LRTA Control System
Stiffness Measurement

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Outline

• Introduction
• UH-60 LRTA control system
• Experimental Setup/Loading
• Sample Results
• Control System Stiffness
• Fixed System Calculations
• Conclusions
NFAC/LRTA/UH-60 Airloads Rotor
LRTA Stationary Actuators
LRTA Stationary Links

Link 1

Link 2
Test Setup

- I Beam Support
- Hub Arm Spindle
- Rotary Position Encoder
- Moment Arm

[Image of test setup with labeled components]
Collective Loading
Cyclic Loading
Sample Results

Collective Loading
75° Azimuth

Applied Pitching Moment, ft-lbs

Measured Spindle Deflection, Deg

\[ y = -995.29x + 6334 \]
Sample Results

Collective Loading
345° Azimuth

Applied Pitching Moment, Ft-lbs

Measured Spindle Deflection, Deg

y = -597.71x + 95220
Sample Cyclic Loading

Cyclic Loading
15° Azimuth

Y = -313.2 +1523.1
Y = -347.68 +1893.9
Sample Results

Colective Loading
195° Azimuth, Dyn Actuactor On

Applied Pitching Moment, ft-Lbs

Measured Spindle Deflection, Deg

\[ y = -2326.8x + 223664 \]
Measured Collective Stiffness

Control System Stiffness, ft-lbs/deg.

Rotor Azimuth, Deg

- Dyn Actuators locked Out
- Dyn. Actuators Active
- Aircraft
Measured Reactionless Stiffness

Control System Stiffness, ft-lbs/
Deg.

Rotor Azimuth, Deg

- Dyn.Actuators locked Out
- Dyn.Actuators Active
- Aircraft
Measured Cyclic Stiffness

Control System Stiffness, ft-lbs/deg.

Rotor Azimuth, Deg.

- Dyn. Actuators locked Out
- Dyn. Actuators Active
- Aircraft
Control System Stiffness Model

\[ K_{\text{col}} = \frac{1}{N} \sum_{m=1}^{N} K^{(m)} \]

\[ K_{\text{cos}} = \frac{2}{N} \sum_{m=1}^{N} K^{(m)} \cos \Psi_m \]

\[ K_{\text{sin}} = \frac{2}{N} \sum_{m=1}^{N} K^{(m)} \sin \Psi_m \]

\[ K_{\text{react}} = \frac{1}{N} \sum_{m=1}^{N} K^{(m)} (-1)^m \]
Fixed Control System Stiffness

\[
\begin{bmatrix}
M_{col} \\
M_{cos} \\
M_{sin} \\
M_{react}
\end{bmatrix} =
\begin{bmatrix}
1354 & -952 & 35 & -7 \\
-53 & 496 & -6 & 9 \\
-4 & -6 & 713 & 43 \\
7 & 2 & -10 & 1036
\end{bmatrix}
\begin{bmatrix}
\theta_{col} \\
\theta_{cos} \\
\theta_{sin} \\
\theta_{react}
\end{bmatrix}
\]
Conclusion

- LRTA Control System Stiffness was measured
- Negligible differences between Dynamic Actuator active/ locked out
- LRTA Control System Stiffness is similar but stiffer than aircraft
- Negligible differences between the LRTA and aircraft reactionless stiffness