# Development of an I/F Software for Patran/Thermal and ESARAD

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*All the space you need*

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## Problem Definition

**The Structural Analysis "World":**

- Use of FEM meshes - edge nodes
- Thermo-elastic distortion analysis from thermal input
- Lack of ray tracing (no specular reflection)
- No orbital analysis capability

**The Thermal Analysis "World":**

- Use of FDM - surface centered nodes
- Ray tracing and orbital load analysis implemented

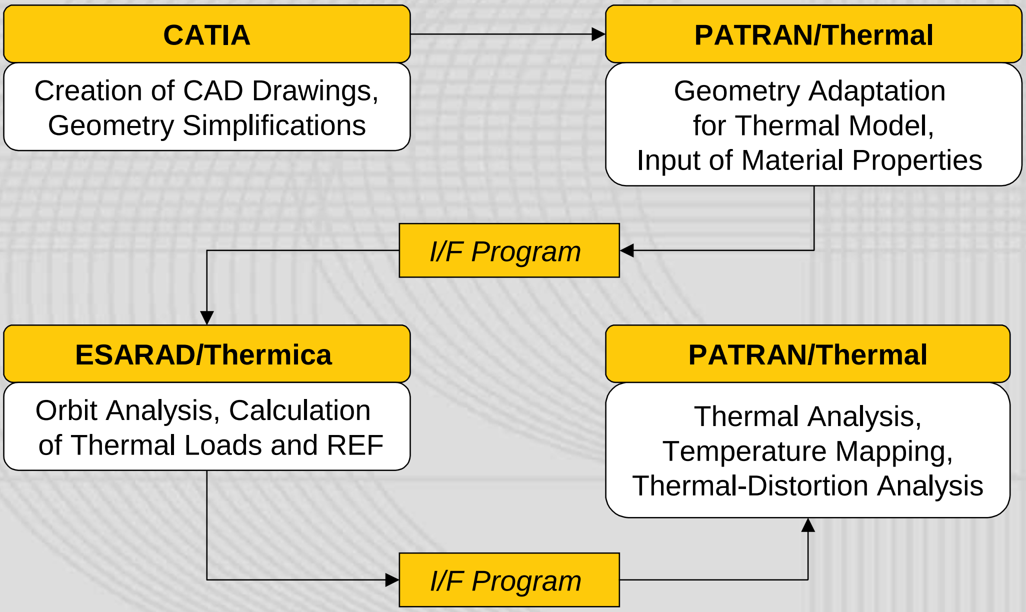
**Current Drawbacks:**

→ Mainly manual temperature mapping from FDM to FEM mesh

→ Separate effort for thermal and structural model creation

# Interface Approach

## Analysis Work Flow:






# Interface Approach

## Structural Analysis

PATRAN/NASTRAN

## Thermal Analysis

**PATRAN/Thermal:**

- Geometry creation
- Thermal mesh creation (edge nodes used)
- Calculation of linear conductors
- Definition of thermo-optical properties
- Definition of internal heat loads

ESARAD/Thermica:

- Calculation of REF
- Orbit Analysis

PATRAN/Thermal:

- Temperature calculation

# Advantages

- Exchange of geometry data according to project needs
- No duplication of geometry
- Makes best use of capabilities of both "worlds":
  - Pre- and post-processing capability of PATRAN
  - PATRAN/Thermal functions to calculate linear conductors
  - Orbit analysis tools and ray-tracing in ESARAD/Thermica
- Capable of generating automated temperature mapping of structural model for thermal distortion analysis without extrapolation

→ Addition of functionality and saving of time



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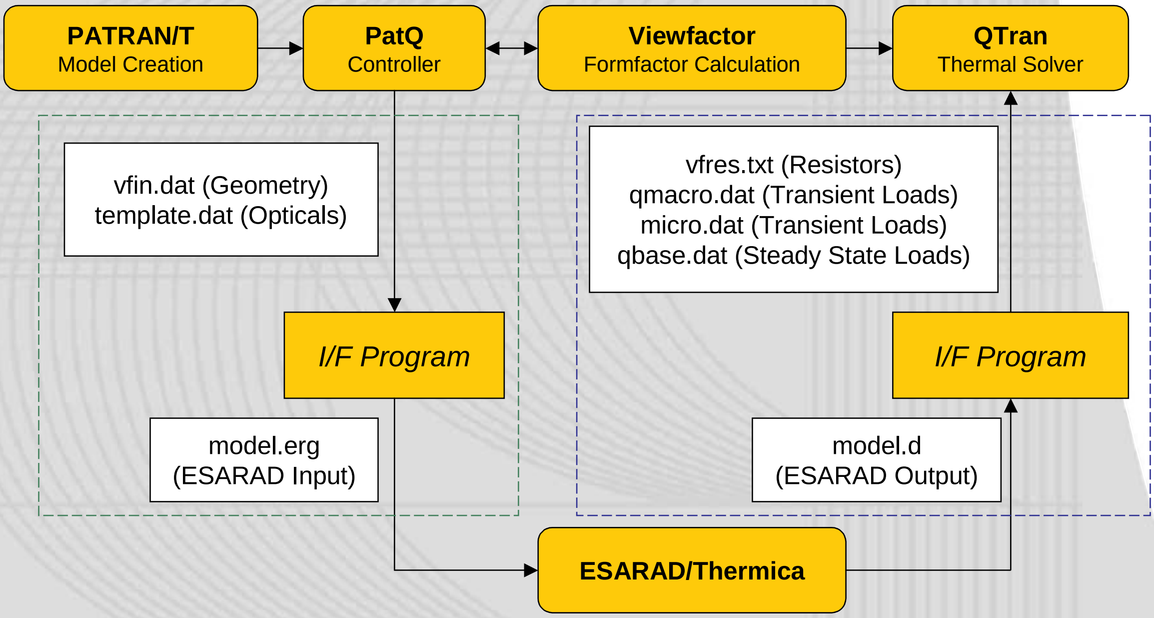
# Data Transfer



# Interface Patran/T to ESARAD

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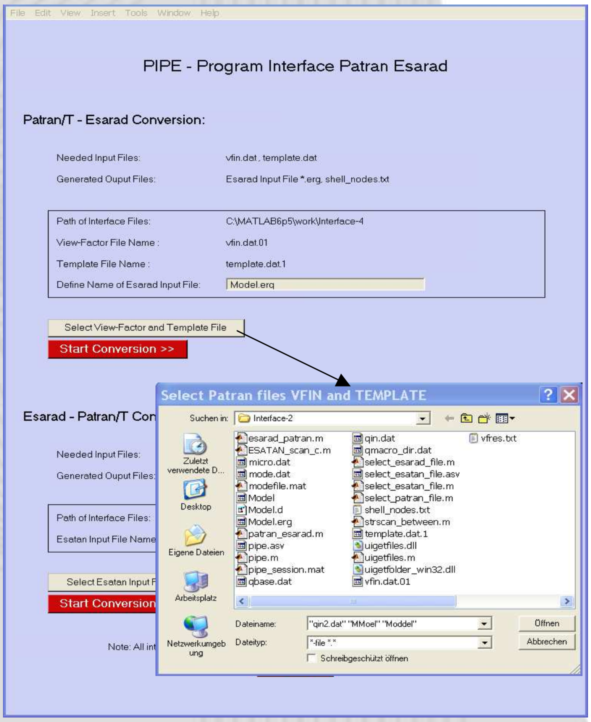
- Define Esarad geometry file: **.erg*
- Select the view factor input file: *vfin.dat*
- Select thermo-optical property data: *template.dat*

→ Automated transfer to Esarad geometry file:

Opticals, points, triangles, rectangles and groups

(one model hierarchy level can be defined via media node)






# Interface ESARAD to Patran/T

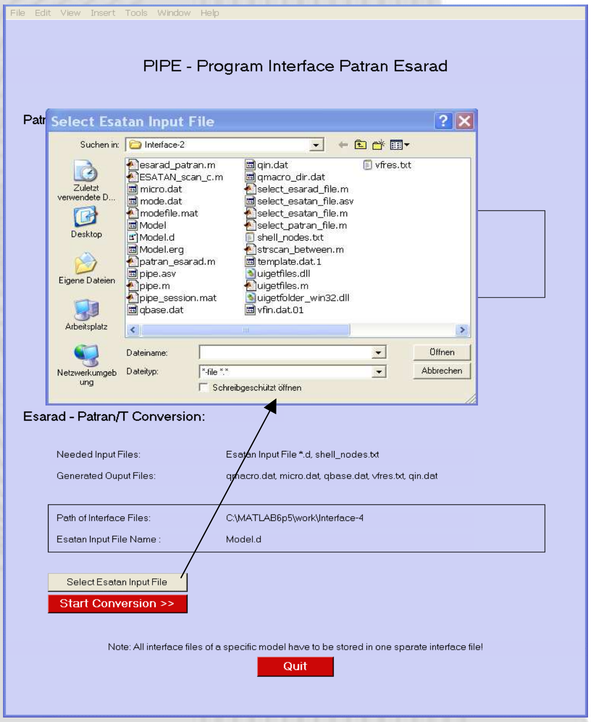
EADS ASTRIUM

- Select the Esatan input file: **.d*

→ Automated definition of thermal loads in *qmacro.dat, qbase.dat*, *micro.dat*

→ Creation of *vfres.txt* containing radiative couplings for <u>edge nodes</u> in Patran/Thermal

→ Adaptation of *qin.dat* to read ASCII file *vfres.txt* before solving



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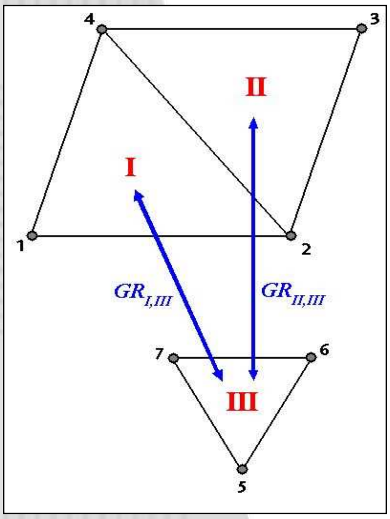
# Verification of Radiative Approach

## Radiative Model:

- Three triangles of same size with same normal vector
- Surface Indices: $p, q = I, II, II$ Edge Indices: $i, j = 1, 2, \dots 6$
- Number of edges: $n_I = 3, \quad n_{II} = 3, \quad n_{III} = 3$
- REF of triangles: $GR_{I,III} = GR_{II,III}, \quad GR_{I,II} = 0$




## HF calculated in ESARAD:

$$\dot{Q}_{TOT,ESARAD} = \dot{Q}_{I,III} + \dot{Q}_{II,III} = \sigma \cdot \left[GR_{I,III} \cdot \left(T_I^4 - T_{III}^4\right) + GR_{II,III} \cdot \left(T_{II}^4 - T_{III}^4\right)\right]$$

## HF calculated in PATRAN:

$$\dot{Q}_{TOT,PATRAN} = \sigma \cdot \left[\begin{array}{l} \frac{\left(T_1^4 - T_7^4\right)}{R_{1,5}} + \frac{\left(T_1^4 - T_6^4\right)}{R_{1,6}} + \frac{\left(T_1^4 - T_5^4\right)}{R_{1,7}} + \frac{\left(T_2^4 - T_5^4\right)}{R_{2,5}} + \frac{\left(T_2^4 - T_6^4\right)}{R_{2,6}} + \frac{\left(T_2^4 - T_7^4\right)}{R_{2,7}} \\ + \frac{\left(T_3^4 - T_5^4\right)}{R_{3,5}} + \frac{\left(T_3^4 - T_6^4\right)}{R_{3,6}} + \frac{\left(T_3^4 - T_7^4\right)}{R_{3,7}} + \frac{\left(T_4^4 - T_5^4\right)}{R_{4,5}} + \frac{\left(T_4^4 - T_6^4\right)}{R_{4,6}} + \frac{\left(T_4^4 - T_7^4\right)}{R_{4,7}} \end{array}\right]$$

→ HF values are identical for: $R_{i,j} = \sum_{p,q} \frac{n_p \cdot n_q}{GR_{p,q}}$

# Test Examples

## Model Comparison

- First a satellite model is built in ESARAD
- Temperature calculations are performed with ESATAN using ESARAD nodes

- A second similar satellite model is built in PATRAN
- Temperature calculations are performed with PATRAN/Thermal using edge nodes

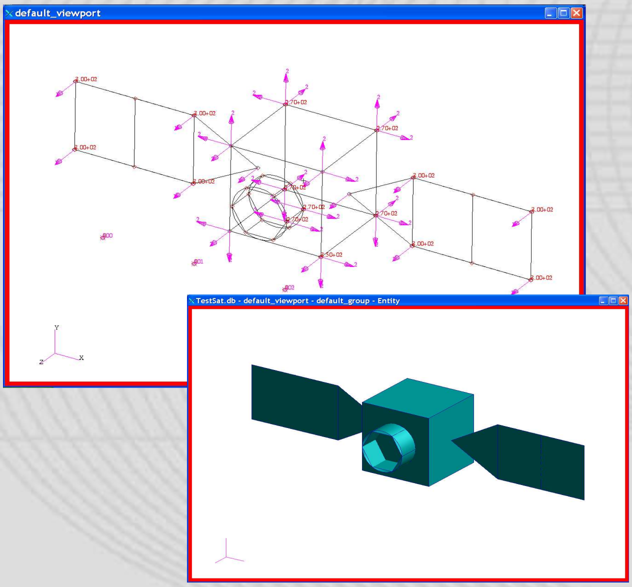
→ Verification of correct geometry transfer from PATRAN to ESARAD
→ Verification of correct transfer of thermo-optical properties
→ Verification of correct calculation of external loads for both geometries



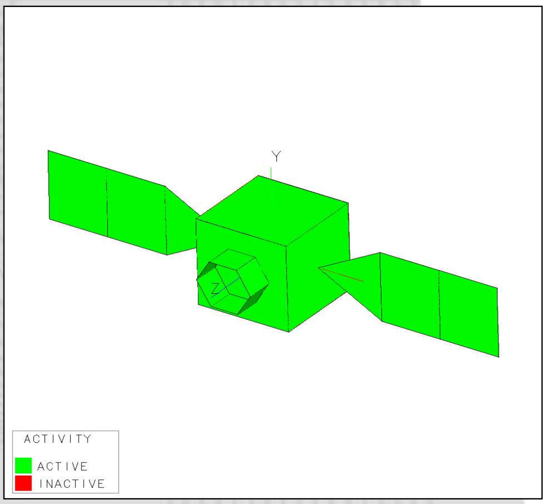
# Test Examples

## Geometry Transfer

Geometry build in PATRAN/Thermal:




After Transfer to ESARAD:



# Test Examples

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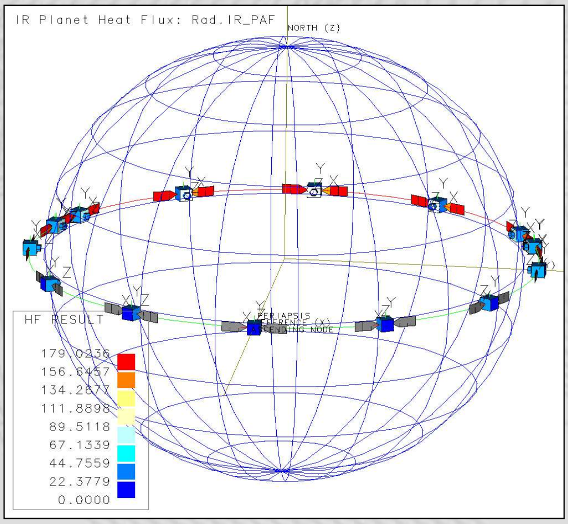
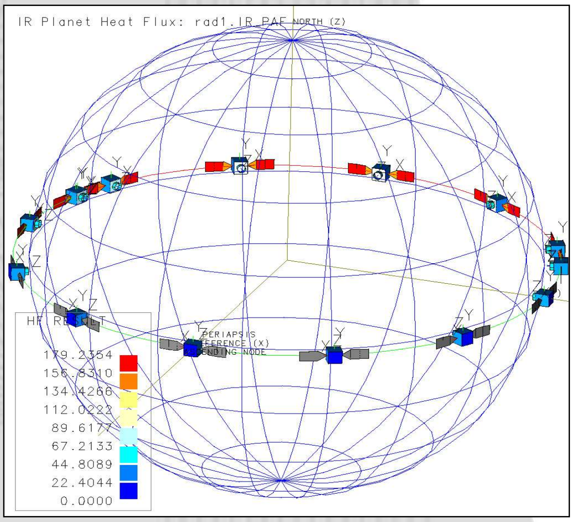
## Planet Heat Flux Results

Geometry converted from PATRAN:




Geometry created in ESARAD :






# Test Examples

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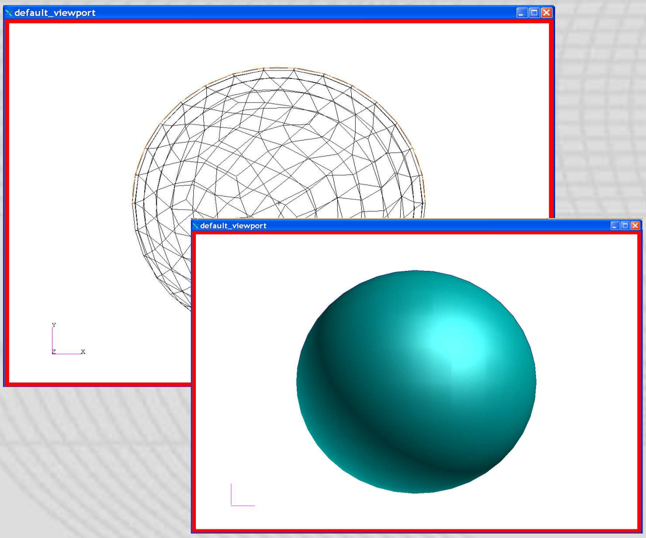
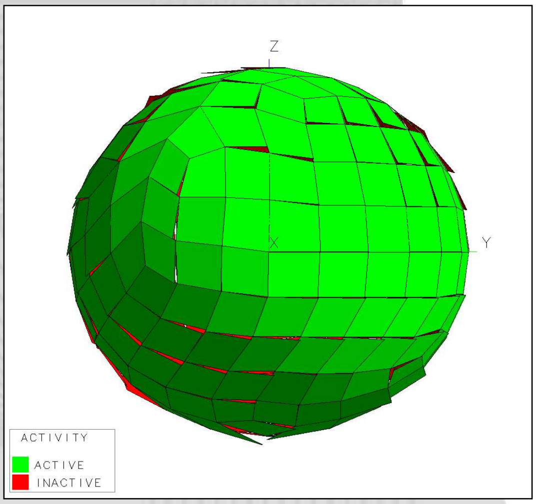
## Ball Model

Build and meshed in PATRAN/Thermal:




… and what arrived in ESARAD:




→ There is still a significant amount of work ahead !

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# Summary

- I/F software has been implemented to link ESARAD and PATRAN for analysis of thermal distortion problems.
- An algorithm has been developed to assign the REF from ESARAD to PATRAN/Thermal.
- Triangular and rectangular surfaces are supported
- I/F software is coded in Matlab
- Future activities:
  Creation of I/F to Thermica,
  Verification of temperature calculation,
  Software test in real project environment