Actuator Re-design Example

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Actuator Redesign

- Goal: Simulated re-creation of real-life actuator redesign problem
- Achievements:
 - Developed Rosetta design model of servovalve, cylinder and actuator
 - Developed power constraint and functional models
 - Hand translated Rosetta models into MATLAB system representations
 - Used interactions to represent constraint and functional model interaction
 - Used MATLAB model to demonstrate early detection of constraint violation
- Status:
 - Actuator problem analyzed and Rosetta models written
 - Generated interaction result between power and functional models
 - Analytically predicted power constraint violation based on MATLAB models



Prior Airplane Design Experience with Altering an Existing Design Time (Summer 92) Need: 92 **Require flutter stiffness** while minimizing weight The accumulators were added for several reasons including this. Solution Option #2: Solution Option #1: Put stiffness in actuator Put stiffness in structure (increase diameter of piston and actuator) (Early 94) (~93) Impact: Impact: Increased hydraulic fluid flow Mold line change **Option Not Fully Explored** (to maintain surface deflection rates for flying gualities) Increased drag Reduced LO Structural redesign **Required bigger hydraulic Option not fully explored** pump and accumulators since it was not the minimum-weight design solution (Late 93) (Appeared Late 94) Probably not -Added weight (Full Impact in Late 95) **Required boring out** largest available pump Reached Required boring out largest pump which would Lowered reliability power extraction fit in allowable physical envelope as constrained Lowered Time limit from engine by OML and internal structure Between Overhaul 95 Reached power extraction limit from engine and power transmission limit of AMAD gearbox

in upper left-hand corner of flight envelope (high and slow)

Using Systems Design Tools – Actuator



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Design Assumptions / Limitations

- Specifics of the operating modes are not available
- Only the servovalve and cylinder piston are modeled
 - **Power Assumptions**
 - Maximum engine power approx 2.4 e7 ft-lbs/s
 - 0.5% or less of engine power available to power hydraulic system
 - About 12.5% of hydraulic power used in an actuator
 - Maximum power available to actuator is about 15,000-20,000 ftlbs/sec
- Efficiency Assumptions
 - Engine--90%
 - Hydraulic pump--60%
 - Servovalve--90%
 - Hydraulic cylinder-99%
- Modeling done in conjunction with KU Aerospace department faculty



Functional Servovalve Equations







2 max



max

P = differential pressure

 $P_s =$ source pressure

Functioal Servovalve Equations (cont)



Rosetta Functional Servovalve Equations

begin continous

//Nonlinear steady state valve equation.

F1: Q/Q max = U/U max *

((1 - P/P_S) * sgn(U/U max))^0.5;

end servovalve fcn;



The Redesign Problem

- Additional force required to overcome flutter in high
 - speed operating mode
 - Differential pressure relatively low due to high speed operation
- Power obtained by increasing piston area in the cylinder
 - Assumed starting point of 2.5in²
 - Increased to 2.75in²
- Actuator power budget assumed to be 15,000-20,000 ft-Ibs/sec
- Functional model indicates no problems and additional force is obtained



Results of MATLAB Model Run



Interaction With the Power Model

- The actuator has an associated power limitation of 15,000-20,000 ft-lbs/sec
 - The power constraint model is expressed is separated from

