SUGGESTIONS FOR THE MIL-PRIME-STANDARD ORGANIZATION

(Informal Report)

E. Frank Carlson
The Boeing Company

The forthcoming MIL-PRIME-STD and MIL-PRIME-HANDBOOK offer potential for significant improvement in the specification of flying qualities requirements. The MIL-PRIME-STD will give the basic framework for the specification of flying qualities. Suggestions and rationale for detailed requirements will be given in the MIL-PRIME-HANDBOOK.

Each SPO will be able to tailor the flying qualities requirements to the specific needs and objectives of its programs. The new MIL-PRIME-STD/-HANDBOOK should also facilitate keeping the specifications abreast of a rapidly changing Technology. In my opinion, many of the flying qualities specification problems encountered during the AMST (Advanced Medium STOL Transport) program would have been alleviated by the proposed MIL-PRIME-STD/-HANDBOOK concept.

In creating this new MIL-PRIME-STD it would be very desirable, from the airplane designer's viewpoint, to rearrange the flying qualities topics relative to the order in which they now appear in MIL-F-8785B. The organization used in MIL-F-8785B follows primarily along the lines of flight phases and the individual parameters used to specify flying qualities. This organization tends to be very difficult for the flight control system designer to use. For example, when designing the pitch axis feel system the designer must compile a list of all requirements related to the pitch axis control forces and displacements. In reviewing MIL-F-8785B he will find that these requirements are scattered through sixteen separate sections of the specification, ranging all the way from section 3.2.2.2.1 to section 3.6.3.1. This type of problem prompted Boeing to evaluate alternate organizational structures when the Design Requirements and Objectives document was written for the YC-14.

The table of contents showing the organization of the YC-14 Design Requirements and Objectives document is given on the following pages. The subjects have been grouped by airplane systems to simplify the control system design tasks. A similar arrangement is recommended for the MIL-PRIME-STD.

3.1 GENERAL REQUIREMENTS AND DEFINITIONS

3.1.1 Operational Philosophy

- 3.1.1.1 Operational Modes
- 3.1.1.2 Flight Phase Categories
- 3.1.1.3 Operating Margins
- 3.1.1.4 State of the Aircraft

3.1.2 Configurations and Loadings

3.1.3 Flight Envelopes

- 3.1.3.1 Operational Flight Envelopes
- 3.1.3.2 Service Flight Envelopes
- 3.1.3.3 Permissible Flight Envelopes

3.1.4 Flying Qualities Levels and Application

- 3.1.4.1 Aircraft Normal State Flying Qualities
- 3.1.4.2 Aircraft Failure State Flying Qualities
  - 3.1.4.2.1 General Failure State Requirements
  - 3.1.4.2.2 Specific Failure States
  - 3.1.4.2.3 Special Failure States

3.1.5 Atmospheric Environment

- 3.1.5.1 Mean Wind
- 3.1.5.2 Turbulence
- 3.1.5.3 Discrete Gust Analysis

3.1.6 Flight Control Systems

- 3.1.6.1 Primary Flight Controls
- 3.1.6.2 Secondary Flight Controls
- 3.1.6.3 Basic/Manual Modes and Subsystems
- 3.1.6.4 Pilot-Assist/Automatic Modes and Subsystems

3.1.7 System Status Indication

- 3.1.7.1 Advisory
- 3.1.7.2 Caution Indication
- 3.1.7.3 Warning System

3.2 LONGITUDINAL FLYING QUALITIES
3.2.1 Control Power

- 3.2.1.1 In-Flight Maneuvers
- 3.2.1.2 Takeoff
- 3.2.1.3 Landing
  - 3.2.1.3.1 Static Balance
  - 3.2.1.3.2 Pitch Acceleration
  - 3.2.1.3.3 Maneuver Control Power
  - 3.2.1.3.4 Glideslope Control
- 3.2.1.4 Stall-Recovery
- 3.2.1.5 Trim Authority

3.2.2 Control Forces and Displacements

- 3.2.2.1 Column Travel
- 3.2.2.2 Breakout Forces
- 3.2.2.3 Constant Speed Maneuver Force and Displacement Gradients
  - 3.2.2.3.1 Stick Force Per g
  - 3.2.2.3.2 Displacement Per g
  - 3.2.2.3.3 Linearity
- 3.2.2.4 Minimum Stick Forces
- 3.2.2.5 Maximum Stick Forces
  - 3.2.2.5.1 Trim Changes
  - 3.2.2.5.2 In-Flight Maneuvers
  - 3.2.2.5.3 Accelerated Flight
  - 3.2.2.5.4 Takeoff
  - 3.2.2.5.5 Landing
  - 3.2.2.5.6 Sideslips

3.2.3 Stability and Response Characteristics

- 3.2.3.1 Minimum Damping
- 3.2.3.2 Pitch Rate Characteristics
- 3.2.3.3 Pitch Attitude Hold
- 3.2.3.4 Flight Path Characteristics
  - 3.2.3.4.1 Hands-Off Flight Path Stability
  - 3.2.3.4.2 Hands-On Flight Path Stability
  - 3.2.3.4.3 Pitch Attitude - Flight Path Relationship
  - 3.2.3.4.4 Load Factor Response

3.4 FLIGHT CONTROL SYSTEMS DESIGN
3.4.1 General Design

3.4.1.1 Flight Deck Controls
3.4.1.2 Powered Control Systems
3.4.1.3 Fail Safety
3.4.1.4 Structural Load Path
3.4.1.5 Dissimilar Load Path
3.4.1.6 Residual Oscillations
3.4.1.7 Stability Margins
3.4.1.8 Endurance Life
3.4.1.9 Warmup
3.4.1.10 Failure Transients
3.4.1.11 Lightening Strikes and Static Atmospheric Electricity

3.4.2 Primary Flight Control System

3.4.2.1 Mechanical Flight Control Elements

3.4.2.1.1 Design for Murphy's Law
3.4.2.1.2 System Load Criteria
3.4.2.1.3 Control Surface Physical Damage
3.4.2.1.4 Control Harmony
3.4.2.1.5 Control Centering
3.4.2.1.6 Power System Checkout
3.4.2.1.7 Segregation of Systems
3.4.2.1.8 Actuator Sizing
3.4.2.1.9 Synchronization of Multiple Actuators
3.4.2.1.10 Control Surface Stops
3.4.2.1.11 Bias and Centering Springs
3.4.2.1.12 Control Surface Actuation

3.4.2.2 Control Augmentation System Elements

3.4.2.2.1 CAS Control Authority
3.4.2.2.2 Gain Scheduling
3.4.2.2.3 Automatic Pitch Trim
3.4.2.2.4 CAS Failure Logic
3.4.2.2.5 Transient Power Effects
3.4.2.2.6 Computers

3.4.2.3 Propulsion Control

3.4.3 Secondary Flight Control System

3.4.3.1 General Criteria

3.4.3.1.1 Flight Deck Controls
3.4.3.1.2 Asymmetric Conditions
3.4.3.1.3 Emergency Operation
3.4.3.1.4 Stabilizer Actuation
3.4.3.1.5 Flap Actuation
3.4.3.1.6 Flap Retraction

3.3 LATERAL-DIRECTIONAL FLYING QUALITIES

3.3.1 Control Power

- 3.3.1.1 Roll Maneuvers
- 3.3.1.2 Yaw Control
- 3.3.1.3 Crosswind Takeoff and Landing
- 3.3.1.4 Asymmetric Thrust
- 3.3.1.5 Trim

3.3.2 Control Forces and Displacement

- 3.3.2.1 Control Travel
- 3.3.2.2 Breakout Forces
- 3.3.2.3 Control Forces
- 3.3.2.4 Turn Coordination
- 3.3.2.5 Control Sensitivity
- 3.3.2.6 Control Linearity

3.3.3 Stability and Response Characteristics

- 3.3.3.1 Roll Mode Response
  - 3.3.3.1.1 Roll Attitude Command/Hold
  - 3.3.3.1.2 Roll Rate Command
  - 3.3.3.1.3 Bank Angle Oscillations
  - 3.3.3.1.4 Roll Rate Oscillations
- 3.3.3.2 Heading Control
- 3.3.3.3 Turn Coordination
- 3.3.3.4 Roll-Sideslip Stability
- 3.3.3.5 Roll-Sideslip Coupling
- 3.3.3.6 Pilot Induced Oscillations

3.3.4 Stalls

3.3.5 Pilot Assist Modes

- 3.3.5.1 Heading Hold
- 3.3.5.2 Heading Select
- 3.3.5.3 Automatic VOR/TACAN Navigation
- 3.3.5.4 Category II Landing Approach
- 3.3.5.5 Flight Director Modes

Wayne Thor, ASD: Do you currently use MIL-F-8785B as a design Handbook?

Answer: No, we do not use MIL-F-8785B as a design handbook. We design a flight control system which we believe will meet the requirements of the spec. Then we evaluate this flight control system against the requirements. We will have to go through the same process with the new MIL-PRIME-STD. Nothing will have changed in this regard.

We have successfully used the proposed organization for the YC-14 Design Requirements and Objectives (DR&O) document. I have shown a summary of the way the DR&O was organized - a complete table of contents is shown in my paper. We found that all of the requirements contained in MIL-F-8785B can be melded into the proposed organization scheme. The first attempt at a DR&O for the YC-14 was organized much like MIL-F-8785B. This caused significant problems for the designers to use.

Hansel Stegall, NASA JSC: Aren't you going to have the same problem with your proposed organization as you accuse the spec? Why rewrite the spec to conform to a new organization? Why not add a cross-reference index at the back?

Answer: No, I do not think it would be satisfactory to simply provide a cross index of requirements to relate subsystem design (such as a feel system) to the various sections of the MIL-PRIME-STD. This would be clumsy. It is not obvious why it is necessary to stick with the same organization as currently in MIL-F-8785B. Some definite improvements are possible.

This request to reorganize the flying qualities requirements is perhaps more significant to Boeing than to some other aerospace companies. Some of our engineers have not spent their entire career working with MIL-F-8785B. It is a definite problem for them to use this spec, since they must spend so much time reading through the various sections to find the ones that apply to their particular design problem(s). This is well illustrated by the pitch feel system where the designer must compile the requirements from 16 major sections of

MIL-F-8785B where design values are given. It should not be necessary to do this sifting and sorting. It leads to an increased probability of oversight and errors in addition to a waste of good engineering manpower. The designer should be able to go to the table of contents in the MIL-PRIME-STD and quickly identify all applicable requirements. This is not possible with the MIL-F-8785B organization.