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A Neural Based Intelligent Flight Control System for the NASA F-15 Flight Research Aircraft

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A flight control concept that can identify aircraft stability properties and continually optimize the aircraft flying qualities has been developed by McDonnell Aircraft Company under a contract with the NASA-Dryden Flight Research Facility. This flight concept, termed the Intelligent Flight Control System, utilizes Neural Network technology to identify the host aircraft stability and control properties during flight, and use this information to design on-line the control system feedback gains to provide continuous optimum flight response. This self-repairing capability (Figure 1) can provide high performance flight maneuvering response throughout large flight envelopes, such as needed for the National Aerospace Plane. Moreover, achieving this response early in the vehicle's development schedule will save cost.

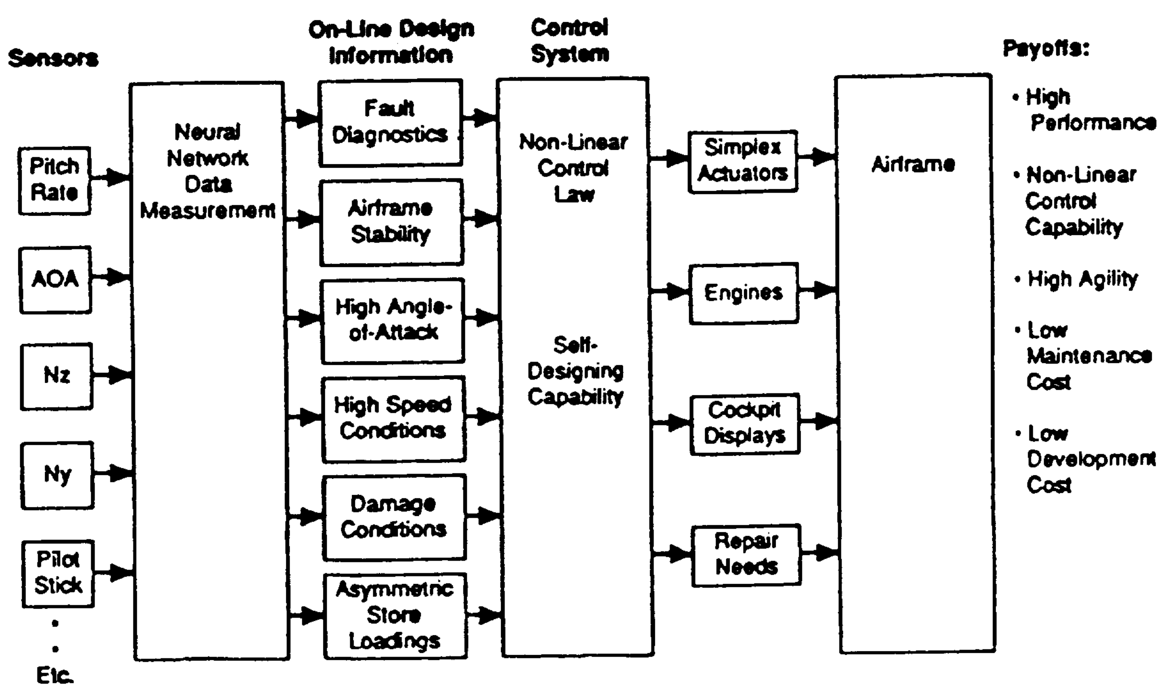

Figure 1. Self Designing Neural Flight System

The Intelligent Flight Control System (Figure 2) incorporates an Aircraft Performance Model to provide the ideal system response. On-time measurements of

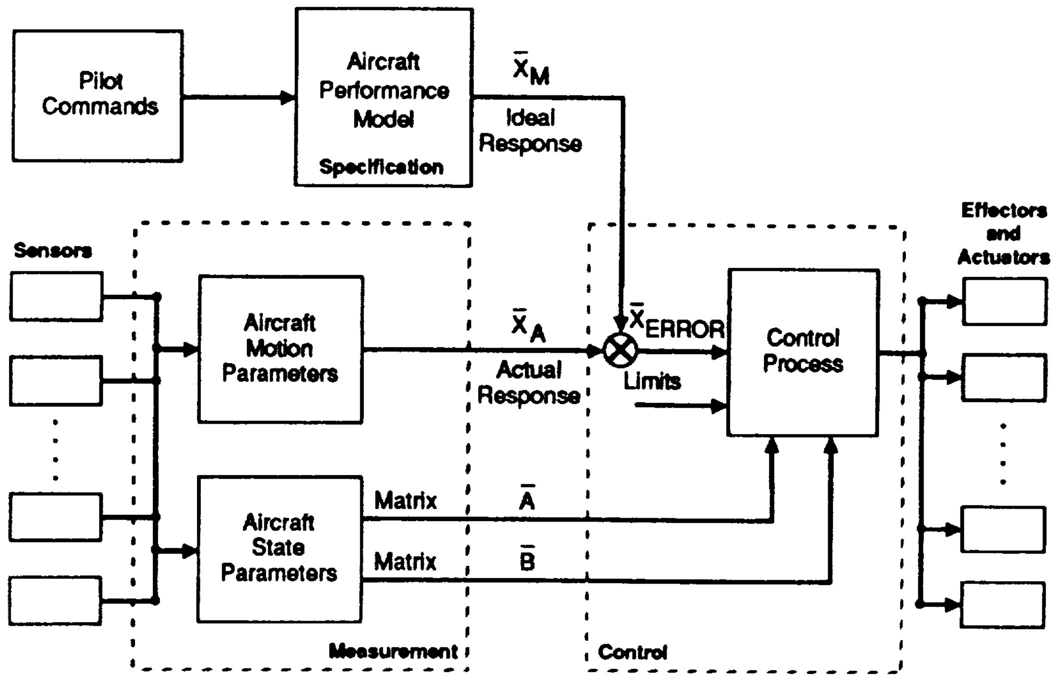

Figure 2. Intelligent Flight Control System

the aircraft state parameters are determined by neural network models that relate aircraft stability coefficients (Figure 3), utilizing aircraft sensors such as Angle of Attack (AOA) as inputs to the networks. Thus, aircraft stability and control coefficients are continuously updated, and used in the control process to achieve the ideal desired response to pilot steering commands. The concept was designed to the NASA F-15

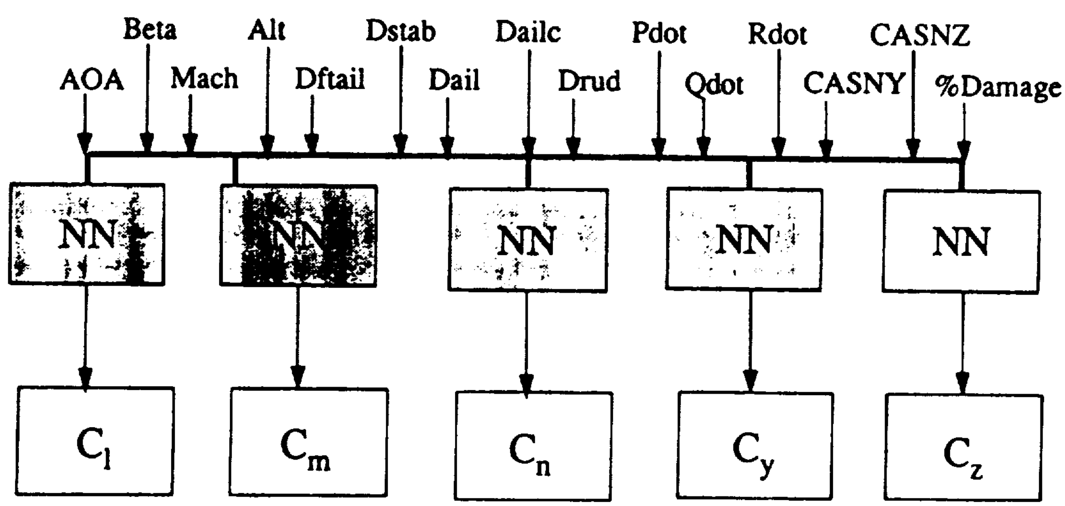

Figure 3. Neural Network Organization

flight vehicle characteristics. Simulated response of the Intelligent Flight Control system to a pilot stick command is shown in Figure 4.

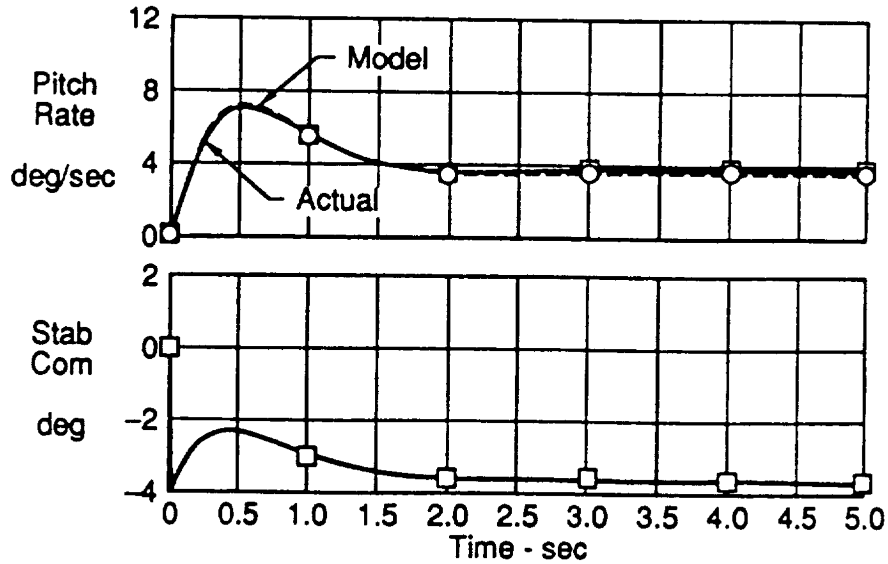

Figure 4. Intelligent Flight Control System Response
Mach 0.7 @ 20,000 Ft, GW=40,685 lb, 1 inch Longitudinal Stick Step

As a test of the concept, aircraft conditions representing a damaged wing was introduced into the problem, using the F-15 wind tunnel data for a 50% missing right wing (Figure 5). Neural Networks were developed to measure the damage, and tested using simulated time histories of the control system sensors as inputs to the networks.

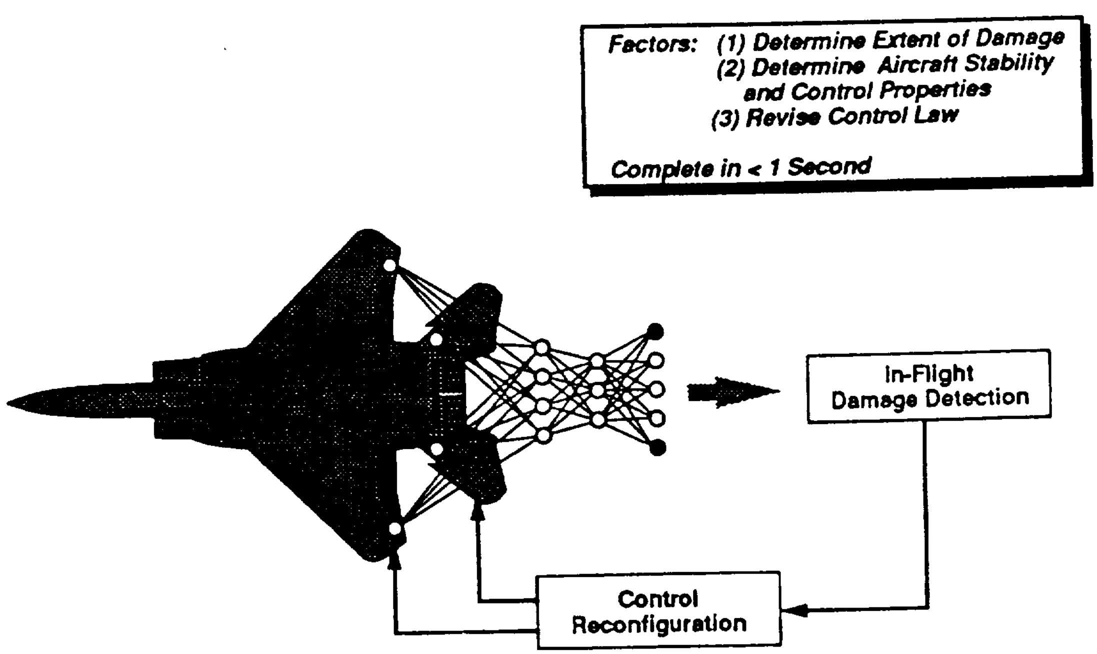

Figure 5. An Example Problem: Control of a Damaged Aircraft

Figure 6 illustrates the aircraft response time history when the wing damage occurs.

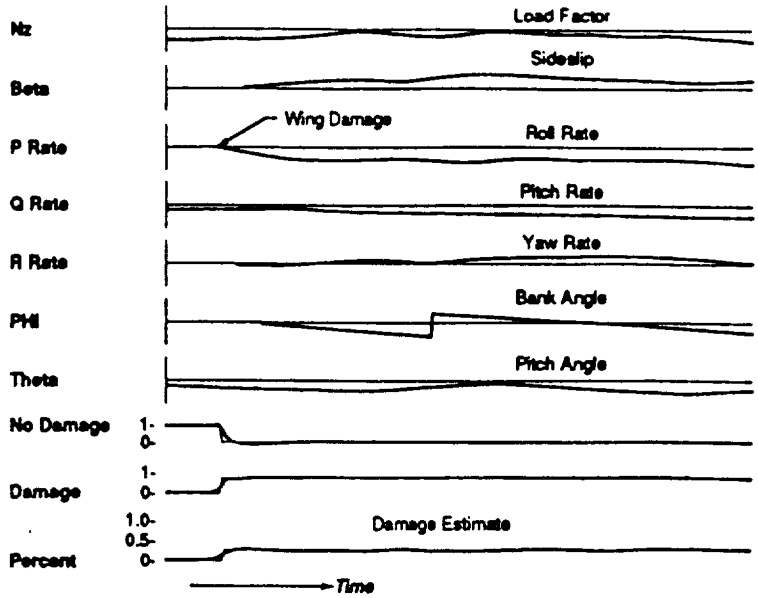

Figure 6. F-15 Response: Right Wing 50% Missing

The information from the Neural Networks will be used to quickly reconfigure the aircraft control surfaces and regain stable, controlled flight.

The Neural-based Self Designing Control Concept that is the basis of the Intelligent Flight Control system can be applied to future fighter and transport vehicles (Figure 7) to optimize engine and flight control performance.

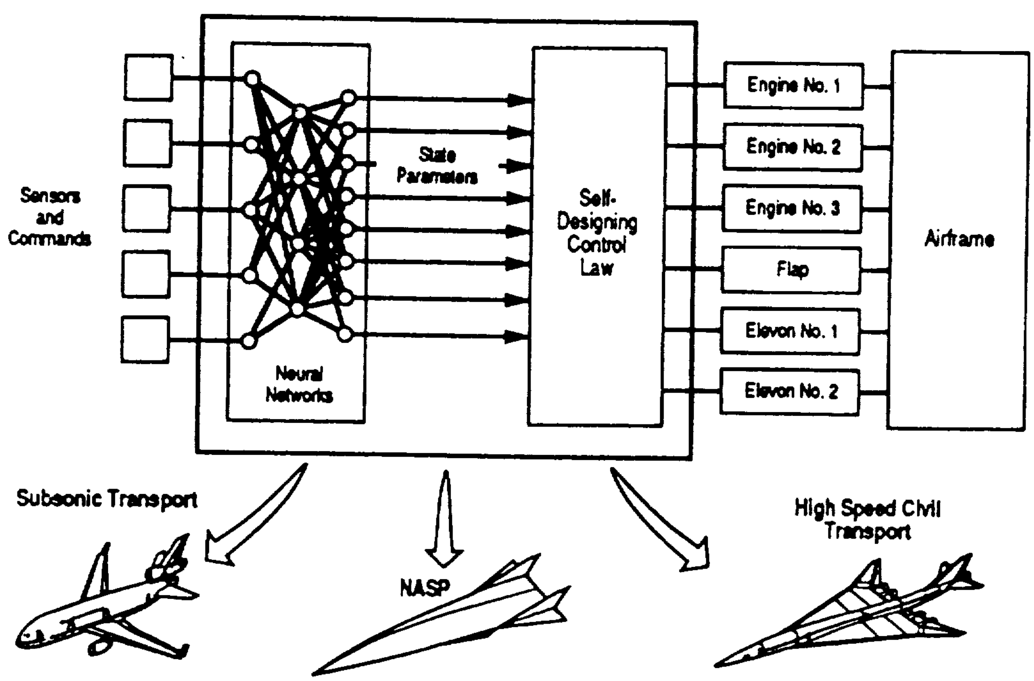

Figure 7. Neural-Based Self-Designing Flight/Propulsion Control