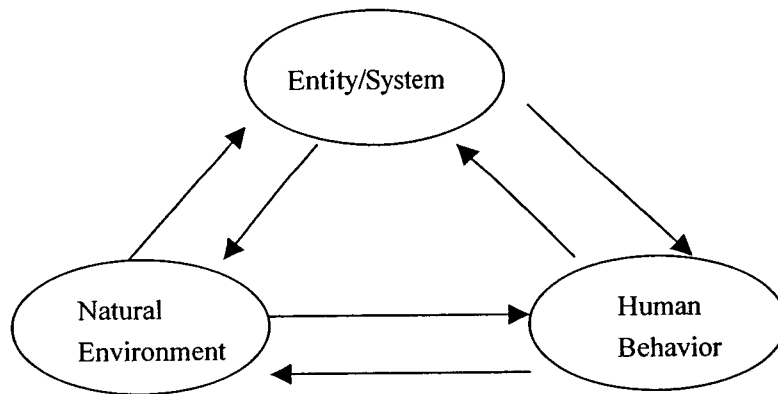

Fig.1   Real world simulation

Aircraft is a complex dynamic system, which has 6 degree of freedom movement, described by nonlinear time-variant differential equations, its aerodynamic coefficients are changed following Mach number, altitude, angle of attack, ···. The on-board equipment, as flight control system and navigation system, have multi-mode time-variant dynamics (control / navigation laws).

Aircraft Simulation System must generate the flight environment on ground. Some of the simulated flight environment are used for on-board sensors, some are faced to pilot (Fig. 2).
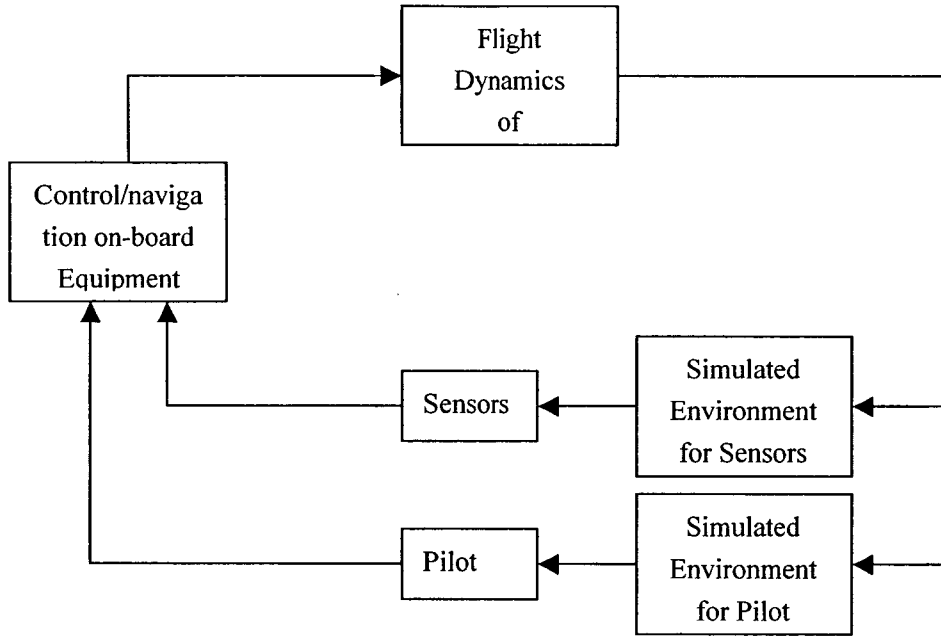
Fig.2   Flight simulation

1. Hardware-in-the-loop Simulation (HILS)

For more approximation to real situation, the sensors, control computers, actuators of flight control / navigation system, usually insert in the simulation loop. The 3 axis platform, static/dynamic air pressure generator, for example, are the simulation equipment for sensors environment. Dynamics of aircraft is described by mathematical models (Fig. 3).
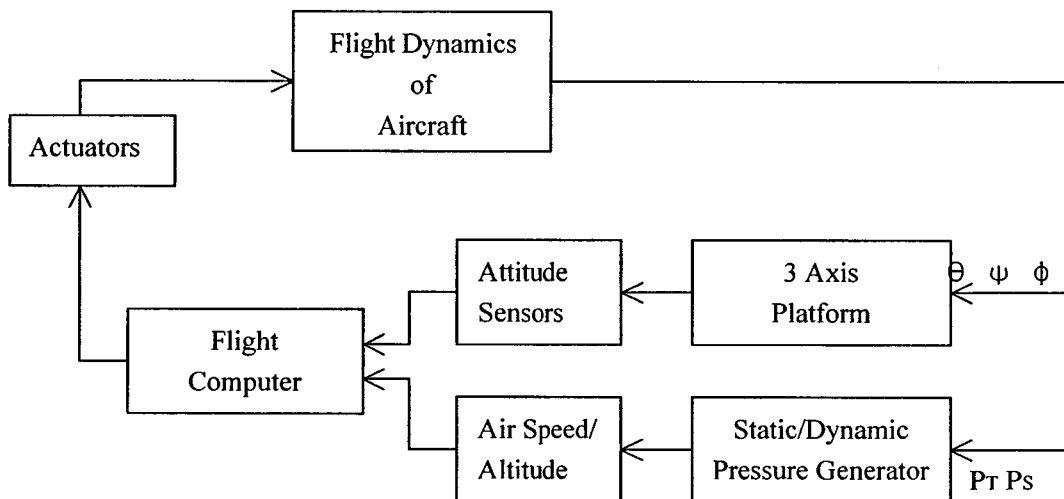

Fig.3   HIL simulation

2. Man-In-the-Loop Simulation(MILS)

The simulation environment of MILS for pilot is different from the simulation environment of HILS for sensors. This simulation environment will provide the feeling to operator. The visual system, motion system, control loading system provide the visual cue, moving cue, and feedback force cue to pilot. Dynamics of Aircraft is also described by mathematical models.
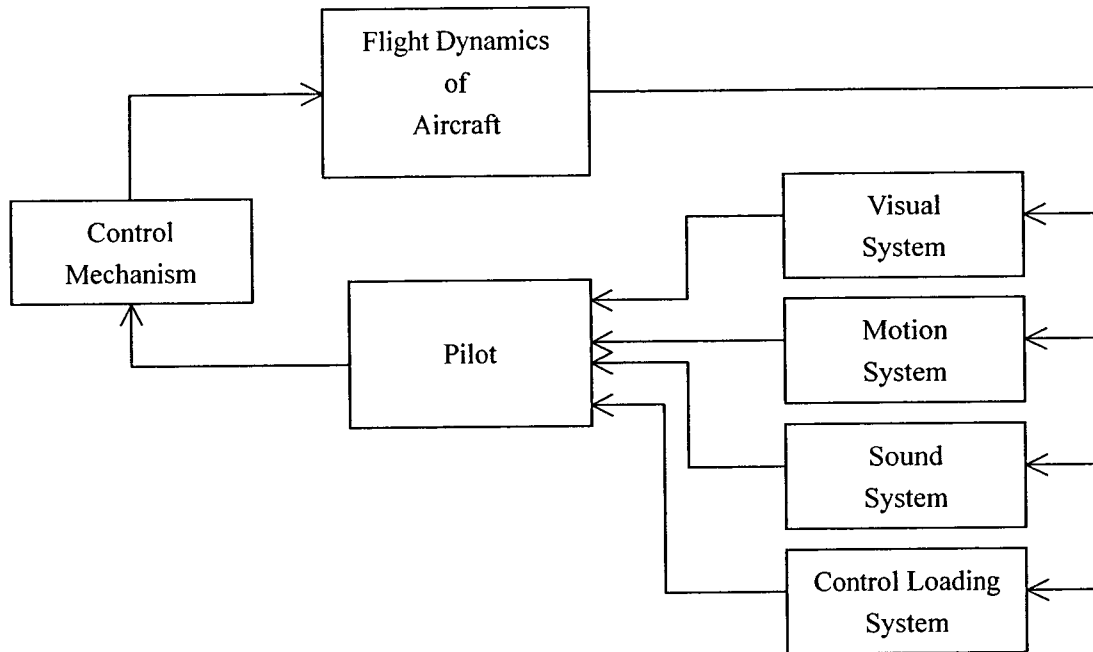
Fig.4   MIL simulation

3. Computer Generated Aircraft (CGA)

CGA is a digital entity using modeling and computer software to describe flight dynamics of aircraft and human decision behavior(Fig. 5).
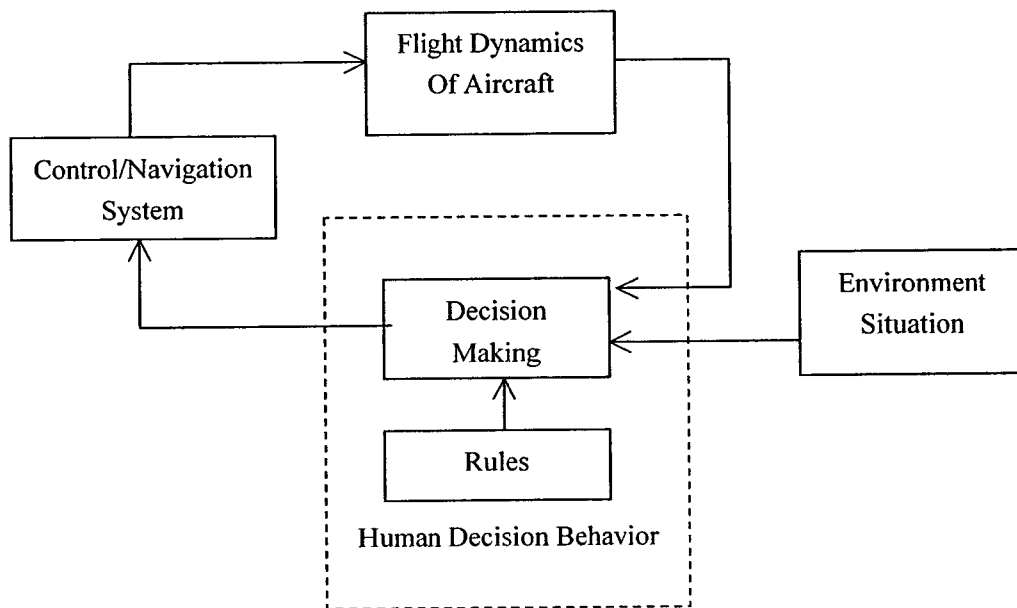
Fig.5   Computer Generated Aircraft

CGA is one kind of computer generated forces (CGF), especially used in virtual battlefield.

4. Dynamics virtual prototype for aircraft

Aircraft dynamics virtual prototype is very important in the requirement analysis/definition phase and concept design phase of R&D of new type aircraft. The designer can use virtual prototyping (VP) technology to evaluate flight performance, stability and control, and flight dynamic quality, including airplane nature dynamics and flight control/navigation dynamics.
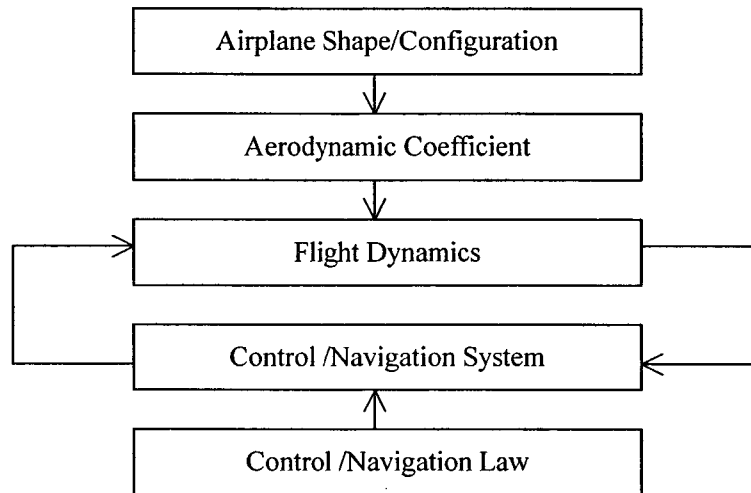

Fig.6   Dynamics VP for Aircraft

5. Integrated Simulation System for Aircraft

The Integrated Simulation system for aircraft is a networked distributed virtual environment, which can realize reuse of resources and interoperation(Fig. 7). This simulation system includes HILS, MILS, CGA and dynamics VP. The simulation task can execute separately or combinatively.
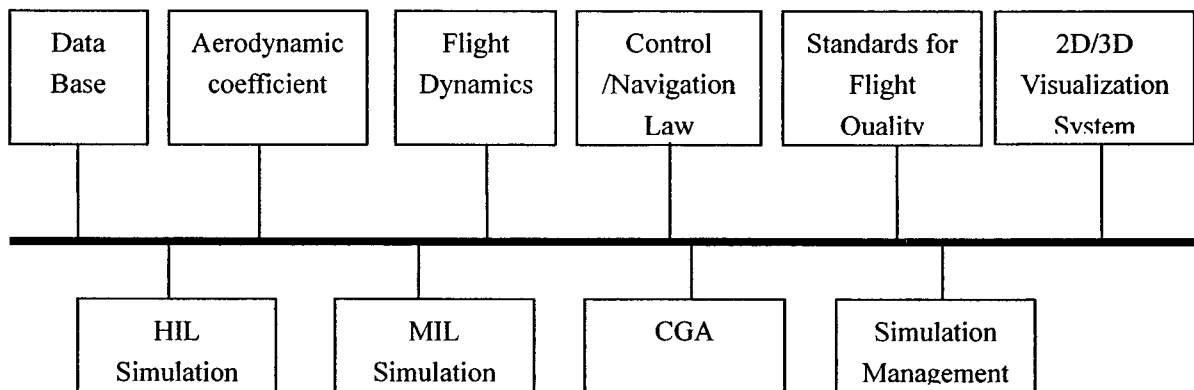

Fig.7   Integrated Simulation System for Aircraft

Conclusion

In our laboratory, the Advanced Simulation Technology laboratory (AST Lab) , we have build a networked distributed virtual environment, which consists of man-in-the-loop simulation, virtual cockpit, computer generated forces, 2D/3D visualization system, management system etc.