Neural Flight Control Autopilot System

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- **Introduction**
- **System Design**
- **Implementation**
- **Testing and Improvements**
- **Conclusions**

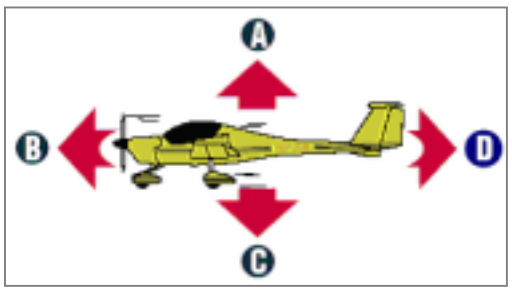
Introduction

- Neural Flight Control Autopilot System
- Aviation Knowledge
- Neural Network Control Technique

- **Intelligent Cockpit Environment** ICE
- **Neural Flight Control Autopilot System**
- **Project Goal**
  - **Design a Neural Flight Control Autopilot System**
  - **This system is able to control the airplane to take off, fly up and fly down**
  - **Develop a prototype running in a computer simulated environment**
  - **Investigate the ability of the Neural Flight Control System**

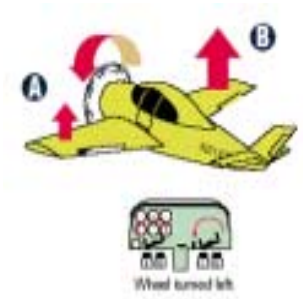
Introduction • Aviation Knowledge

- **4 Forces and 3 Controls**



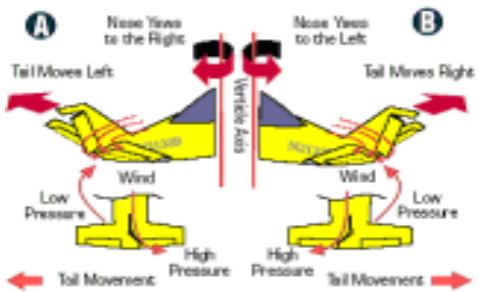
A – Lift, B – Thrust,

C – Weight, D - Drag



. Ailerons Control

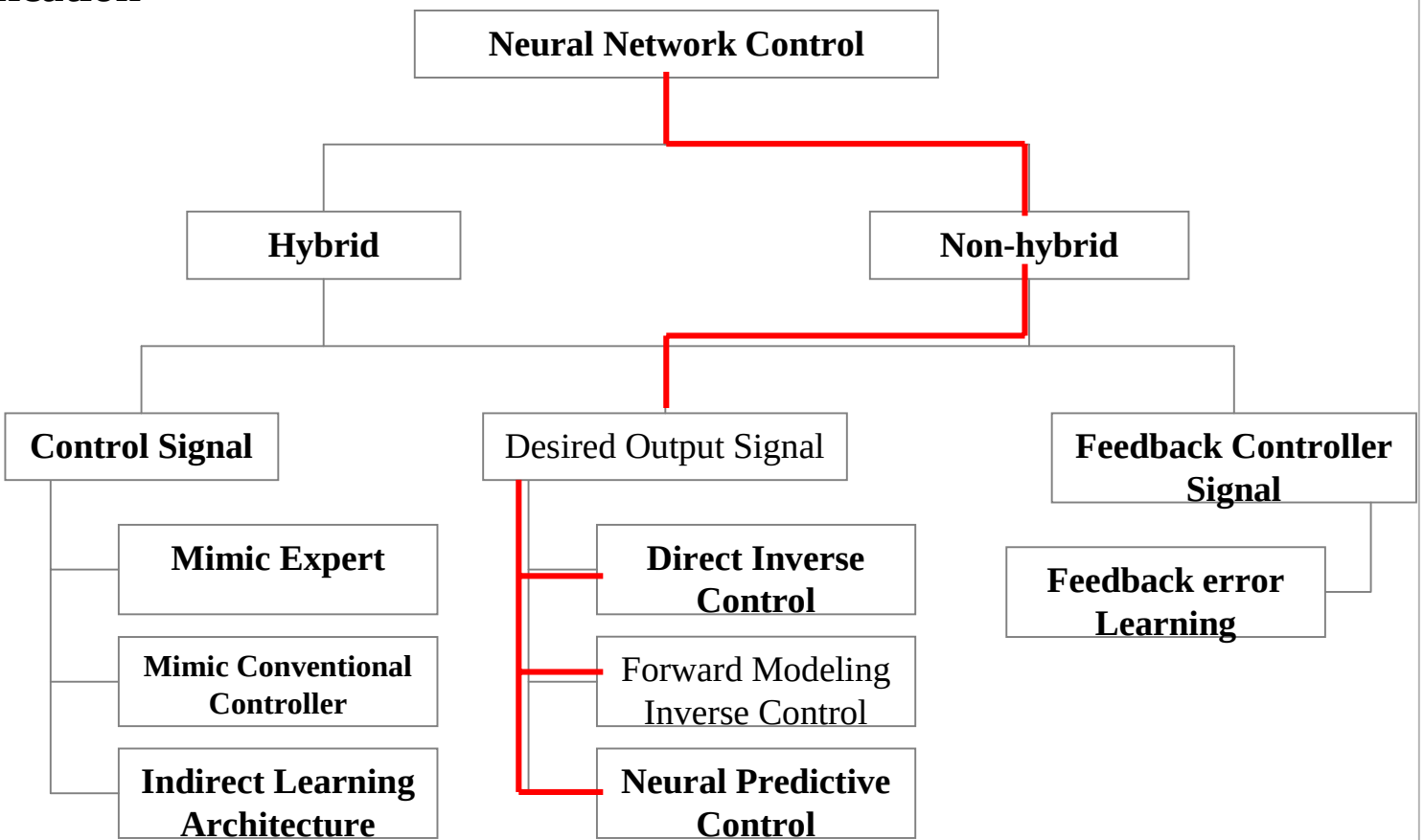
. Elevator Control



. Rudder Control

Introduction • Neural Network Control Technique

- **Neural Network Control**
  - **Classification**



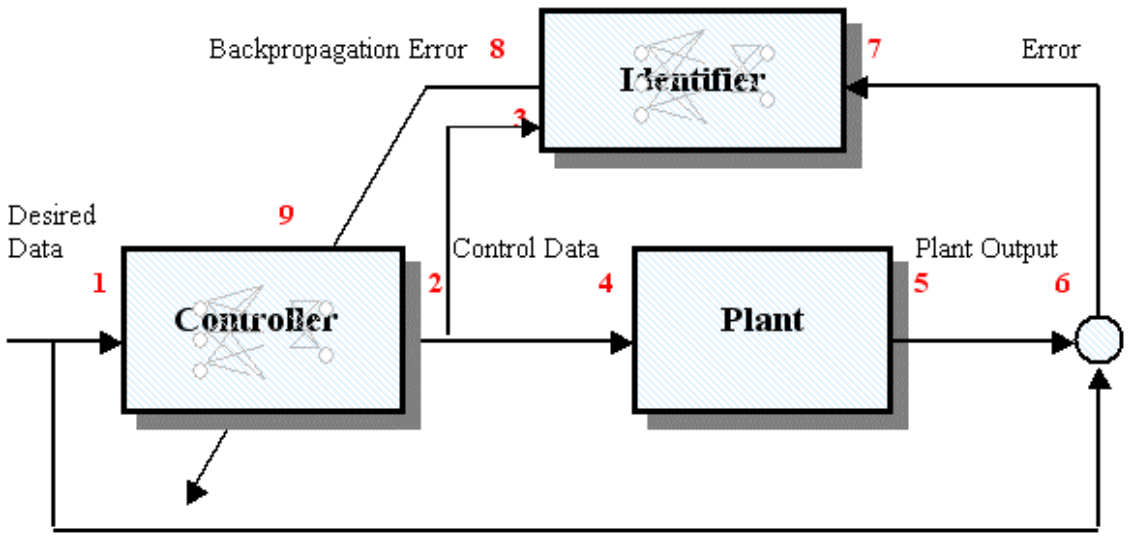
Introduction • Neural Network Control Technique

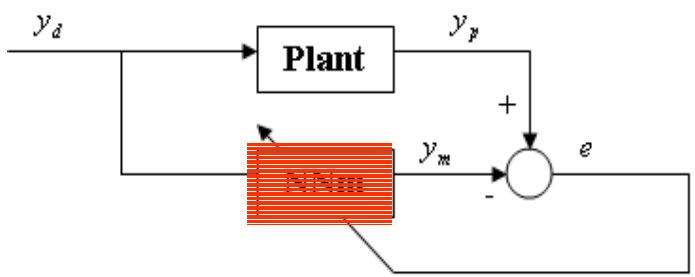
- **Topology Comparisons**
  - Direct Inverse Control Vs. Forward Modeling and Inverse Control
  - Neural Predictive Control Vs. Forward Modeling and Inverse Control
- **Conclusion**

  Adopt Forward Modeling and Inverse Control Topology

Introduction • Neural Network Control Technique

- **Forward Modeling and Inverse Control**
  - **Working Principle**

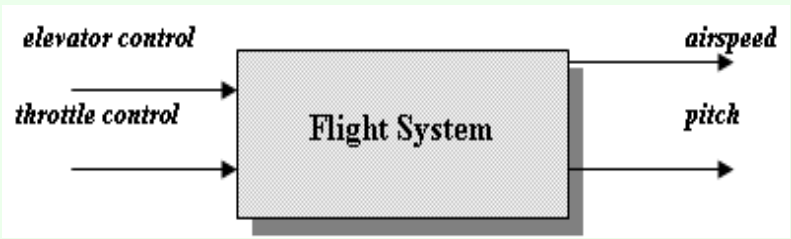


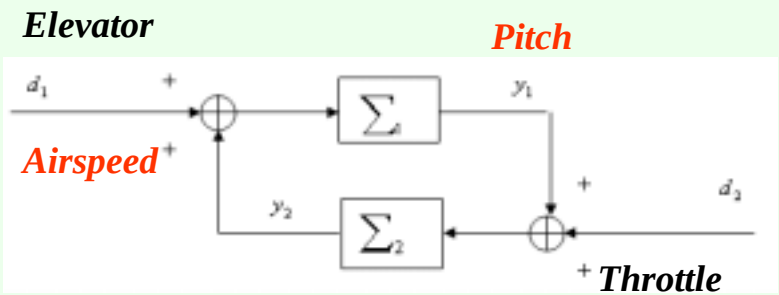


Introduction • Neural Network Control Technique

- **Forward Modeling and Inverse Control**
  - **Identifier**

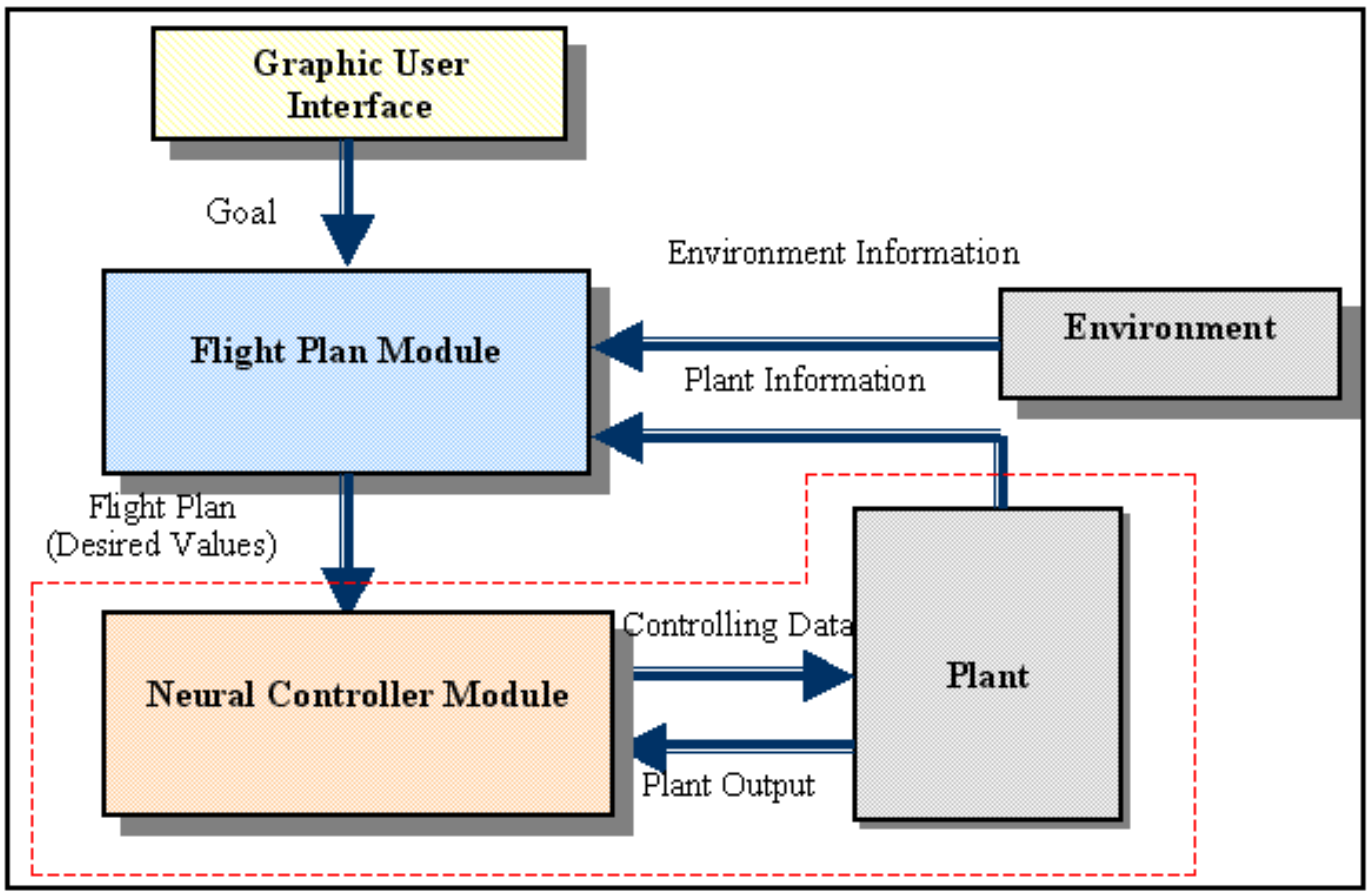
Airplane System Input-Output Modeling





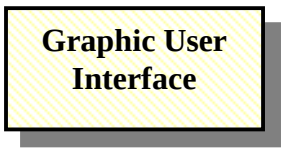
System Design

- General System Scheme
- Modules
- Module Specification



System Design • Modules

- **Graphic User Interface Module**

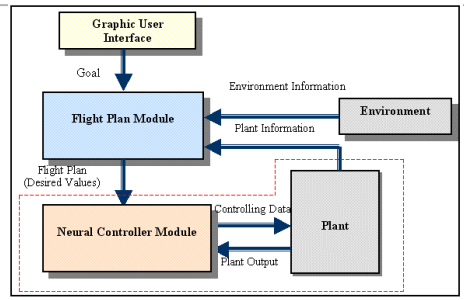


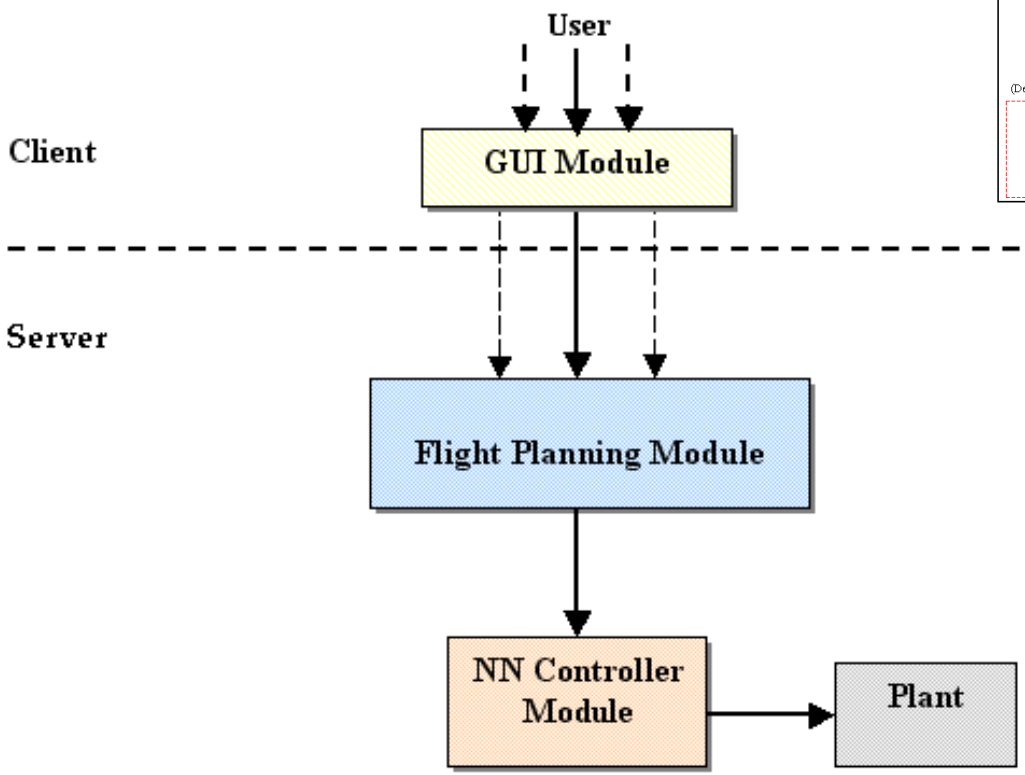
- **Flight Planning Module**

- **The Neural Network Controller Module**

System Design • Modules Specifications

- **Interaction Relationship between Modules**





- **Modules Specifications**

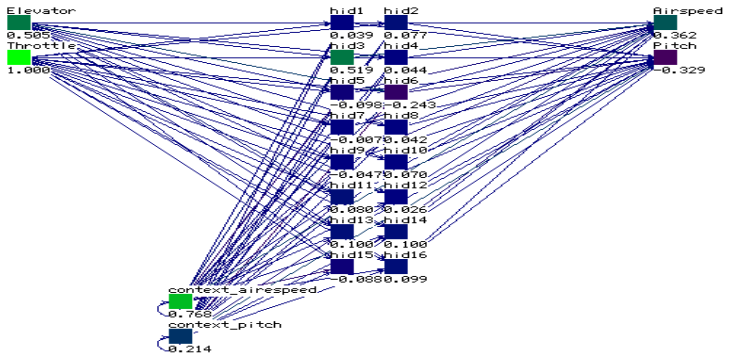
System Implementation

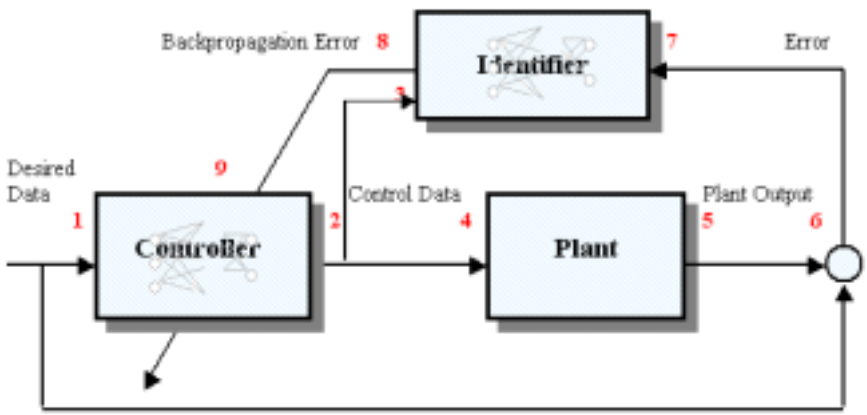
- **Programming Environments**
- **Module Implementation**
  - **Neural Controller Module**
  - **Flight Planning Module**
  - **Graphic User Interface Module**

System Implementation

• Module Implementation

- **Neural Controller Module**
  - **Controller Module Programming**
  - **Modules' Testing**





System Implementation

• Module Implementation

- **Flight Planning Module**
  - **Module's Programming**
  - **Module's Testing**

Iteration	Altitude* (.Feet)	Pitch (Degree)	Pitch Error (Degree)	Throttle Error	Elevator Error
0	596.000000	3.468187	-7.531814	0.061148	0.338214
30	623.000000	12.565063	1.565063	-0.010348	-0.082713
60	677.000000	9.766780	-1.233221	0.007887	0.060794
90	734.000000	10.656216	-0.343785	0.002343	0.019228
…	…	…	…	…	…
170	861.000000	11.218511	0.218510	-0.001320	-0.011035
200	908.000000	10.818810	-0.181191	0.001134	0.008980
230	953.000000	11.004019	0.004018	-0.000025	-0.000201
260	997.000000	10.900331	-0.099669	0.000620	0.004942
290	1045.000000	11.00052	0.000745	-0.000013	-0.000173

System Implementation

- Module Implementation

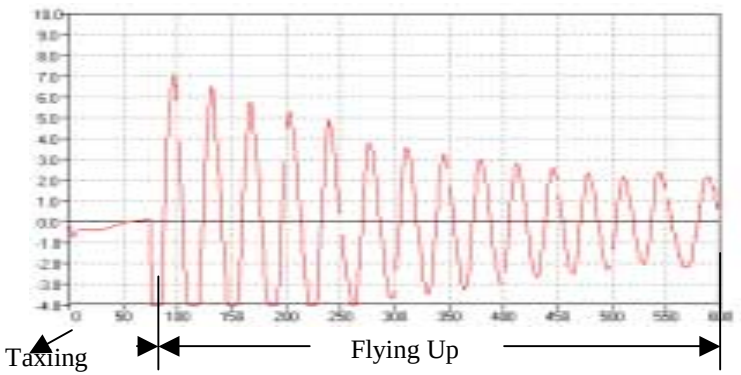
- **Graphic User Interface Module**
  - **Module's Programming**
  - **Module's Testing**

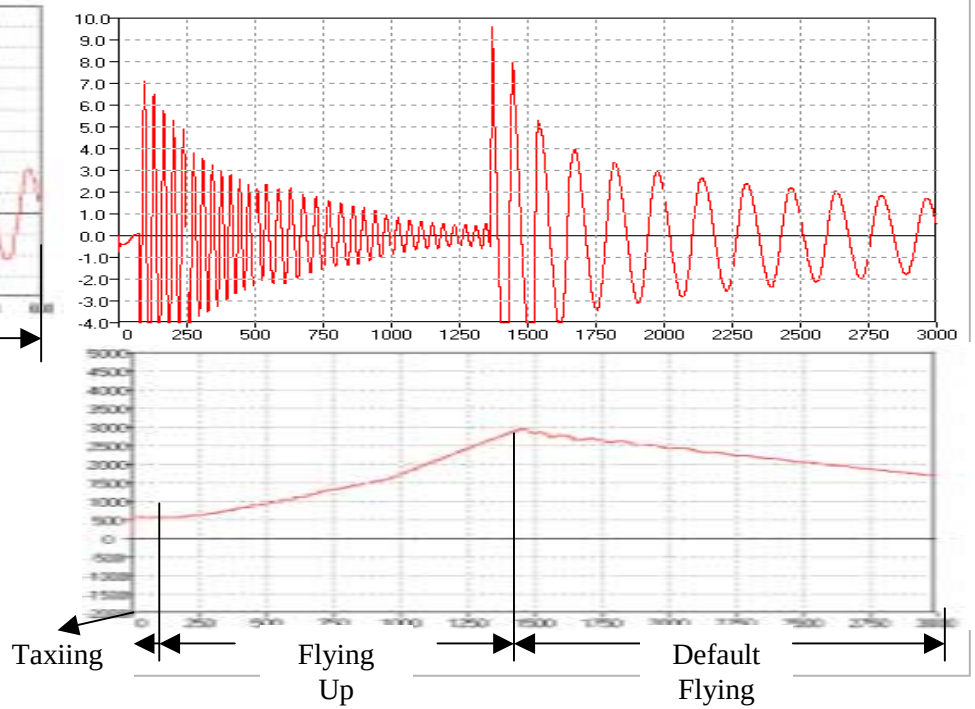
System Testing and Improvement

- **System Testing**
  - **Test the functions provided by this system**
  - **Evaluate the stability of control**

System Testing and Improvement

- **Problems and Improvements**
  - **Airplane shook a lot during the beginning phase of each flight procedure**
  - **Airplane kept descending in a fast way during the default flying procedure**
  - **Airplane changed its behavior dramatically when going from one flight procedure to another**



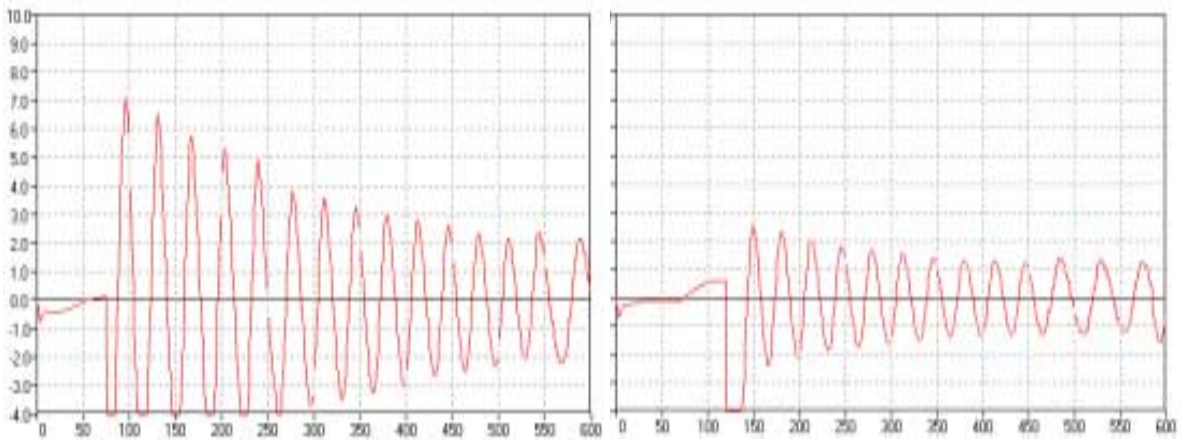


System Testing and Improvement

- **Problems and Improvements**
  - **Airplane shook a lot during the beginning phase of each flight procedure**
    - **Limit the controller's output range**
  - **Airplane kept descending in a fast way during the default flying procedure**
    - **Change the desired pitch value for the default flying procedure**
  - **Airplane changed its behavior dramatically when going from one flight procedure to another**
    - **Modify the reference table to make the desired pitch output increase or decrease to a desired value gradually**

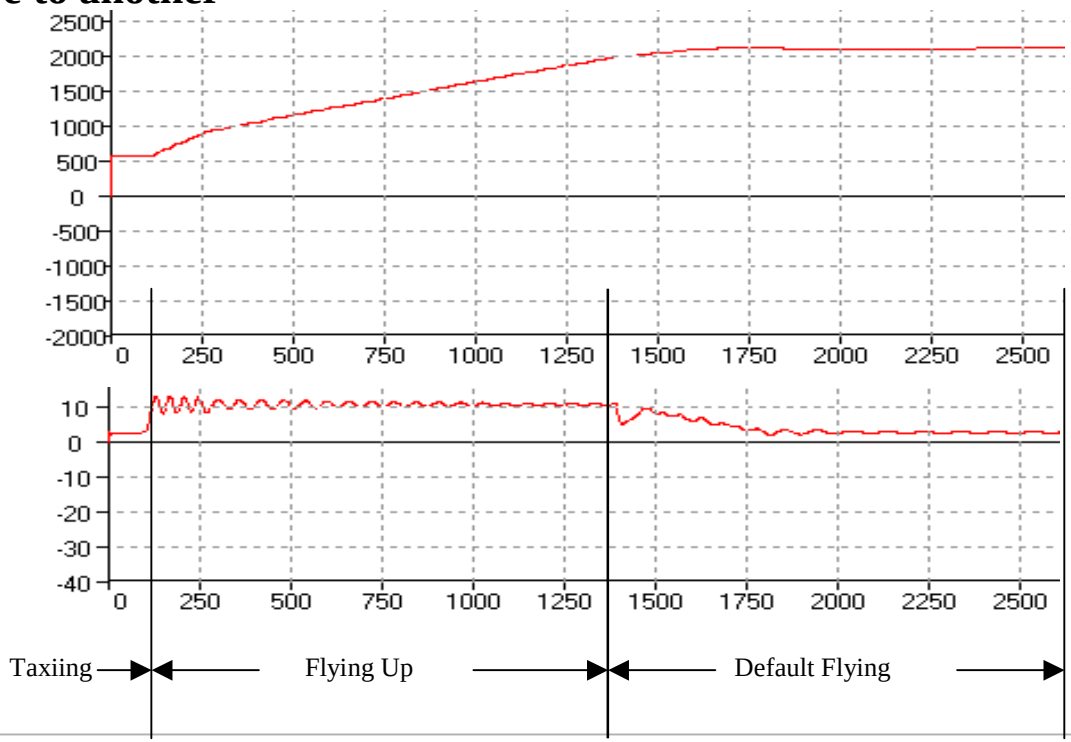
System Testing and Improvement

- **Improvement Results**
  - **Airplane shook a lot during the beginning phase of each flight procedure**



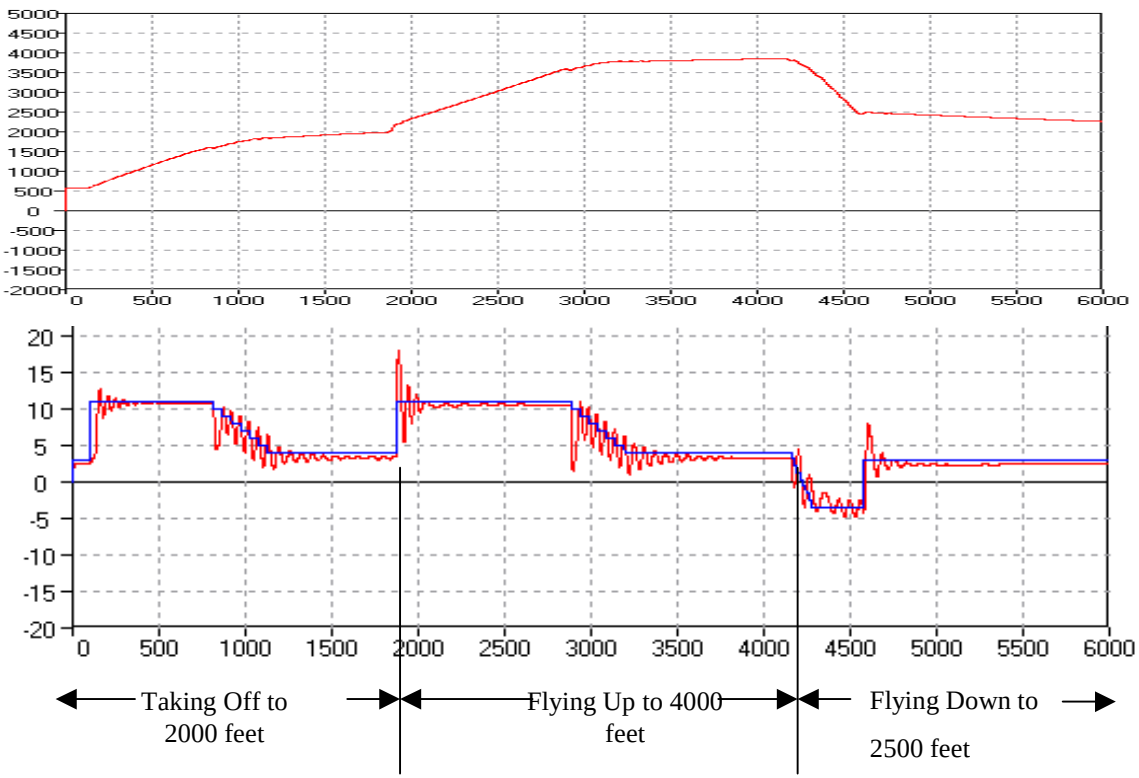
System Testing and Improvement

- **Improvement Results**
  - **Airplane kept descending in a fast way during the default flying procedure**
  - **Airplane changed its behavior dramatically when going from one flight procedure to another**



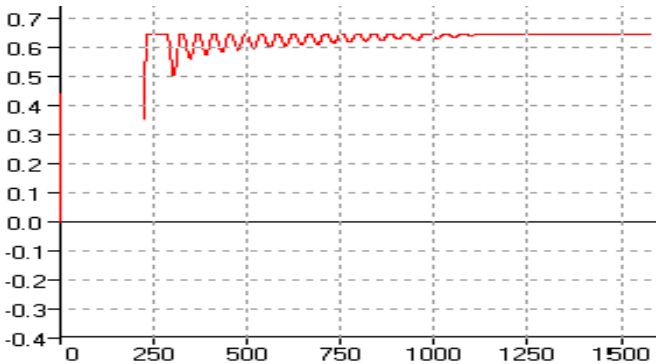
System Testing and Improvement

- **Improvement Results**

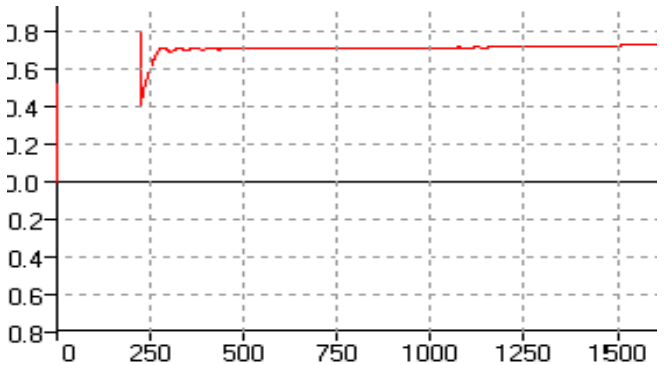


System Testing and Improvement

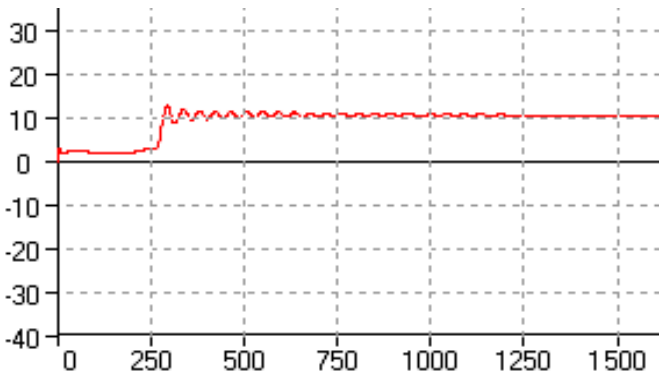
- **Controller Stability Analysis**



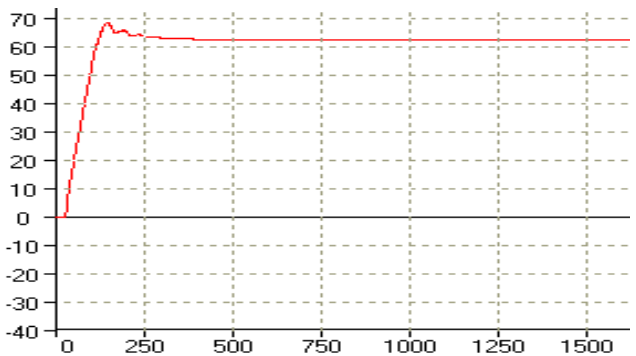
a. The Normalized Elevator Input



b. The Normalized Throttle Input



c. The Pitch Output



d. The Airspeed Output

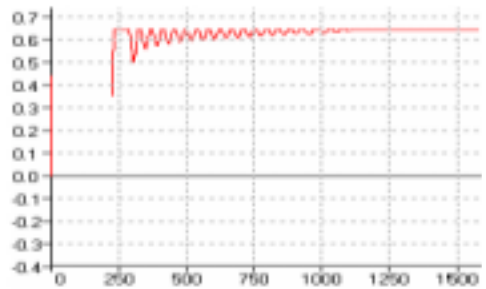
- **The control system is globally asymptotically stable**

Conclusions

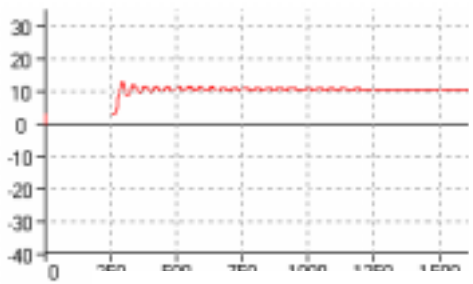
- **Conclusions**
  - **Successfully develop a Neural Flight Control Autopilot System**
    - **to control the airplane to take off, fly up and fly down**
    - **to achieve stable control**
    - **to respond to the flight order immediately**

Conclusions

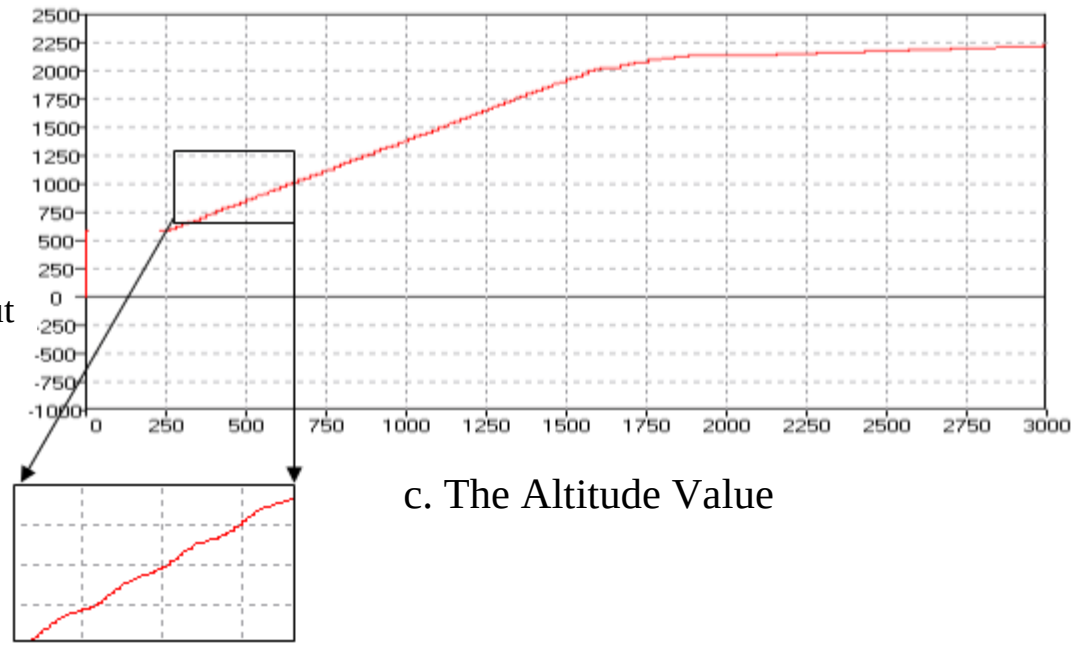
- **Conclusions**
  - **The Advantages and Disadvantages of Neural Flight Control System**



a. The Normalized Elevator Input



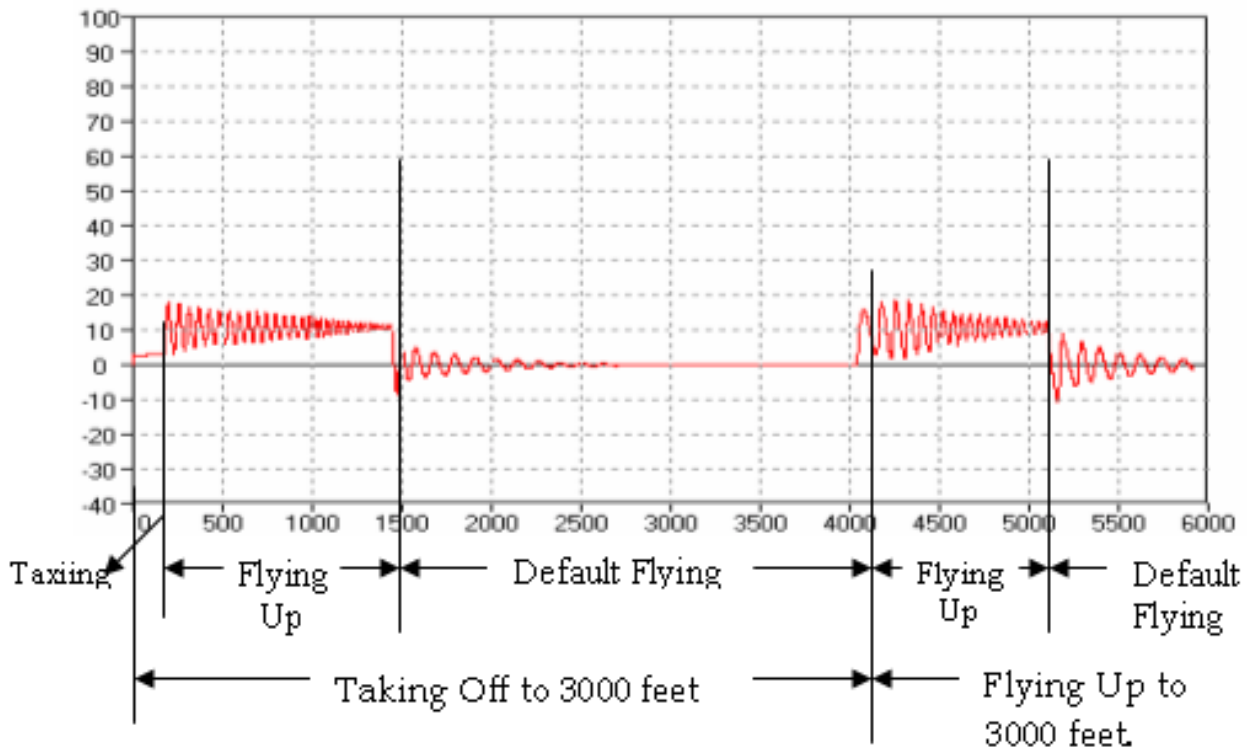
b. The Pitch Value



c. The Altitude Value

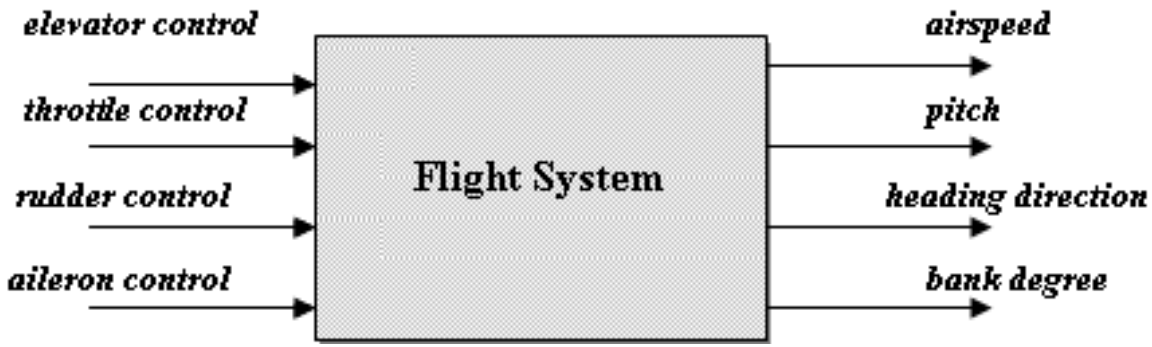
Conclusions

- **Conclusions**
  - **The Advantages and Disadvantages of Neural Flight Control System**

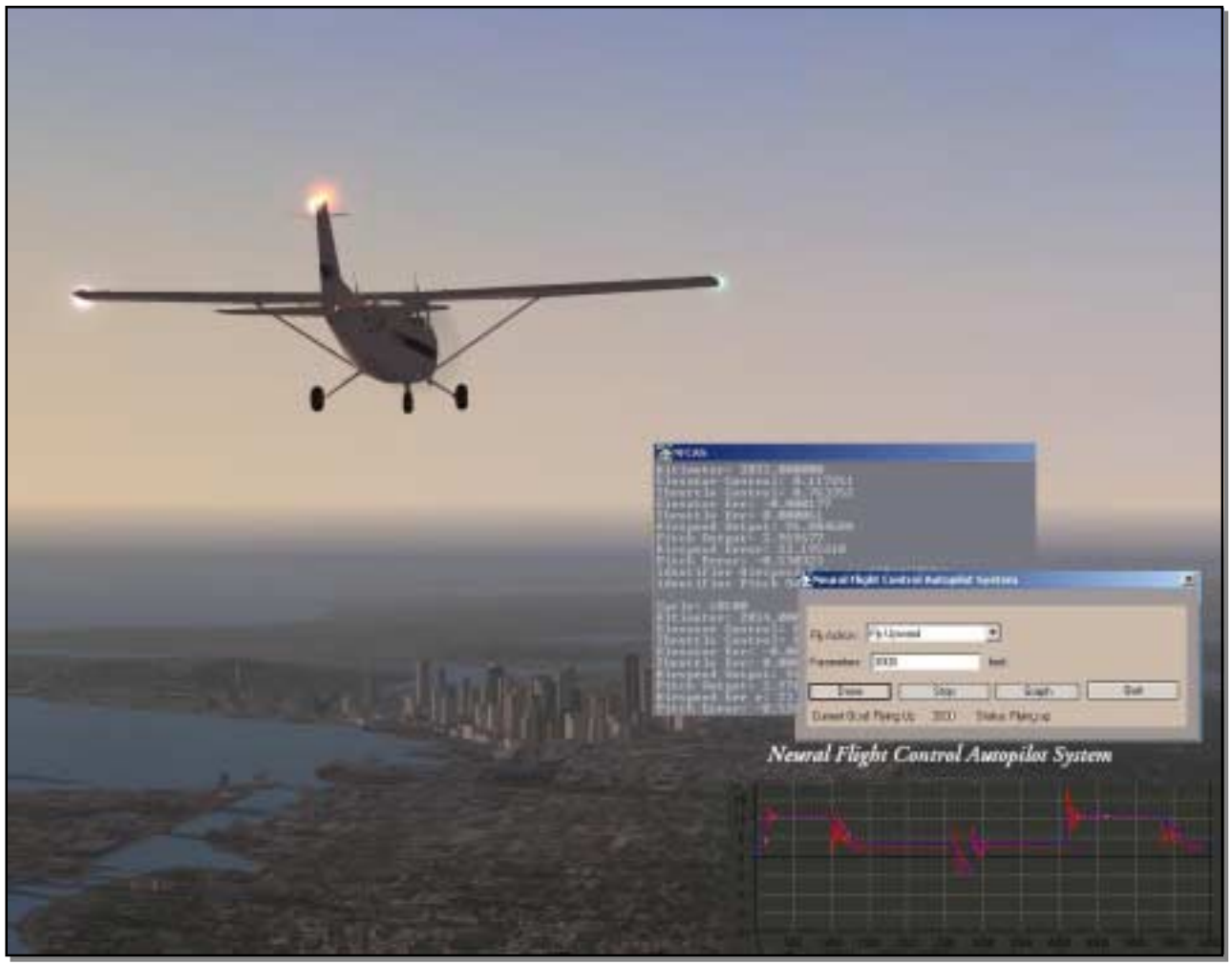


Future Works

- **To control the airplane to make a turn**
- **To control the airplane to land**
- **To make the airplane fly more safely and smoothly**



Demonstration



System Testing and Improvement

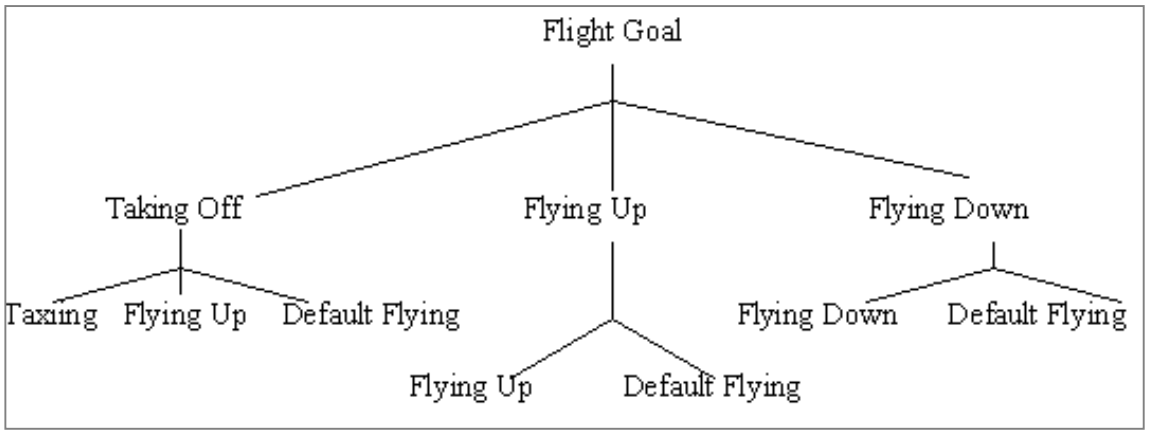
- **Reference Table**

Flight Procedure	Desired Output	
	Pitch Value	Airspeed Value
Taxiing	as current	55 Knots
Flying Up	11 Degree	as current
Flying Down	-3 Degree	100 Knots
Default Flying	0 Degree	as current

Flight Procedure	Desired Output	
	Pitch Value	Airspeed Value
Taxiing	as current	55 Knots
Flying Up	11 Degree	as current
Flying Down	From Current pitch value gradually go to -3 Degree	100 Knots
Default Flying	From current pitch value gradually go to 3 Degree	as current

System Design • Flight Planning Module

• Flight Plans



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