



# Real-time Simulation Tools of Integrated Model and Control for GSMT

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# Overview

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- **Matlab-Based NSC Ray-Tracing**
- **Real-time Raytracing in Simulink**
- **GSMT Pointing/Tracking Simulation in the Virtual Reality (VR)**
- **Control Simulation of Integrated Models**
- **Optimal Control of GSMT AO/aO with Dynamic Reconstruction**



# Matlab-Raytracing

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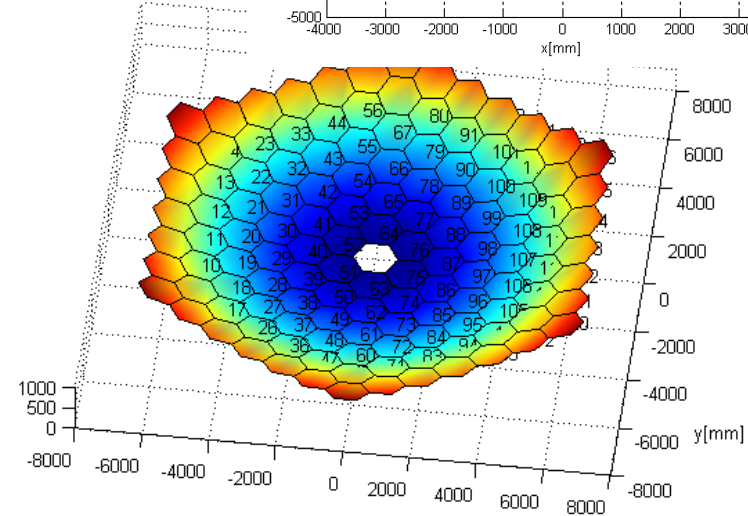
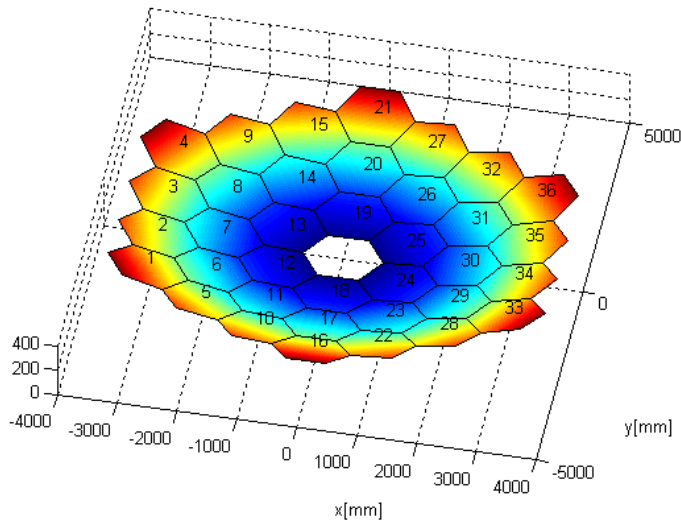
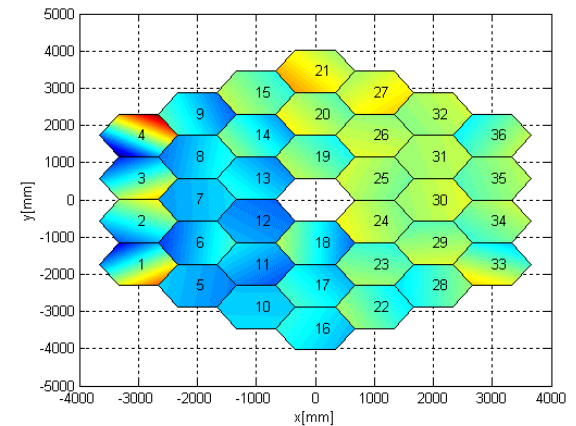
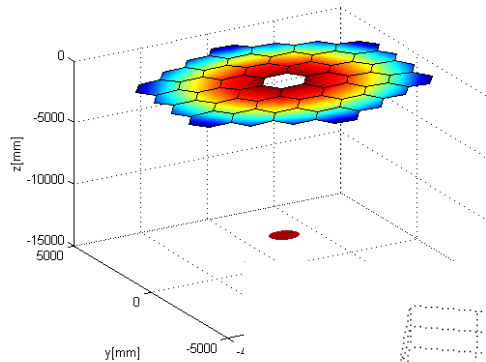
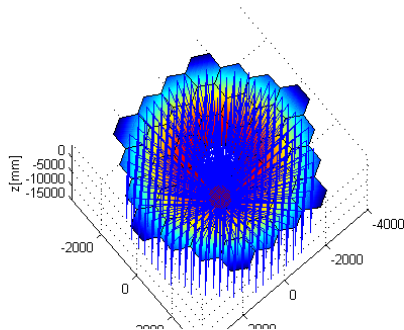
- **Matlab-based ray tracing facilitates integrated modeling and simulation-(Control, Struct Dyn)**
- **MACOS (FOTRAN in Unix – communication with Matlab via script file output)**
- **IMOS – integrated modeling with structure, dynamics, thermal and optics –but the limited capability of the optics (SC only. Only 5 m.files are provided for ray tracing)**
- **Extended IMOS- Geometric NSC ray-tracing for GISM and GSMT and a series image analysis tools in the matlab environment. Aims at the performance of OSLO, Code-V, Zemax,MACOS**



# Procedures

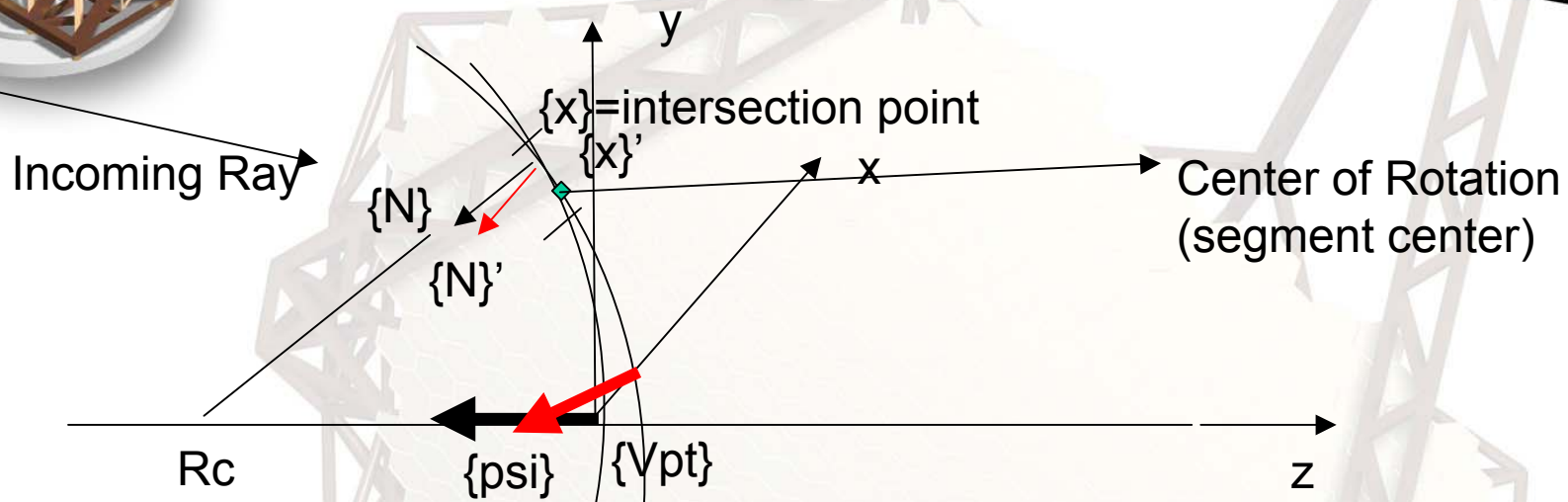
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- `Seg_gen.m` -> `gism.m(optrace3d.m)` -> `gen_graph.m`



# NSC Ray-tracing of Segments

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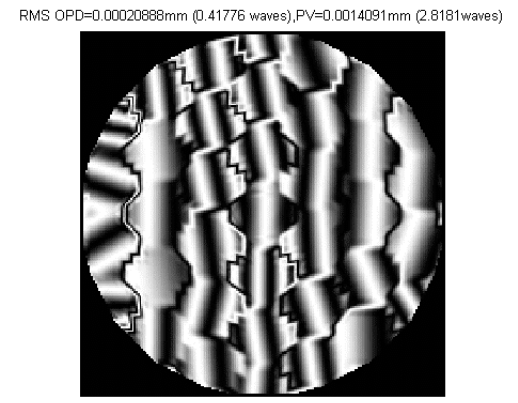
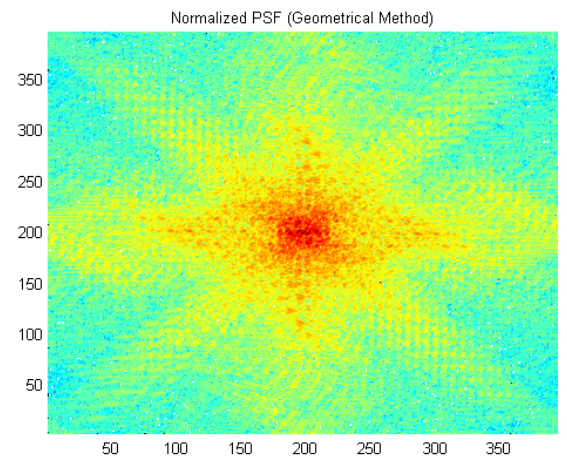
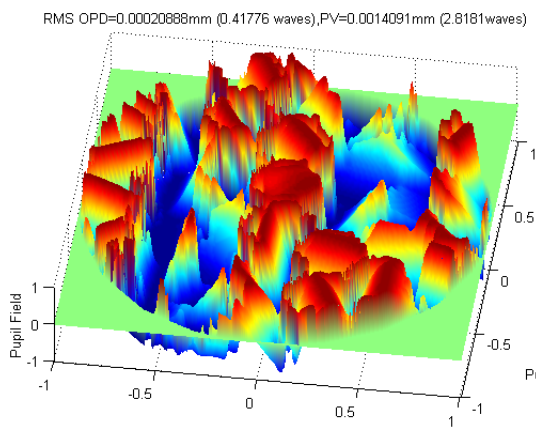
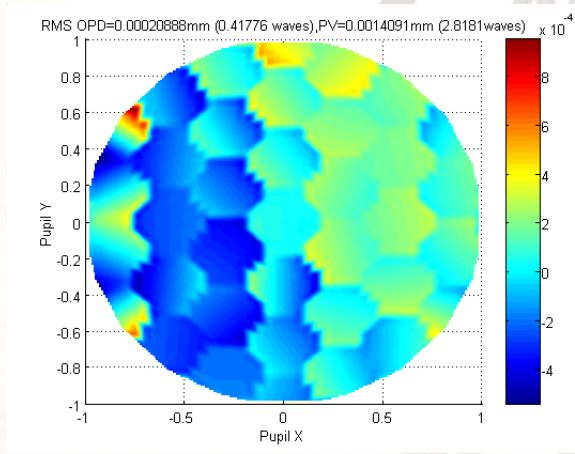
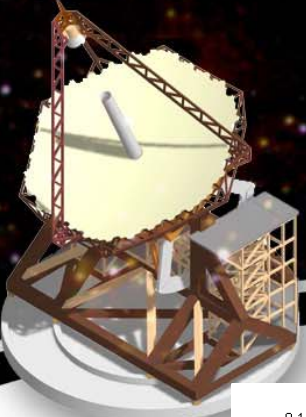
$\{x\}$  is calculated in a similar manner then calculate  $\{N\}$  by the following

$$\{N\} = -f(1+e)\{psi\} + \left[ I - e^2 \{psi\}^T * \{psi\} \right] [\{x\} - \{Vpt\}]$$



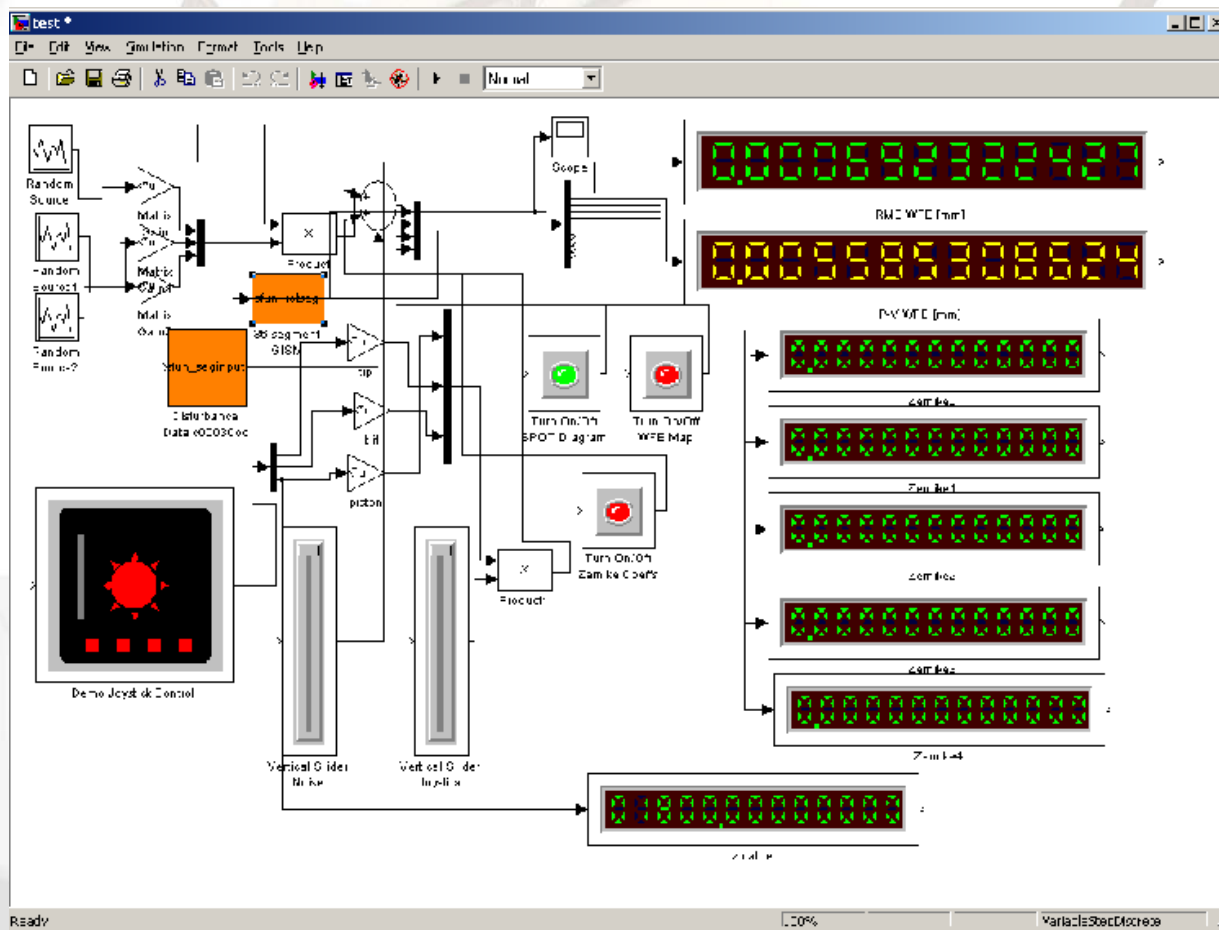
# Results

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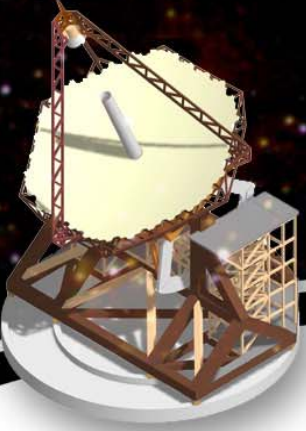


# Real-time Raytracing in Simulink

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# Pointing/Tracking Control



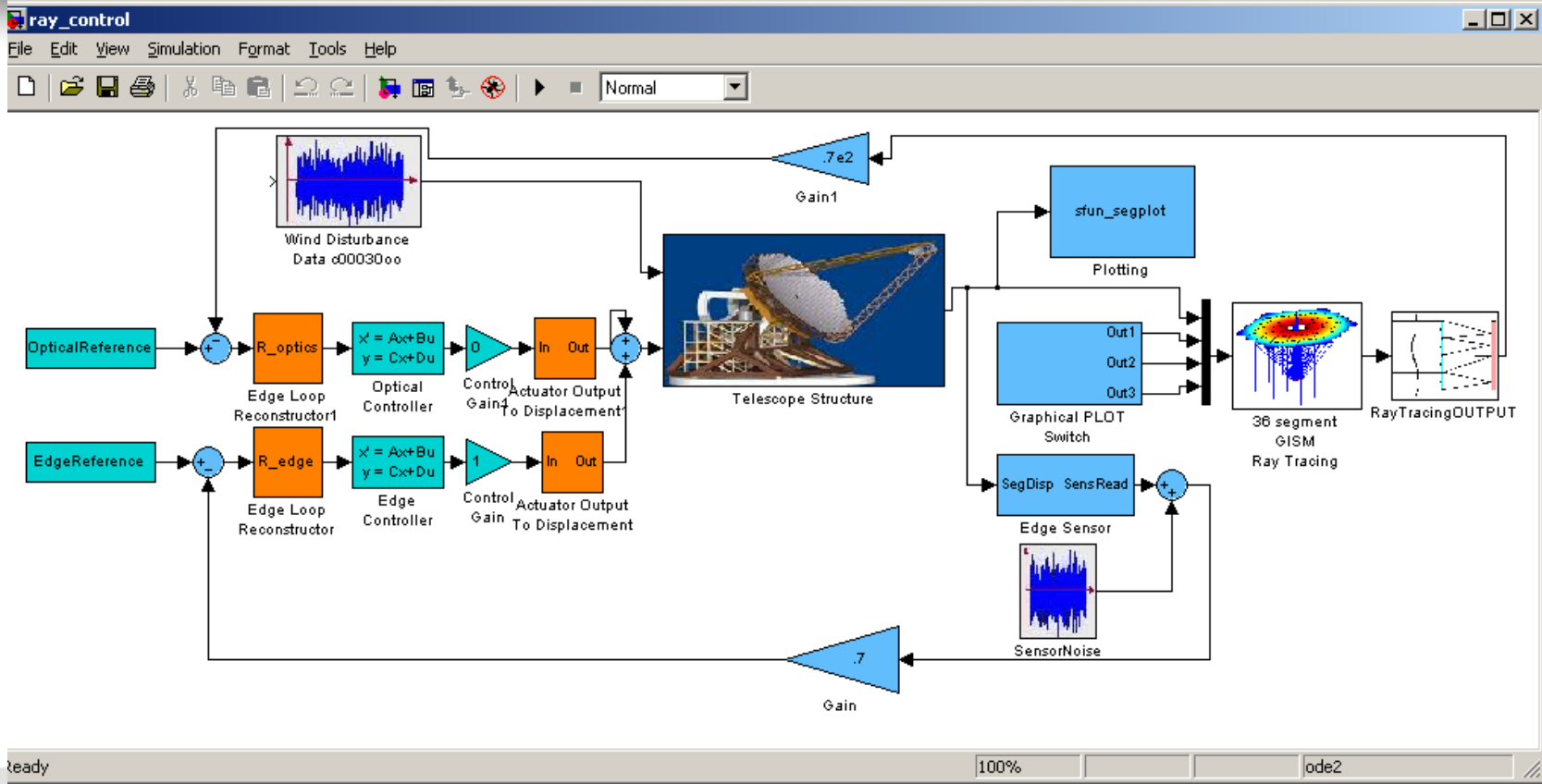
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# GSMT in the Virtual Reality World!!



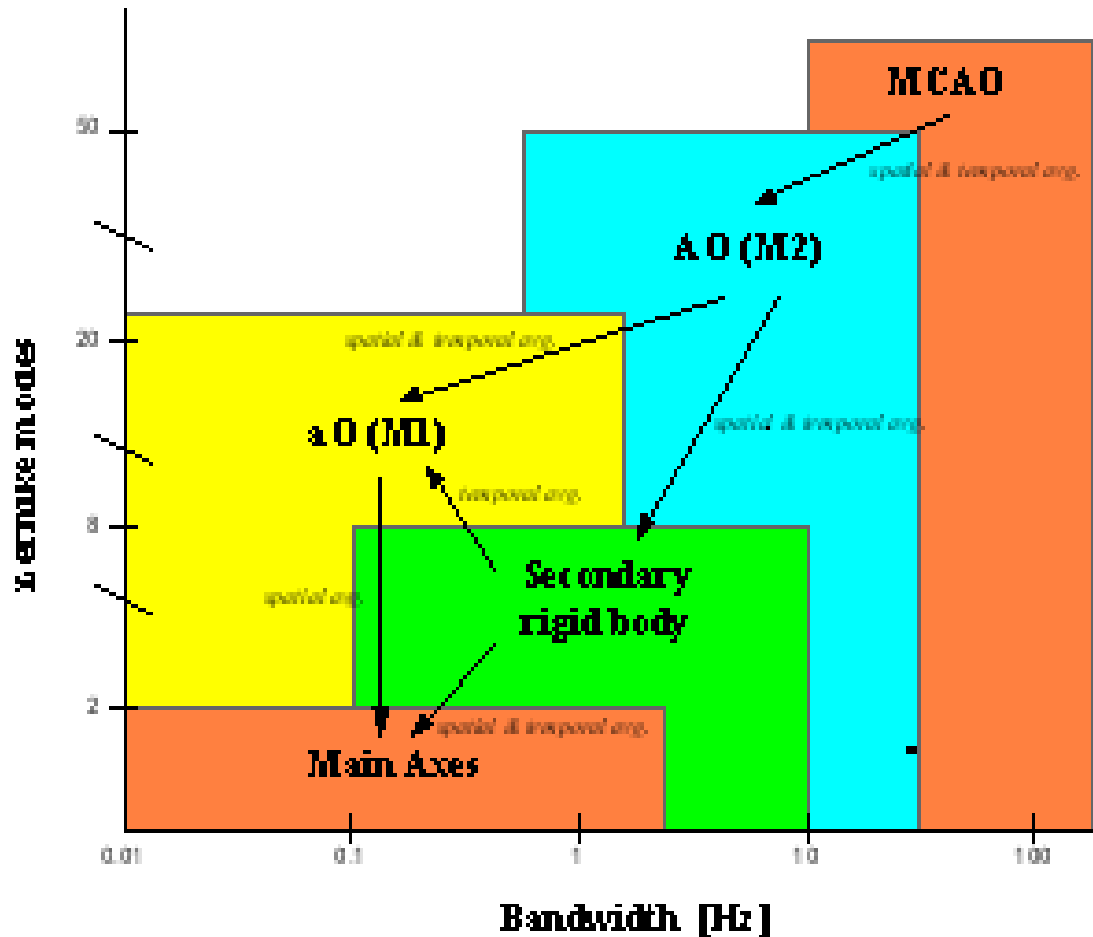
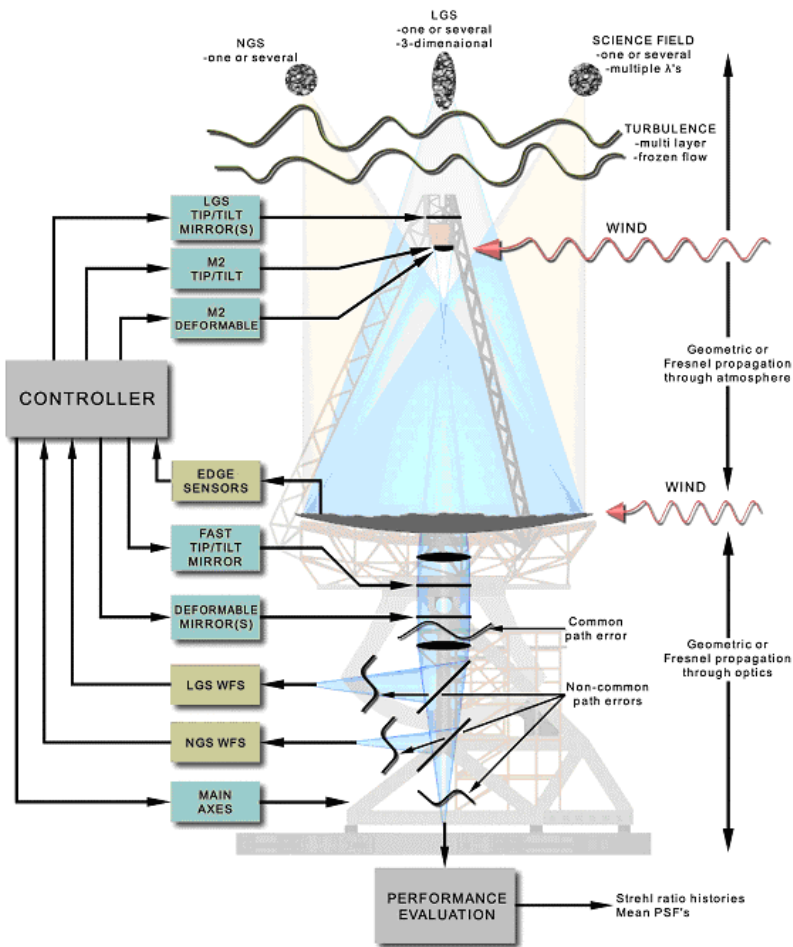
# Control Simulation of Integrated Models

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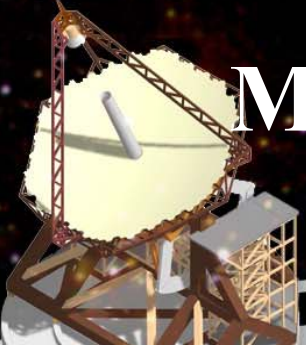


# Optimal Control of GSMT AO/aO

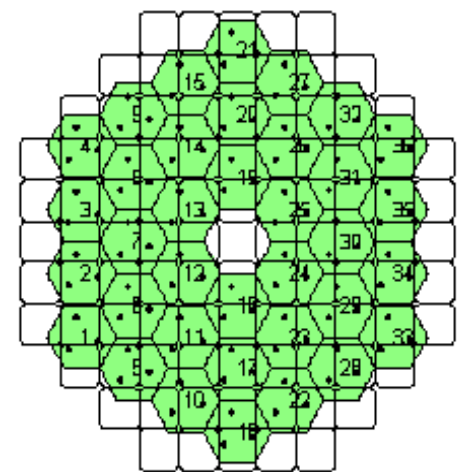
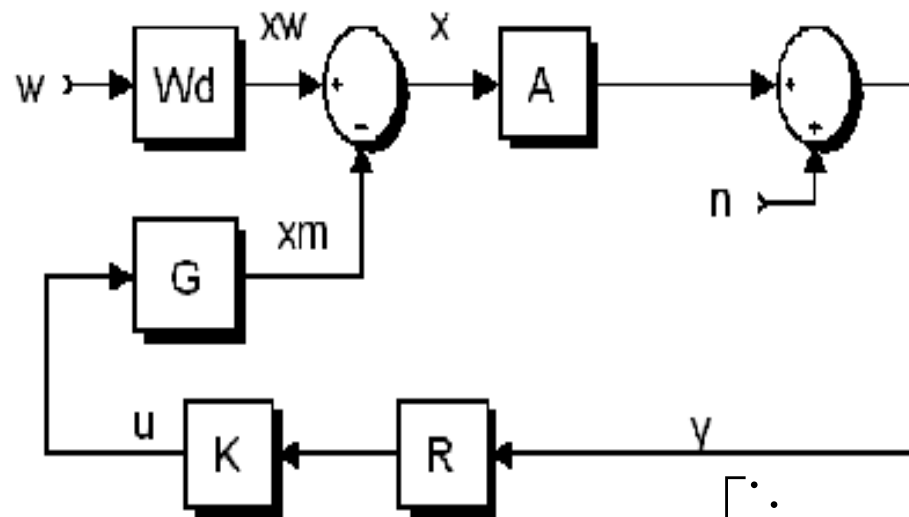
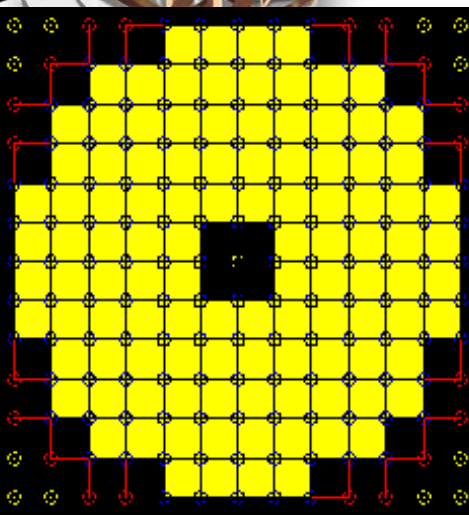
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# Minimum Variance Reconstructor



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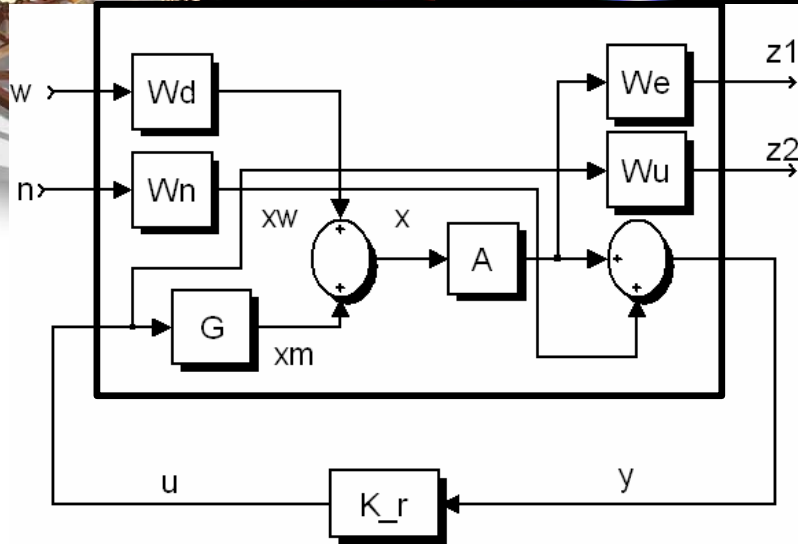
$$y = Ax + n$$

$$K(s) = \begin{bmatrix} \dots & \dots & \dots \\ \dots & \frac{k}{s} & \dots \\ \dots & \dots & \dots \end{bmatrix}$$

$$x = Ry = (A^T C_n^{-1} A + C_\phi^{-1})^{-1} A^T C_n^{-1} y$$



# Optimal Control with Dynamic Reconstruction



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$$P(s) = \begin{bmatrix} \begin{bmatrix} W_e A W_d & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} W_e A G \\ W_u \end{bmatrix} \\ \begin{bmatrix} A W_d & W_n \end{bmatrix} & A G \end{bmatrix}$$

$$\dot{x} = A_G x + B_G u = \begin{bmatrix} 0 & I \\ -\Omega^2 & -2Z\Omega \end{bmatrix} x + \begin{bmatrix} 0 \\ M^{-1} \Phi^T B_0 \end{bmatrix} u$$

$$W_e(s) = \begin{bmatrix} \dots \\ \frac{b_i}{a_i s + 1} \\ \dots \end{bmatrix}$$

$$A_{new} = \frac{s + \alpha}{s} A$$

$$z_{k+1} = z_k + \alpha_k p_k(a_i, b_i)$$

