Integrated Modeling of Optical Systems

IMOS

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CAUTION

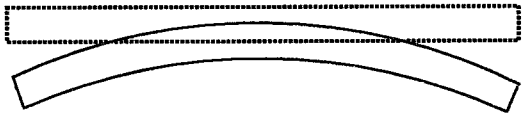
- This material may not be shared with Foreign Nationals.

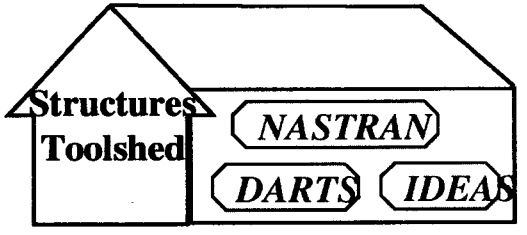
Presentation

- Modeling
- Integrated Modeling
- The Progress of Integrated Modeling
- Examples of Integrated Modeling
- IMOS overview
- IMOS Specifics
- Why is IMOS interested in STEP?

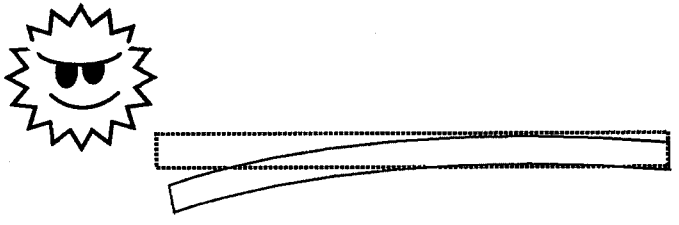
What is Modeling?

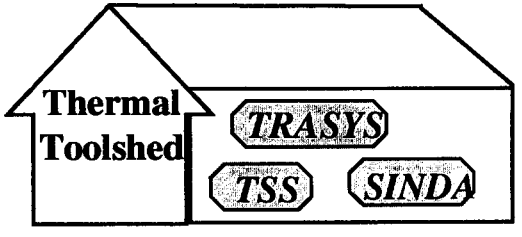
How does the structure vibrate?
How does the structure deform?



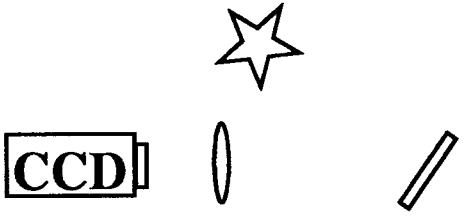


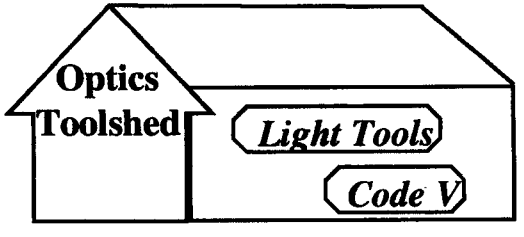
How hot/cold does it get?



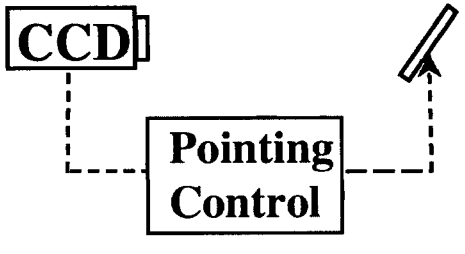


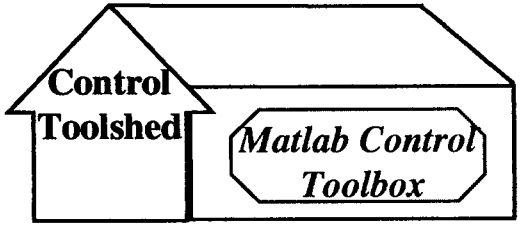
How good is the image?
What if a mirror is misaligned?





How precisely will the alignment be maintained?
How well can disturbances be filtered?





Other Types Of Modeling (Not Part Of IMOS)

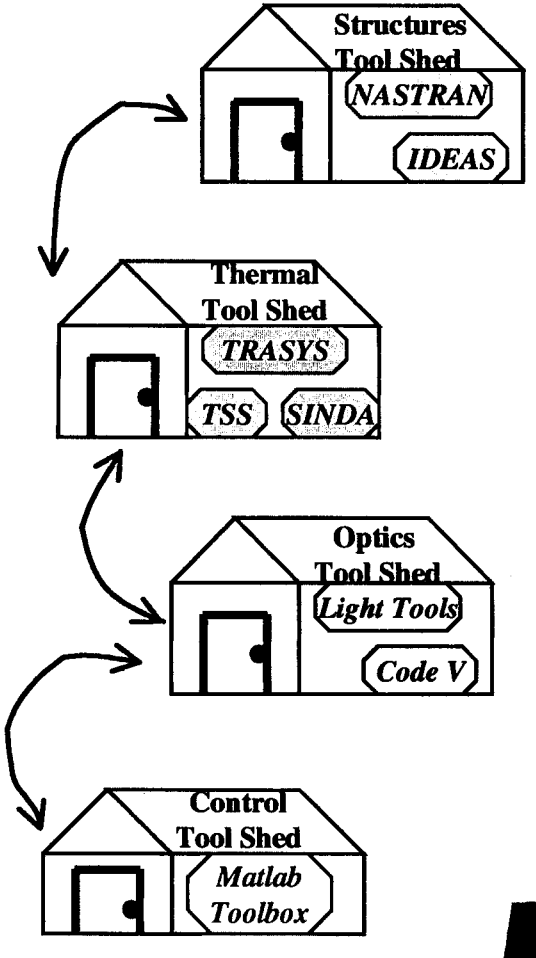
- Cost Modeling
  - If * people are used and the requirements are *, then the total $$$ will be *.
  - If more money is spent on better hardware, then less integration time will be needed, and *** dollars will be saved.

- Software Algorithm Timing
  - Can a more sophisticated/accurate star-centroiding algorithm be implemented for a * Hz cycle?

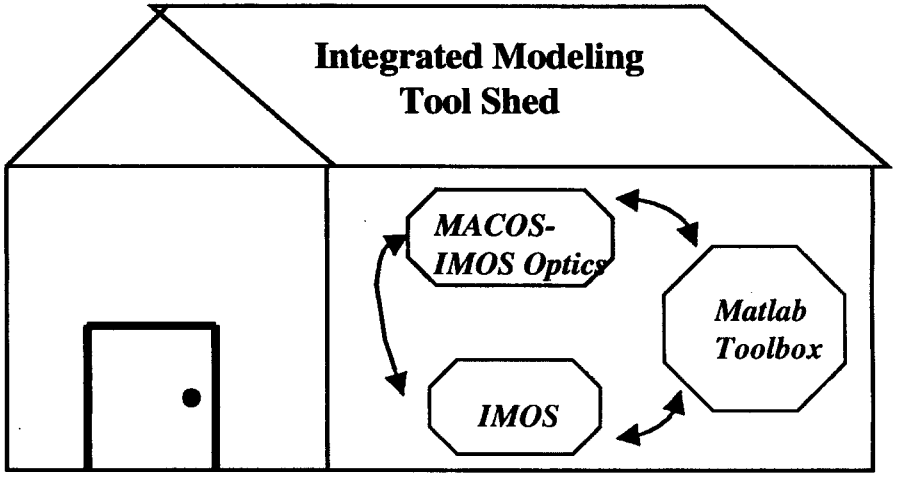
What Is Integrated Modeling?

IMOS/MACOS

Conventional Modeling



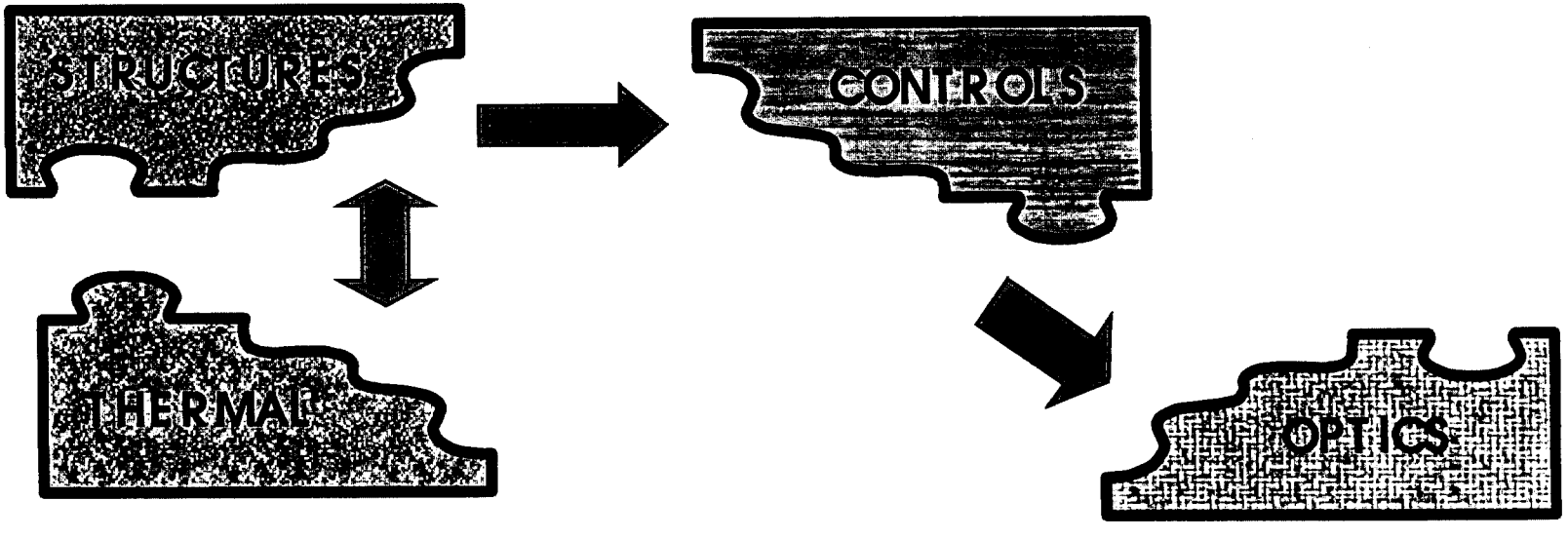
Integrated Modeling



IMOS --- >Finite Element Modeling,
simple Optics, some Thermal
MACOS --- > Optics Modeling
Matlab Toolbox -- > Controls Modeling,
Optimization, + more

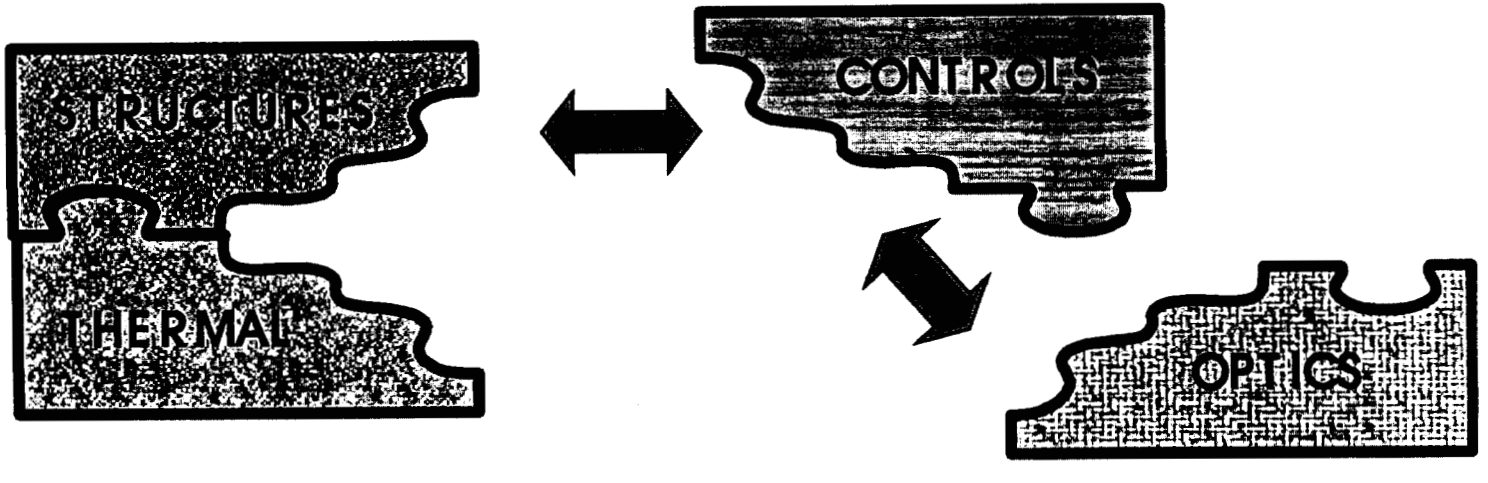
The Differences Between "The Past", "Other IM Tools" and "IMOS"

- **"The Past"**
  - the structural modeler would generated the mass & stiffness matrices (or the frequencies and mode shapes)
  - the controls modeler would develop stability plots for pointing
  - the optics modeler would generated optical performance metrics



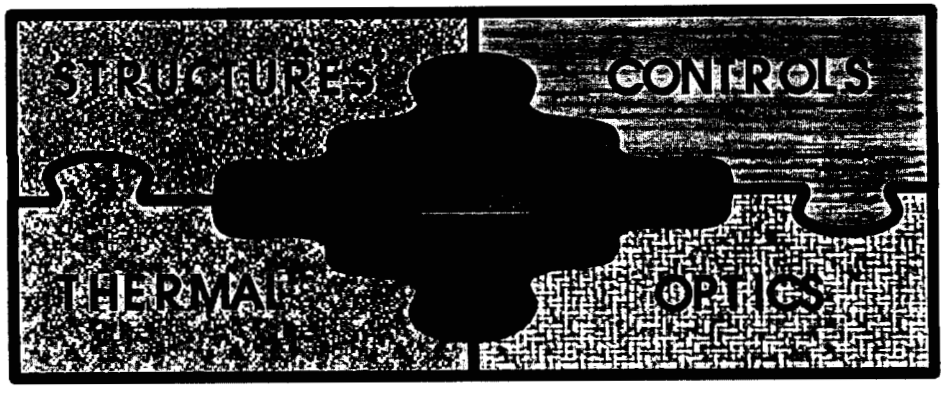
The Differences Between "The Past", "Other IM Tools" and "IMOS"

- **Other "Integrated" Modeling Tools** use (nearly) common models & "translation" to get from one tool to another.
  - the NASTRAN Finite Element Model is *translated* to a thermal program's input deck (structures)
  - the thermal program is started, and thermal analysis is completed
  - temperatures are passed back to structural modeler who calculates the (e.g.) deformations



The Differences Between "The Past", "Other IM Tools" and "IMOS"

- **IMOS** - Analysis is available within a single (environment) (tool)
  - mass & stiffness matrices can be calculated
  - thermal conductances can be added (either calculated using geometric properties or input as a number)
  - temperatures can be calculated
  - optical performance can be calculated (e.g. geometric ray trace)

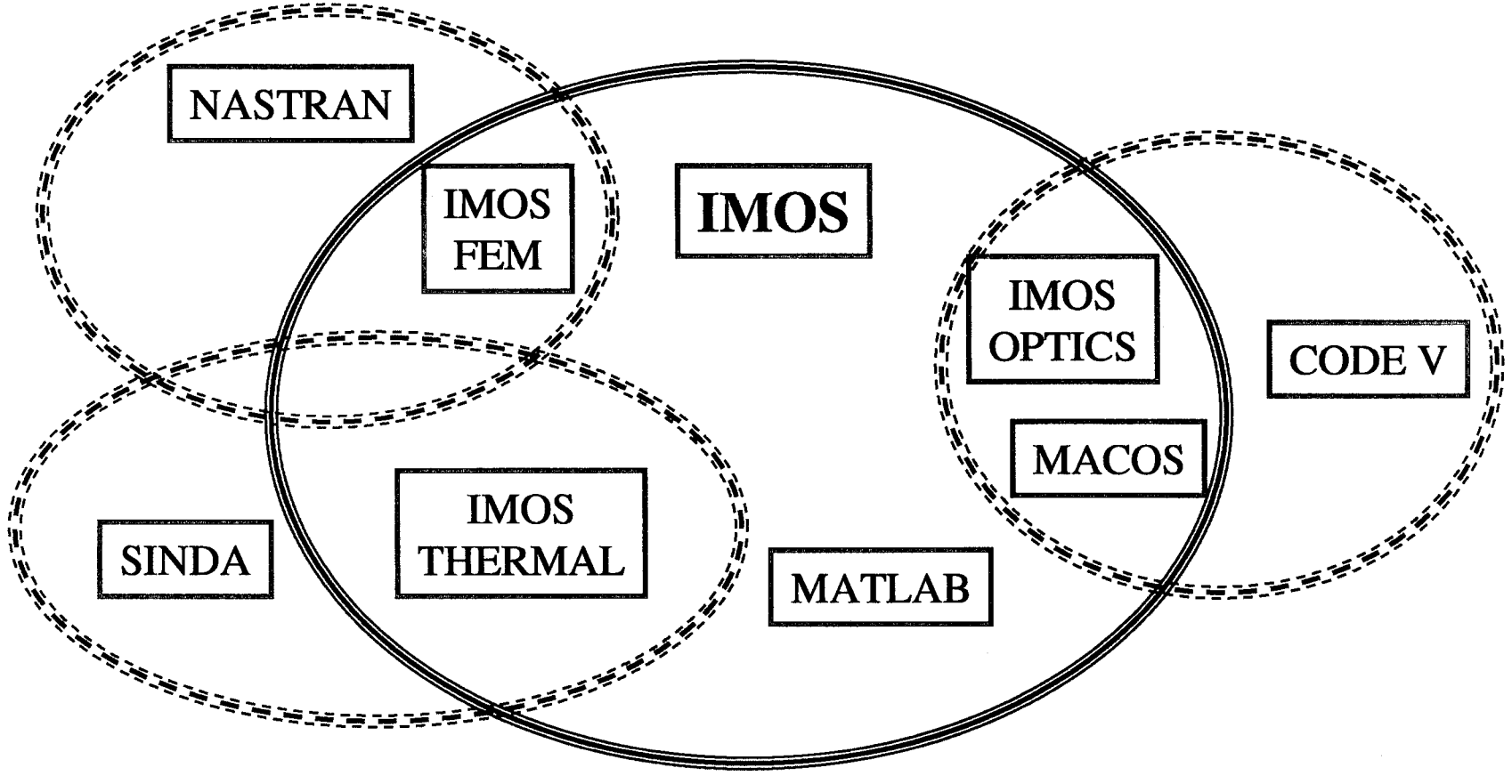


Integrated Modeling Examples

- How well can a given controller maintain imaging performance under realistic disturbances?
  - RW vibrations affect the structure. This misaligns the optics. Could include closed loop control system.
  - Solar radiation is a thermal input. Heating causes temperatures to rise. Changing temperatures cause structure to deform. Again, the optics are now misaligned.
- What heater location minimizes wavefront error on a mirror?
  - Optimally solve for heater locations which give the best improvement in wavefront error on mirror. (Optimization, thermal, structures, optics).
- How do the reaction wheel vibrations affect the image quality?

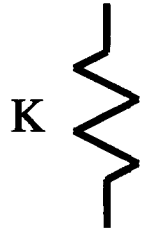
- Cross-disciplinary model validation.

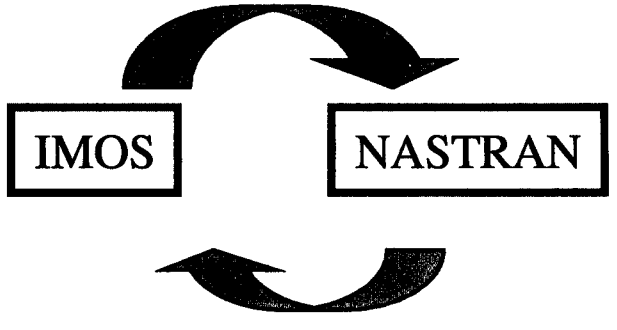
IMOS

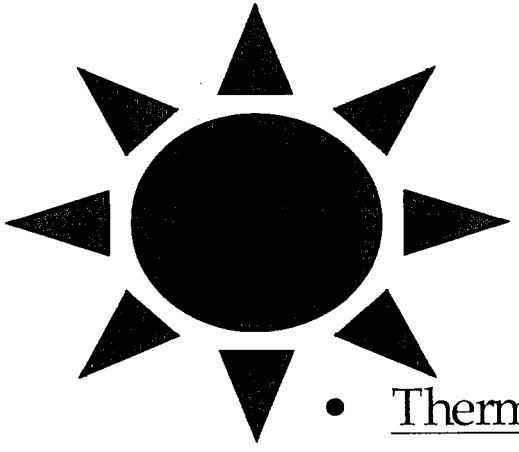

NASTRAN
IMOS FEM
IMOS
IMOS OPTICS
CODE V
MACOS
SINDA
IMOS THERMAL
MATLAB

IMOS Specifics

- Structural Analysis
  - *Finite Element Analysis*
    - > element types - truss, beam, plate (quadrilaterals & triangles), solid elements (coming soon), rigid (RBE2, RBE3), multi-point constraints
    - > material properties - MAT1, MAT2, MAT8, MAT9 (coming soon), PCOMP (calculates properties for laminates)
    - > other - springs, concentrated masses, local coordinates, arbitrary node numbering
    - > analysis types - static (loads), dynamic (eigenvalues), buckling, strain energy
    - > substructuring (coming soon)
    - > translation - NASTRAN to IMOS, IMOS to NASTRAN
  - *Statistical Energy Analysis*
    - > a very limited amount of capability, more coming soon



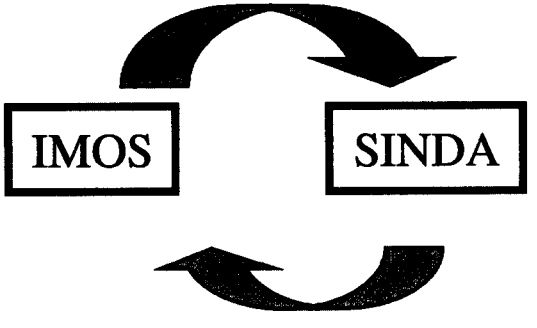




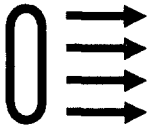
IMOS Specifics

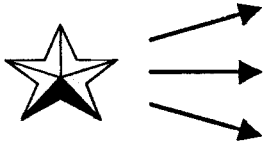
Constant
G(Temp)
Radiation

- Thermal Analysis
  - *Steady State and Transient Solvers*
  - linear conductors & radiation conductors, temperature dependent linear conductors, temperature dependant heat capacitance (nodes)
    - > time dependent heaters
    - > variable levels of convergence
    - > user logic (coming soon)
  - *Assistance In Generating Conductor And Heat Capacitance Values*
    - > use of geometric properties used in finite element model
  - *Interfaces To Other Thermal Tools*
    - > IMOS to SINDA
    - > SINDA to IMOS
    - > IMOS to TSS

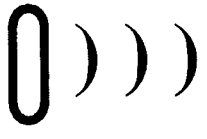


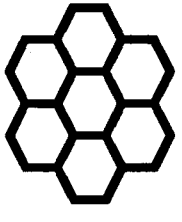
IMOS Specifics





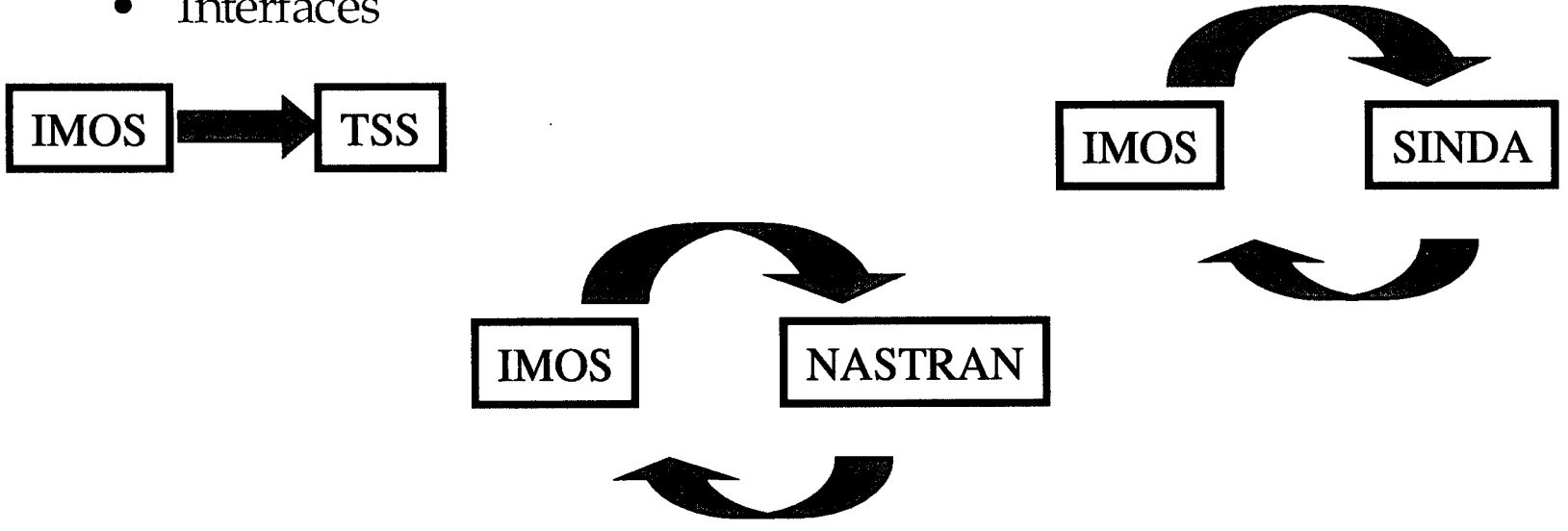
- Optical Analysis
  - *IMOS Optics*
    - > geometric ray trace
    - > conic surfaces
  - *MACOS (Modeling and Analysis for Controlled Optical Systems)*
    - > Surface Types (flats, conics, 10th order aspheres, Zernike, monomial, anamorphic, user-defined, interpolated)
    - > Element Types (refractors, reflectors, lens arrays, reflective gratings, holographic optical elements, reference or dummy, focal planes, segmented mirrors, reflective non-sequential, refractive non-sequential)
    - > Obscurations & Apertures
    - > Coatings
    - > Geometric Ray Trace and Diffraction (near field & far field)
    - > Polarized Light
    - > Source Types (Collimated, Converging, Diverging)
    - > Source Profiles (uniform, Gaussian, cosine-to-a-power, dipole)
    - > Differential Ray Tracing and Linear Optical Models





Why is IMOS interested in STEP?

- Interfaces



- Radiation Calculations & Orbital Heating
  - too expensive and time consuming to introduce a sufficient level of detail needed for problems