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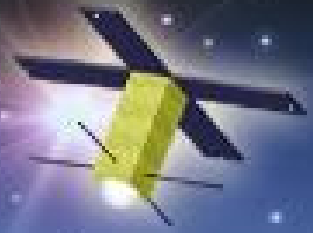
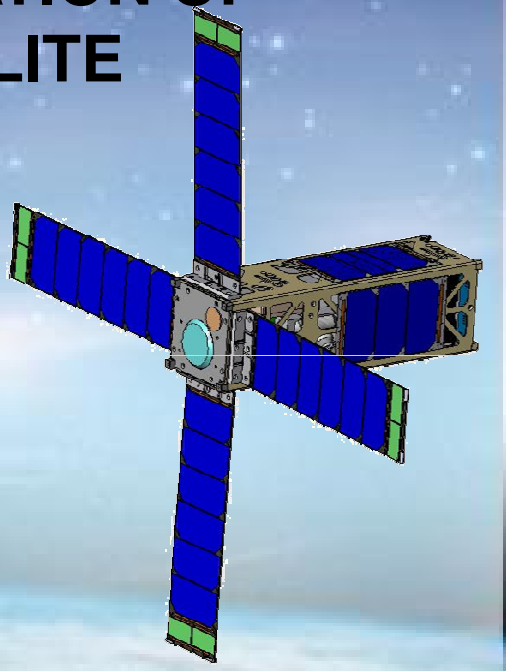


THERMAL AND MECHANICAL OPTIMISATION OF THE FIRST ISRAELI NANO-SATELLITE



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העמותה הישראלית ללווייינות זעירה
This presentation will cover:
•Opening words
•Satellite mechanical design and thermal aspects
•Thermal optimisation
•Analytical Thermal Analysis
•Numerical Thermal Analysis
•Results and the optimisation process
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Opening words

The first Israeli Nano-Satellite program was ignited in 2005 with the forming of INSA, the Israeli Nano-Satellite Association.

The satellite, weighing about 3.5Kg, is being built by a group of experienced professionals from the local space industry working side by side with high school and university students.

This first Nano-Satellite will be used as a test-bed for the bus sub-systems to be used on future projects, and will supply space heritage for local companies' products

The satellite configuration presented here is due to be launched in Q4 2009.

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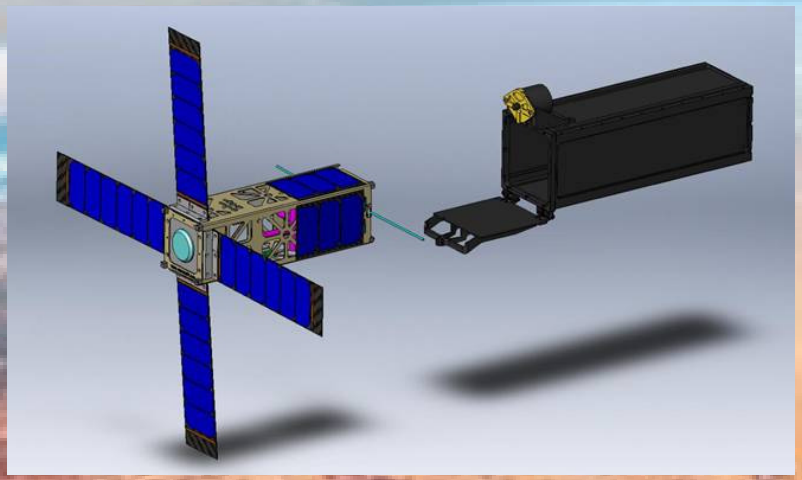
MECHANICAL DESIGN

Modifications of the standard CubeSat structure

Certain areas are considered stay out zones such as the rails on the corners for deployment from the deploying canister (P-POD); however other areas can be drilled or changed according to the satellite design.



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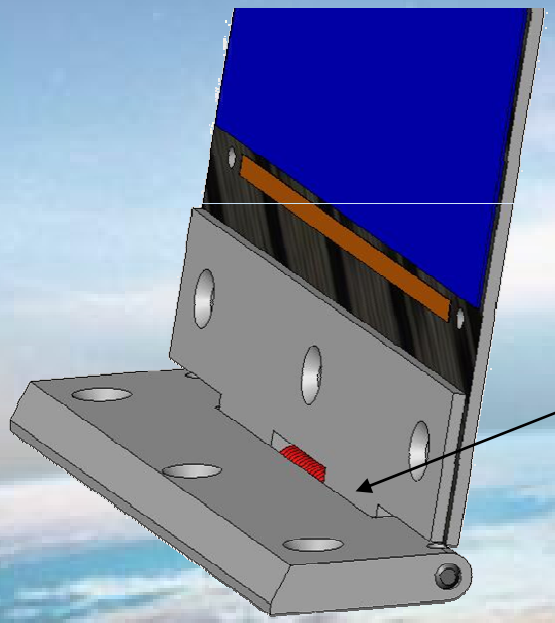
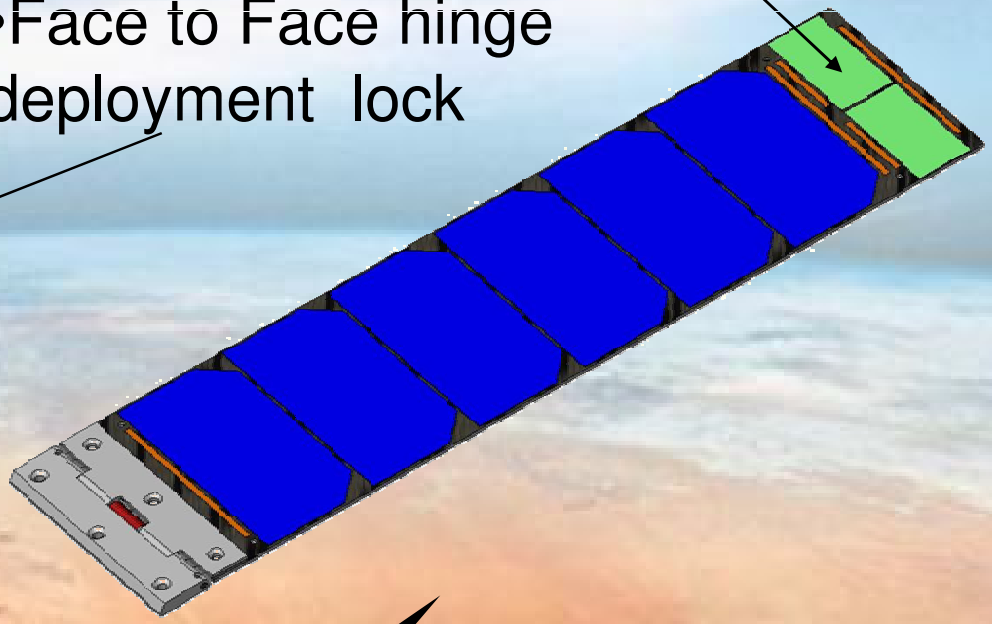
Solar Panels Design

- Composite panel
- MAMAG MLI coating experiment
- Face to Face hinge deployment lock





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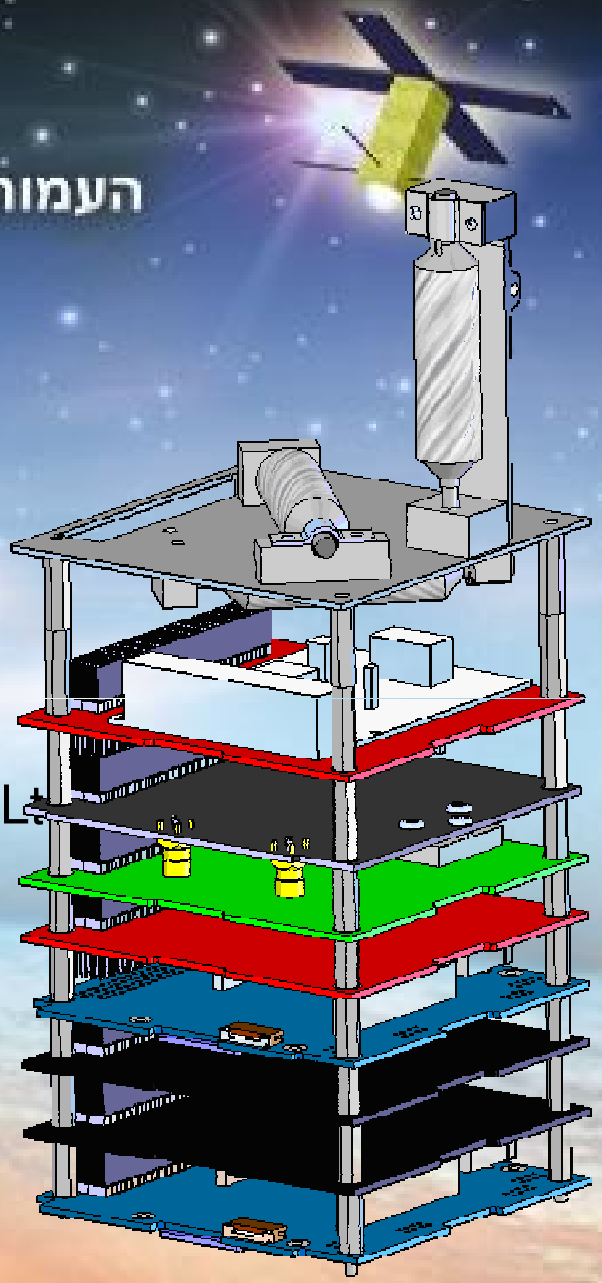
Sub-system accommodation

FM-430 on board computer
EPS-1
EPS-2
FM-430 on board computer
Balancing weight layer
Switch board (developed by INSA and Clyde Space L
ISIS Transponder
ALINCO transponder
Magnet Torquers



Little thermal conduction between cards

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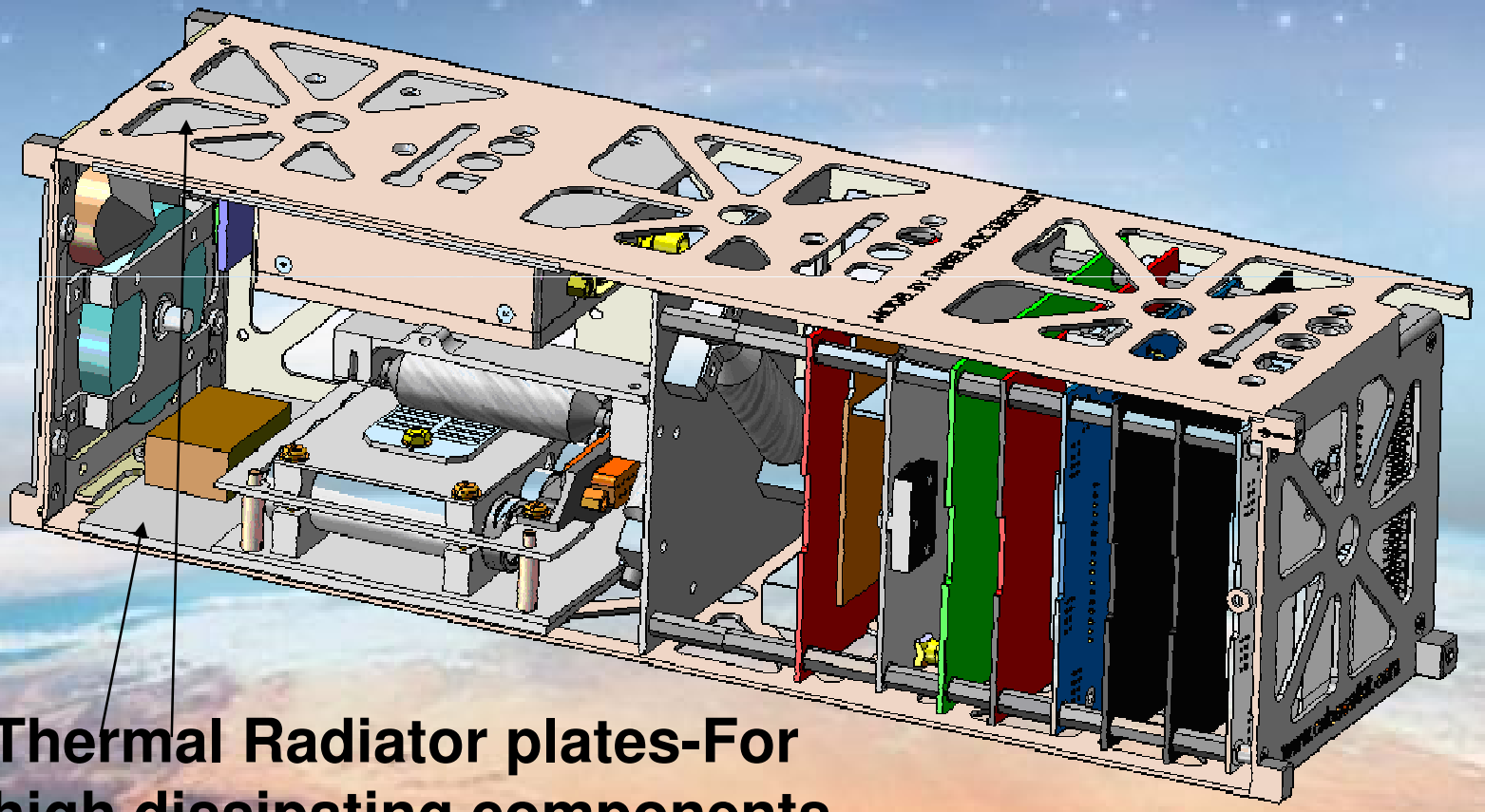
Hardware mounting provisions



Thermal Radiator plates-For high dissipating components (Atomic Clock+Battery)

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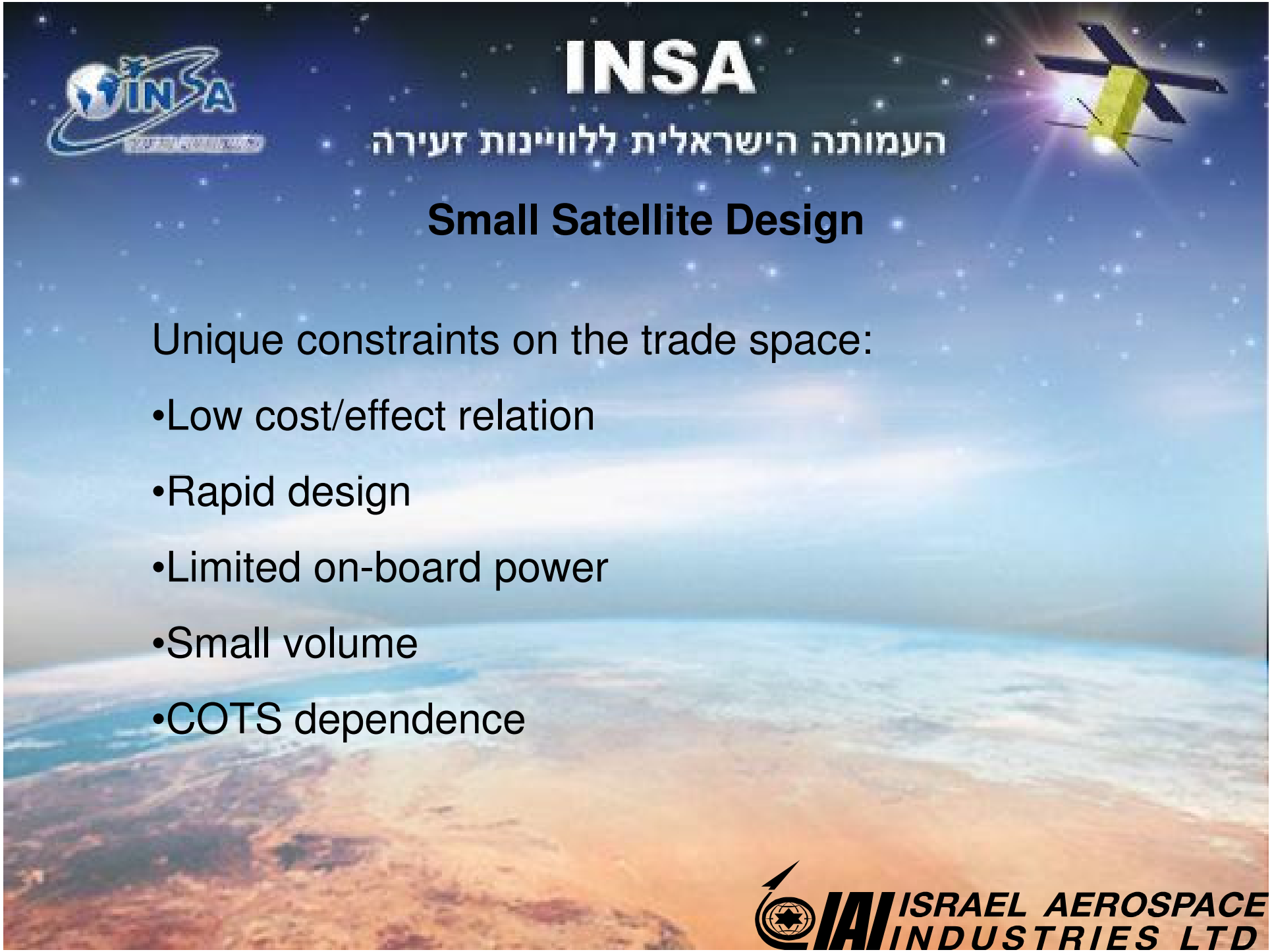
THERMAL OPTIMISATION

Purpose of the thermal analysis:

- Maintain components within operating temperature limits
- Facilitate proper mechanical design
  - Goal → passive control
    - MLI
    - Paints
    - Radiators
    - Conduction pathways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Small Satellite Design
Unique constraints on the trade space:
•Low cost/effect relation
•Rapid design
•Limited on-board power
•Small volume
•COTS dependence
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העמותה הישראלית ללווייינות זעירה

Input and Outputs

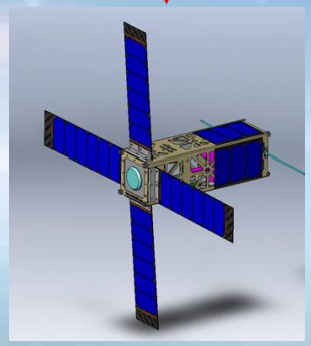
Direct Sunlight

~1400 W/m^2

Generated Heat

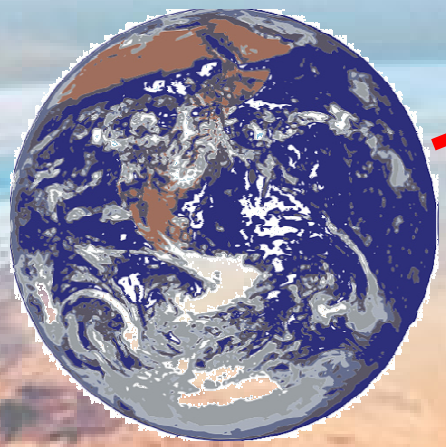
Albedo

~400 W/m^2



Radiated Heat

αT^4



IR Earthshine

~300 W/m^2

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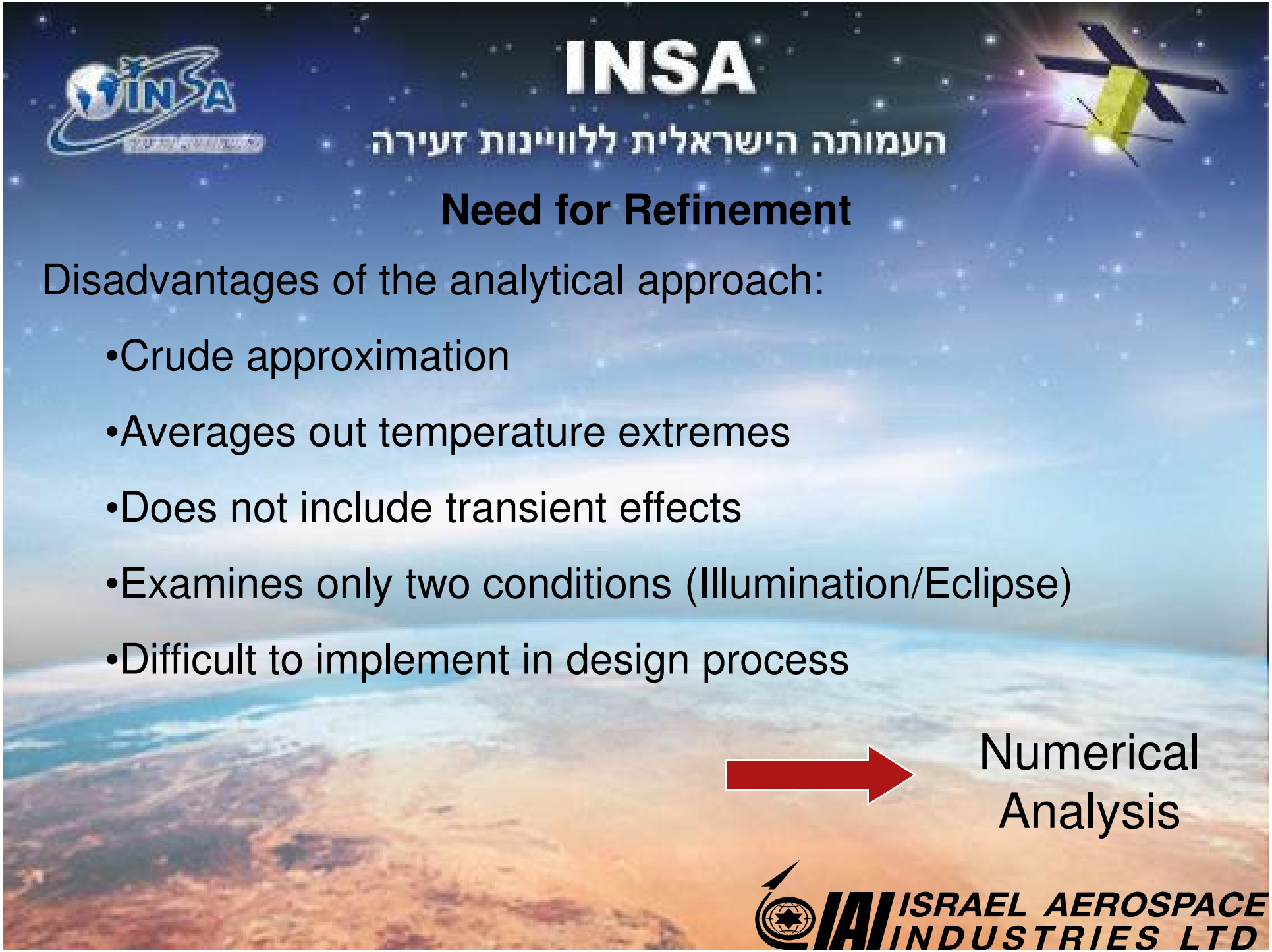
Analytic Approximation

First order approximation as a guideline:

- Simple and quick calculation
- Allows to infer comprehensive satellite temperatures
- Sanity check for future analyses
- Important in lack of information and references
- Provides early answers for parallel design

Solution is based on a “steady-state” energy balance

$$q_{absorbed} - q_{emitted} + q_{power-generated} = 0$$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Need for Refinement
Disadvantages of the analytical approach:
•Crude approximation
•Averages out temperature extremes
•Does not include transient effects
•Examines only two conditions (Illumination/Eclipse)
•Difficult to implement in design process
Numerical Analysis
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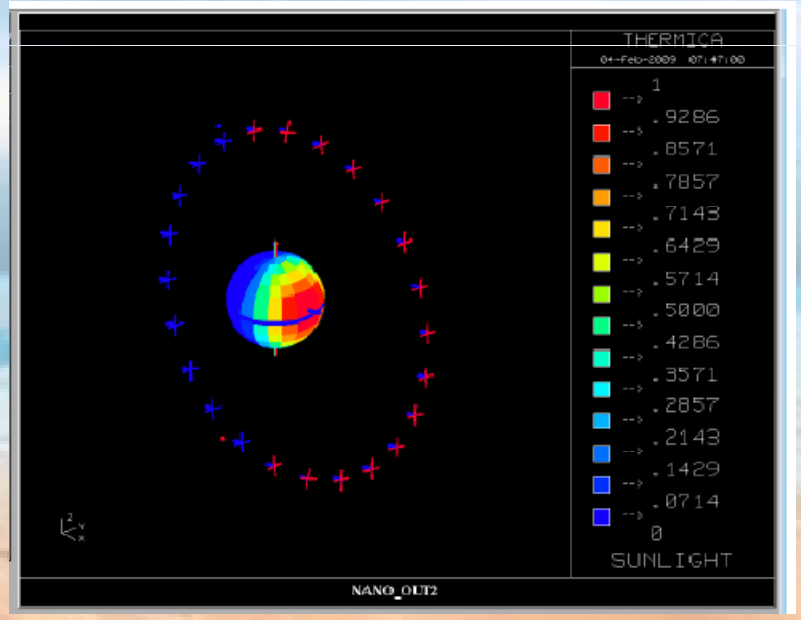
Numerical Thermal Analysis

- 150 finite elements define the geometry
- Orbit: 650km sun-synchronous
- 250 Contacts between elements
  - Conduction
  - Radiation



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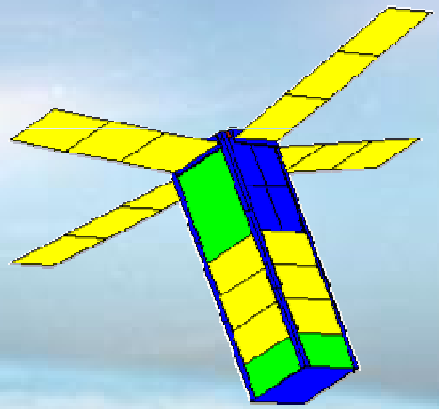
Initial Results and Optimization

First iteration predictions

- Exterior components within limits
- Some electronic boards exceeded allowable ranges



Optimization steps

- Removal of insulation blankets
- Addition of more effective radiators on top and bottom panel

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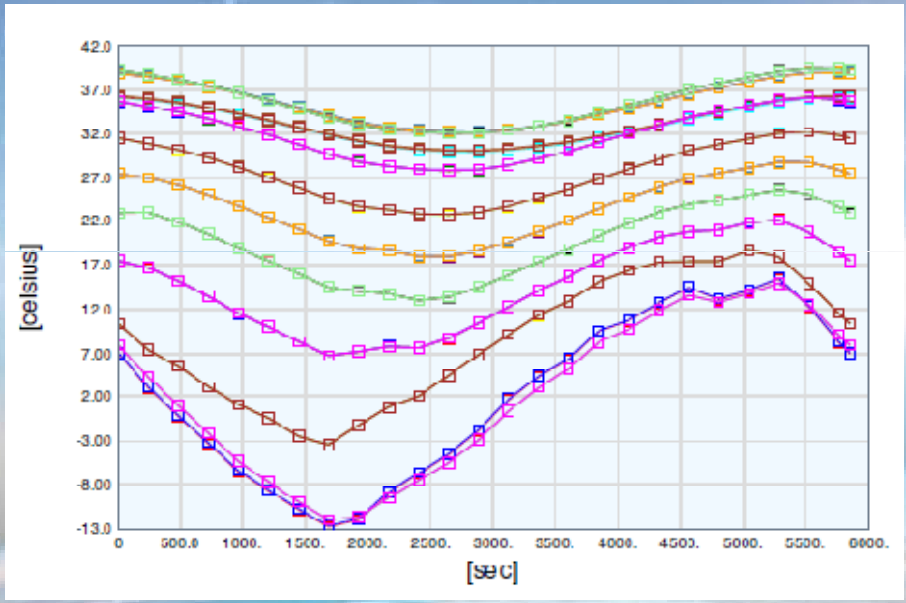
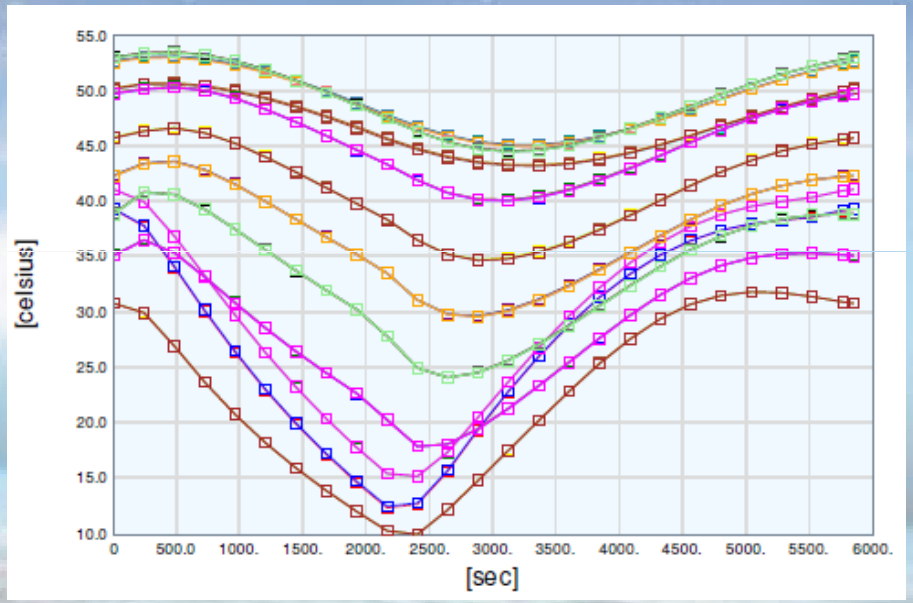
Refined Results

Cold Case



Hot Case



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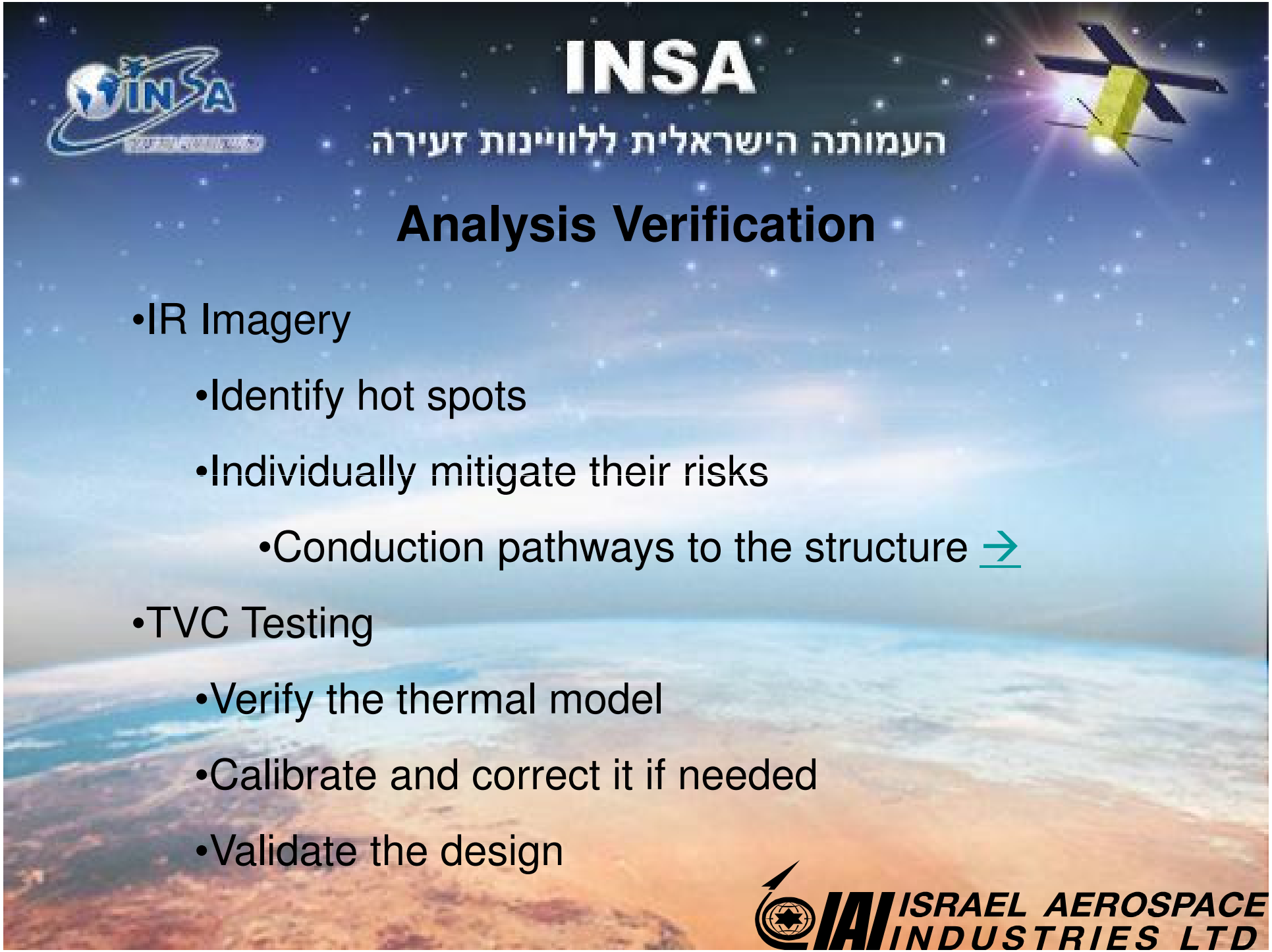
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Analysis Verification
•IR Imagery
•Identify hot spots
•Individually mitigate their risks
•Conduction pathways to the structure →
•TVC Testing
•Verify the thermal model
•Calibrate and correct it if needed
•Validate the design
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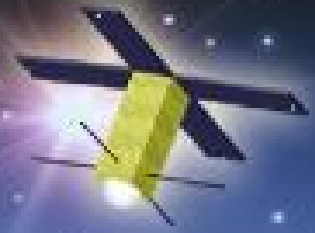
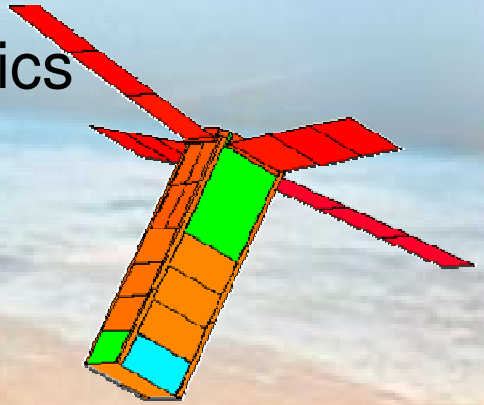


Summary

- Developed process for nano-satellite thermal analysis
- Met all mechanical requirements
- Achieved hand-in-hand development of thermal/mechanical design
- Predict -10℃ to +55℃ for critical electronics



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Thank you for listening
See you all at the launch!
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BACKUP SLIDES
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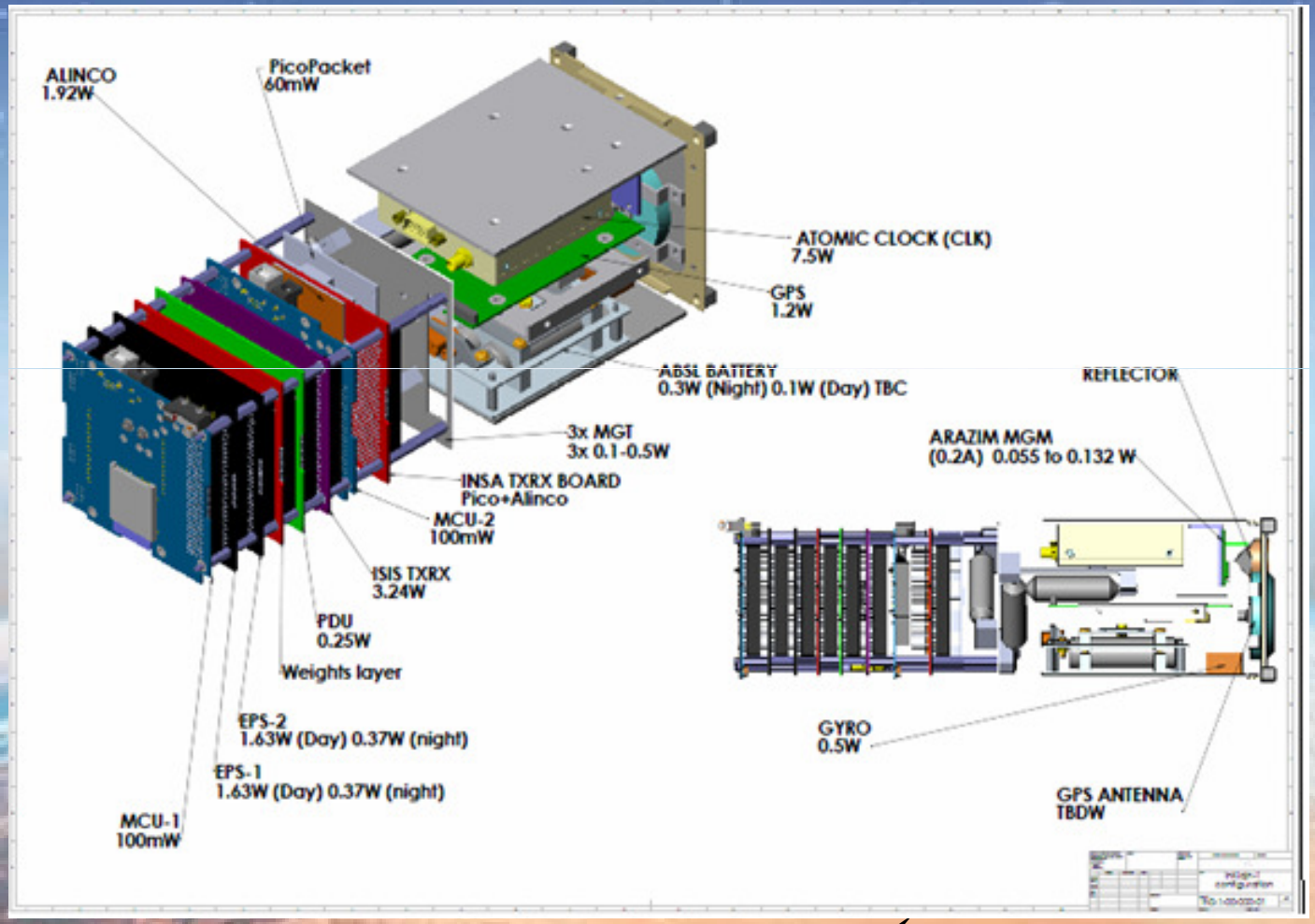
Generated Heat



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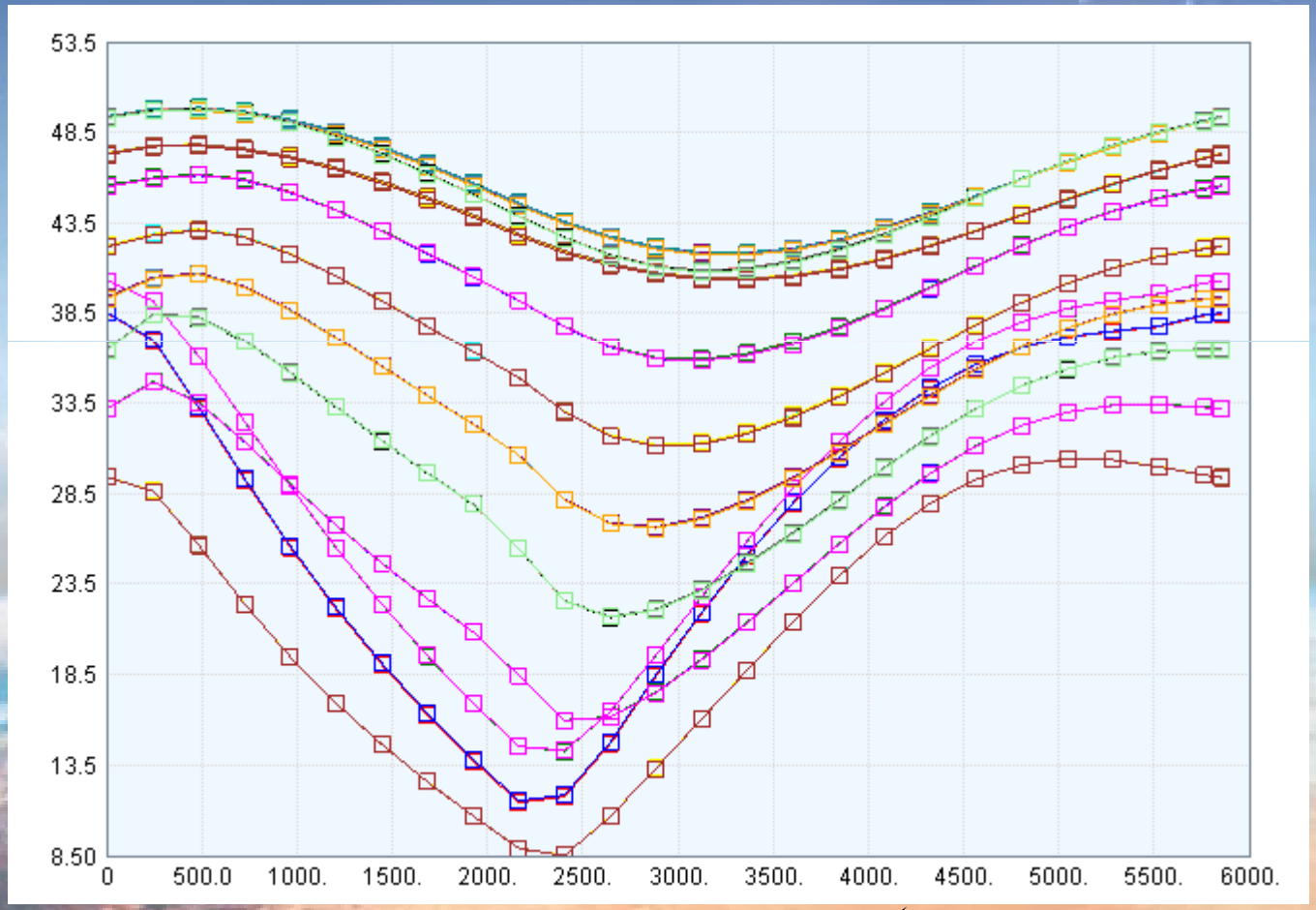
Conduction Pathway Effect



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