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# An Approach to Optical Structures Control

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The stabilization of a large, spaceborne Cassegrain telescope is examined. Modal gain factors and known characteristics of disturbances are used to determine which structural modes affect line-of-sight (LOS) the most and are candidates for active control (FIGURE 1). The approach is to: (1) actively control and maintain alignment of optical components; (2) place structural control actuators for optimum impact on the selected modes for active vibration control; (3) feed back the best available estimate of LOS error for direct LOS control. Local analog loops are used for high bandwidth control and multivariable digital control for lower bandwidth control (FIGURE 2). The control law is synthesized in the frequency domain using the characteristic gain approach. Robustness is measured by employing conicity, which is an outgrowth of the positivity approach to robust feedback system design. The feasibility of the design approach will be demonstrated by conducting a laboratory experiment on a structure similar to a scaled version of the telescope. A low power laser beam is injected into the secondary mirror. Measurements assessing control system effectiveness are then performed on the outgoing beam as it is reflected from the primary.

Relative displacements and tilts of the optical elements are controlled up to some frequency with six alignment actuators per mirror element. Structural control actuators and sensors embedded in some of the members of the optical structure damp out vibrations at higher frequencies. Direct LOS feedback from an "internal" LOS sensor located on the structure is used to trim out the remaining LOS error. Modeling is in two parts: determination of LOS and wavefront errors given structural/mirror motion; and determination of structural/mirror motion given a disturbance. The design model assumes linearity. Performance assessment requires nonlinear models. Classical gain and phase margin obtained by breaking the control loops one-at-a-time can be misleading when evaluating the sensitivity of strongly coupled control loops.

Verification of the design is first accomplished by simulation using high fidelity models of actuators, sensors, and structures. The fundamental question in design verification of control systems for large, spaceborne optical structures is whether we can predict on-orbit behavior with present structural modeling and identification practices. The design and ground test of such a system is the first important step. The next step is demonstration of the same system in space. Once it is known how well we can construct mathematical models on the ground that predict on-orbit behavior, design verification of large structure control systems in space can be separated into ground verification by simulation and on-orbit parameter identification for final control tuning.

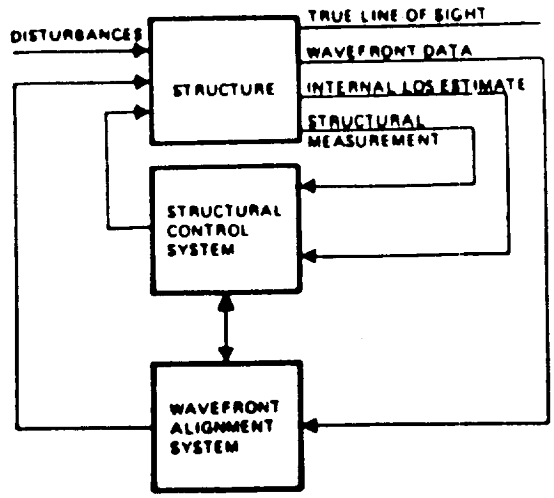


FIGURE 1. Top-Level System Block Diagram

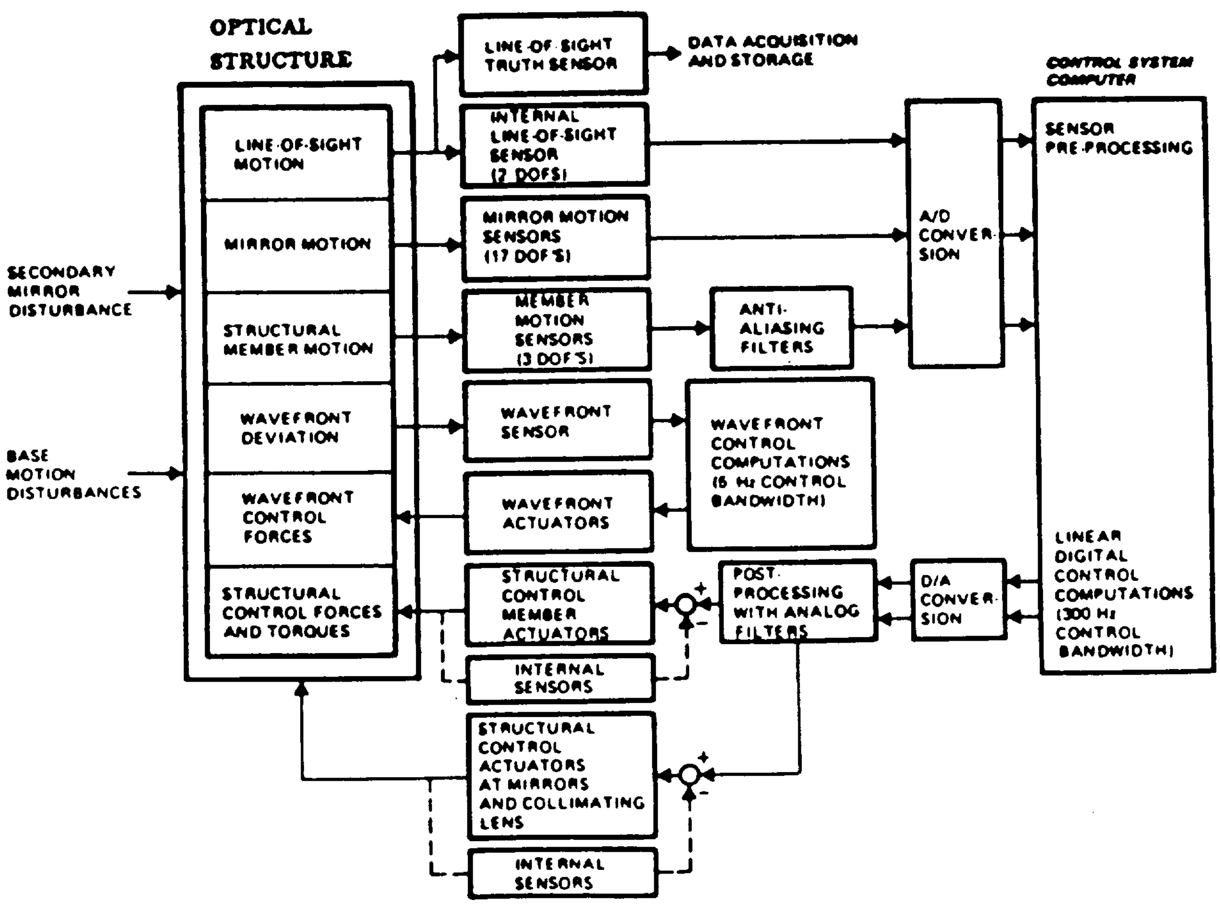


FIGURE 2. Block Diagram for a Laboratory Demonstration