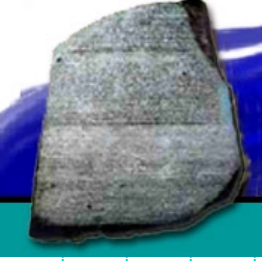

rosetta

Actuator Re-design Example

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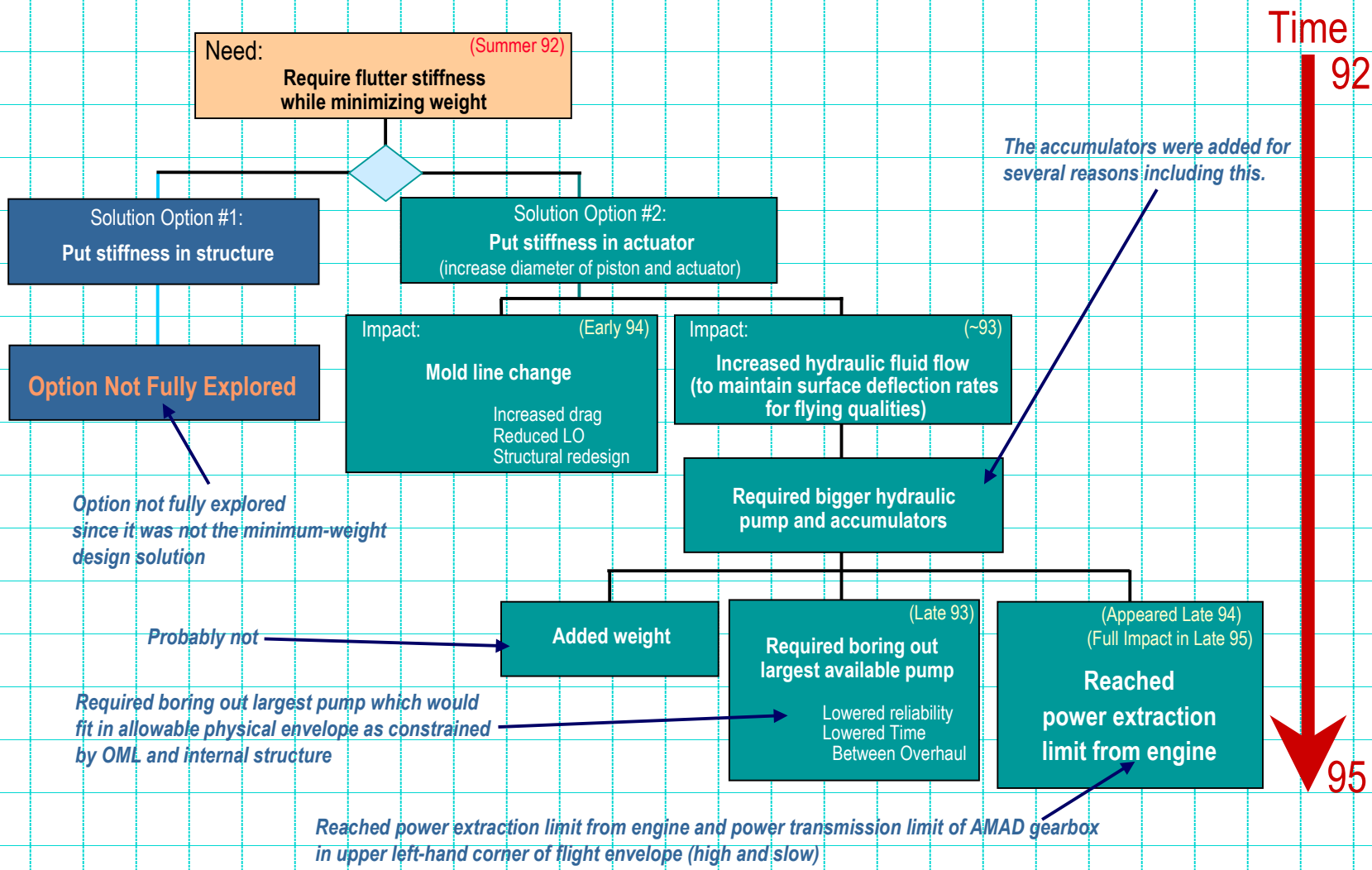
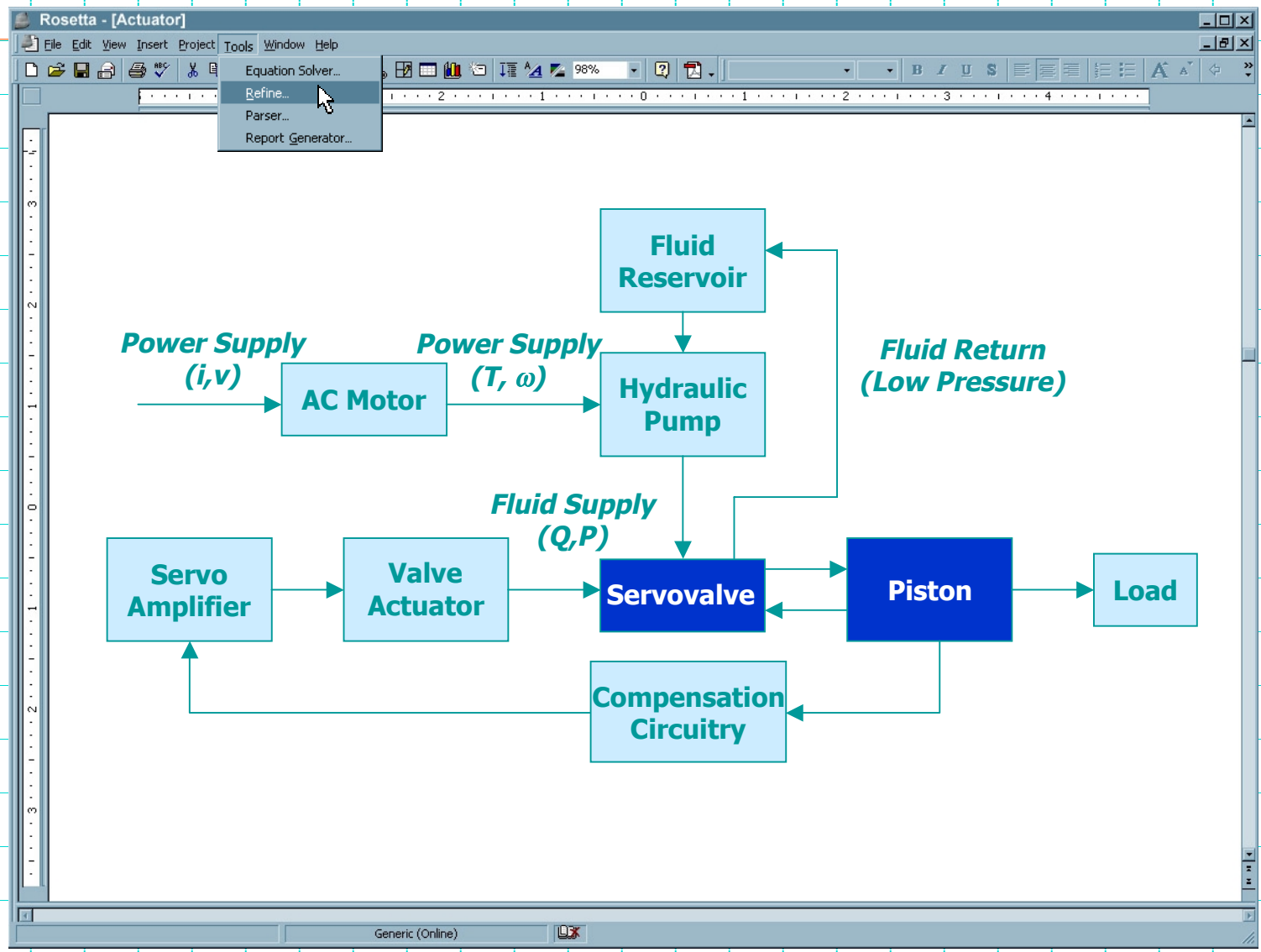
Actuator Redesign

- 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



Using Systems Design Tools –Actuator



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 ft-lbs/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

$$\frac{Q}{Q_{\max}} = \frac{U}{U_{\max}} \sqrt{1 - \frac{P}{P_s}} \operatorname{sgn}\left(\frac{U}{U_{\max}}\right),$$

where

$$\frac{Q}{Q_{\max}} = \%\ \text{max flow rate achieved}$$

$$\frac{U}{U_{\max}} = \%\ \text{max valve opening acheived}$$

$$P = \text{differential pressure}$$

$$P_s = \text{source pressure}$$

Functioal Servovalve Equations (cont)

$$\text{power} = P_s Q_s - P_2 Q_2 + P_1 Q_1$$

$$\left.\begin{aligned} \left|\frac{Q}{Q_{\max}}\right| &\le 1 \\ \left|\frac{U}{U_{\max}}\right| &\le 1 \\ \left|\frac{P}{P_s}\right| &\le 1 \end{aligned}\right\} \text{ constraints}$$

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;

  //Flow, spool disp, diff pressure cannot exceed
  //max
  C1: abs(Q) =< abs(Q_max);
  C2: abs(U) =< abs(U_max);
  C3: abs(P) =< abs(P_S);
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 2.5in^2
  - Increased to 2.75in^2
- Actuator power budget assumed to be 15,000-20,000 ft-lbs/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