De afbeelding kan niet worden weergegeven. Het is mogelijk dat er onvoldoende geheugen beschikbaar is op de co...

Effective approach to microsatellite environmental testing Mechanical and Thermal

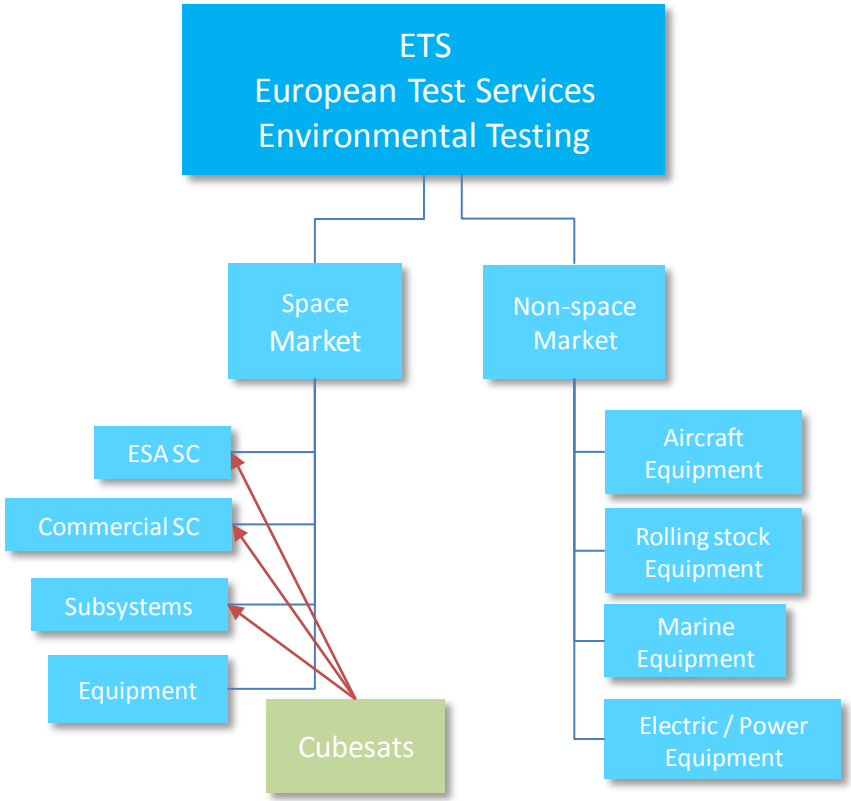
08/06/2016
Leiden@CORPUS

Dario Hermida
dario.hermida@esa.int
European Test Services

De afbeelding kan niet worden weergegeven. Het is mogelijk dat er onvoldoende geheugen beschikbaar is op de co...

Tutorial index

1.- Introduction to environmental testing



De afbeelding kan niet worden weergegeven. Het is mogelijk dat er onvoldoende geheugen beschikbaar is op de computer om de afbeelding te openen of dat de afbeelding beschadigd is. Start de computer opnieuw op en open het bestand opnieuw. Als de afbeelding nog steeds wordt voorgesteld door een rode X, kunt u de afbeelding verwijderen en opnieuw invoegen.

De afbeelding kan niet worden weergegeven. Het is mogelijk dat er onvoldoende geheugen beschikbaar is op de co...

Introduction to environmental testing

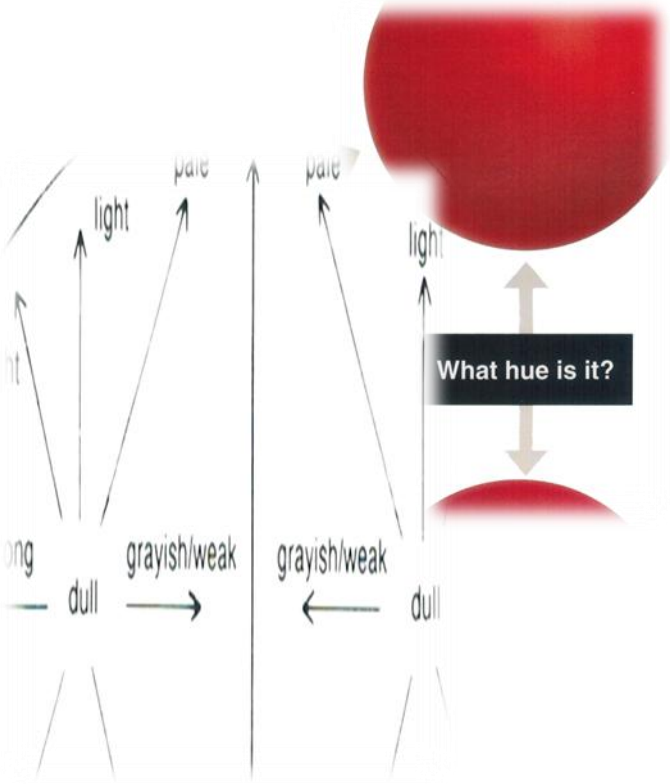
De afbeelding kan niet worden weergegeven. Het is mogelijk dat er onvoldoende geheugen beschikbaar is op de computer om de afbeelding te openen of dat de afbeelding beschadigd is. Start de computer opnieuw op en open het bestand opnieuw. Als de afbeelding nog steeds wordt voorgesteld door een rode X, kunt u de afbeelding verwijderen en opnieuw invoegen.

De afbeelding kan niet worden weergegeven. Het is mogelijk dat er onvoldoende geheugen beschikbaar is op de co...

Introduction to environmental testing

1.1.- Fundamentals and effective approach

- Environmental as part of the design process
  - Contribution to phase A, B.
  - Thinking ahead.
  - Foresee challenges.
- Environmental testing standards
  - MIL-STD-810
    - Mostly practical.
    - Full of examples.
  - ISO/TC 108
    - Nice technical approach.
    - Not for free.
  - IEC 60068
    - Not space focused.
    - Plenty of examples.
  - ECSS
    - Difficult to find what you need.
    - ECSS-E-HB-32-20 Part 7A (2011)
      - Nice start.
      - Full of references for thermal and mechanical.
      - Already superseded, but fine anyway.
- Realistic and effective approach

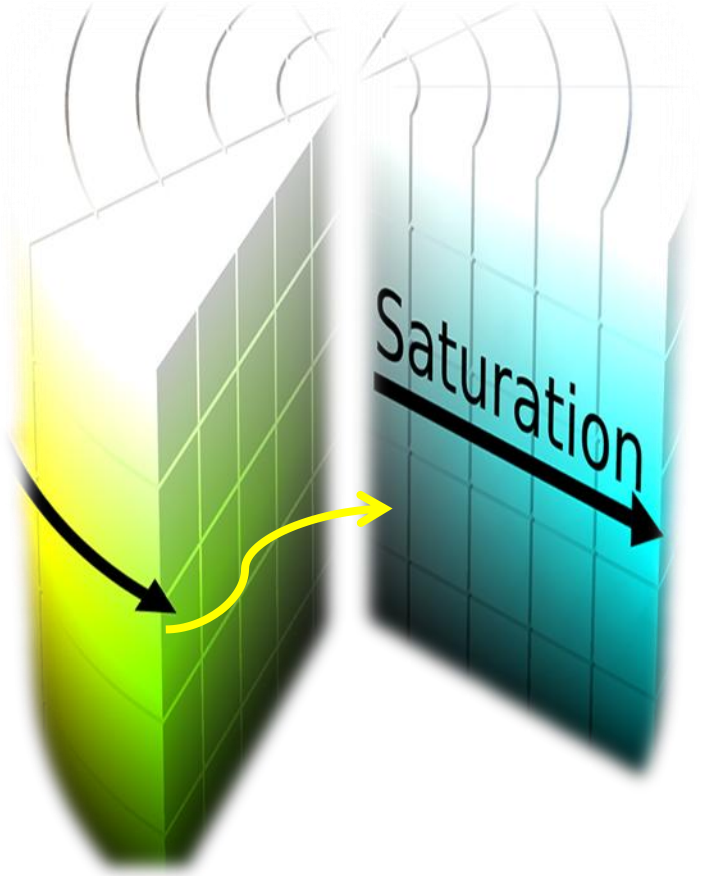


1.1.- Fundamentals and effective approach

- Realistic
  - Being realistic is not nice.
  - Being realistic is tough.
  - Being realistic is usually appreciated years after.
- Effective approach
  - Low budgets
  - Consider testing subsystems before assembly of your Cubesat.
    - Many examples of detecting an early failure.
    - Strongly recommended when developing a new idea using non-flight hardware.
  - Save your efforts for:
    - Acceptance mechanical and thermal tests for your Cubesat.
- Time
  - Mechanical tests usually a matter of 1 day.
  - Thermal tests usually a matter of 5 days.
  - Environmental tests average preparation time for a Cubesat is X months.
    - X can be <1 month with facilities booked, prior experience from facilities operators and Cubesat's team.
    - X can be >6 months facing a full Cubesat test campaign.
    - X is usually expected around 3 months on average, and not easy to achieve.

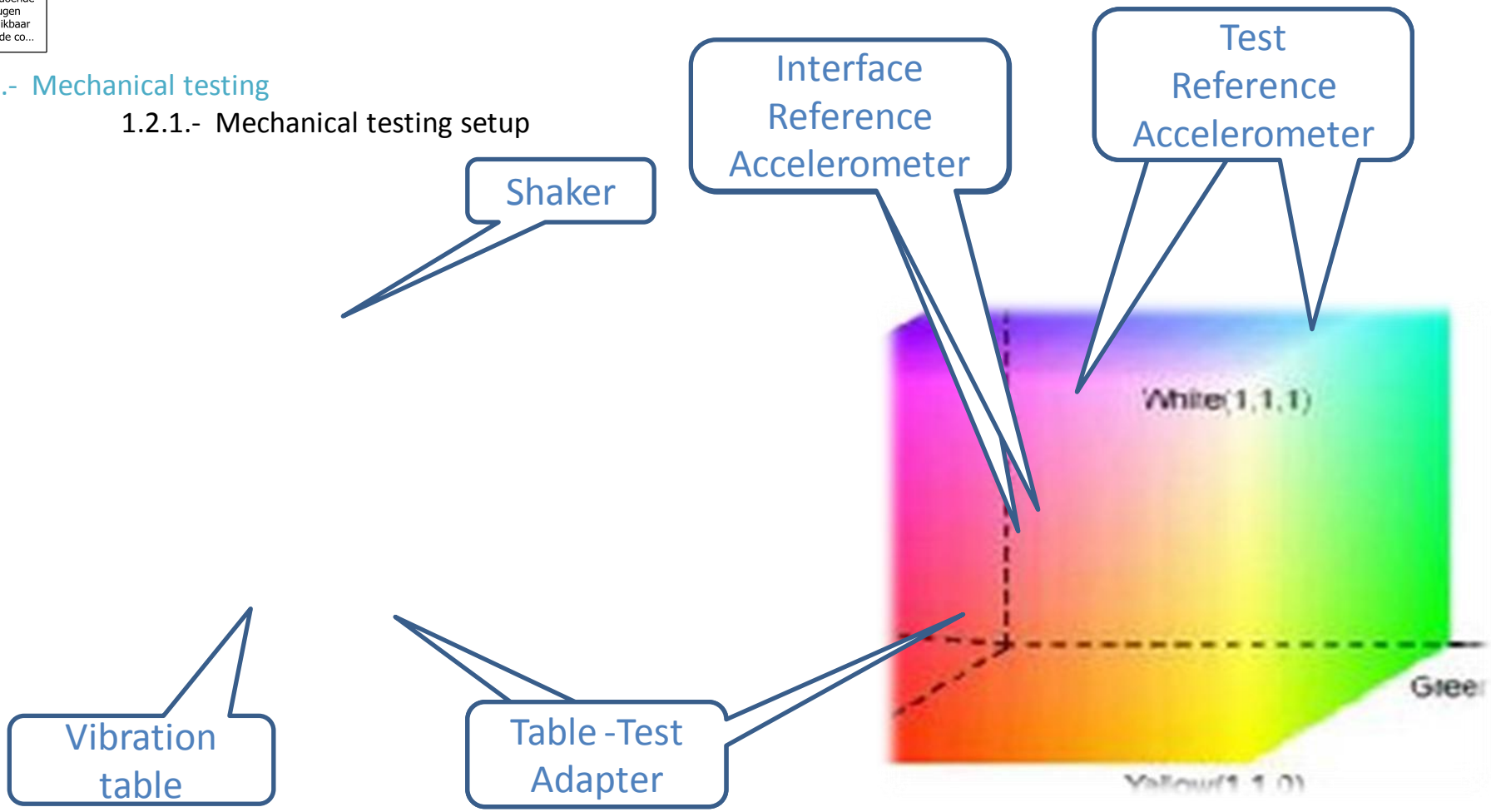
1.1.- Fundamentals and effective approach

- Consider outcome data
  - Early thermal testing on Electrical Power System.
  - Early mechanical testing on Antenna Deployment System.
  - Early platform testing
    - Doubtful data to be used as a reference for the mission.
    - All teams are getting involved in the design process.
- Re-use of data/tests/qualification for future missions.
- This tutorial:
  - It is NOT comprehensive.
  - It is an overview based on:
    - Experience on Cubesat design.
    - Facility operators experience.



1.2.- Mechanical testing

1.2.1.- Mechanical testing setup

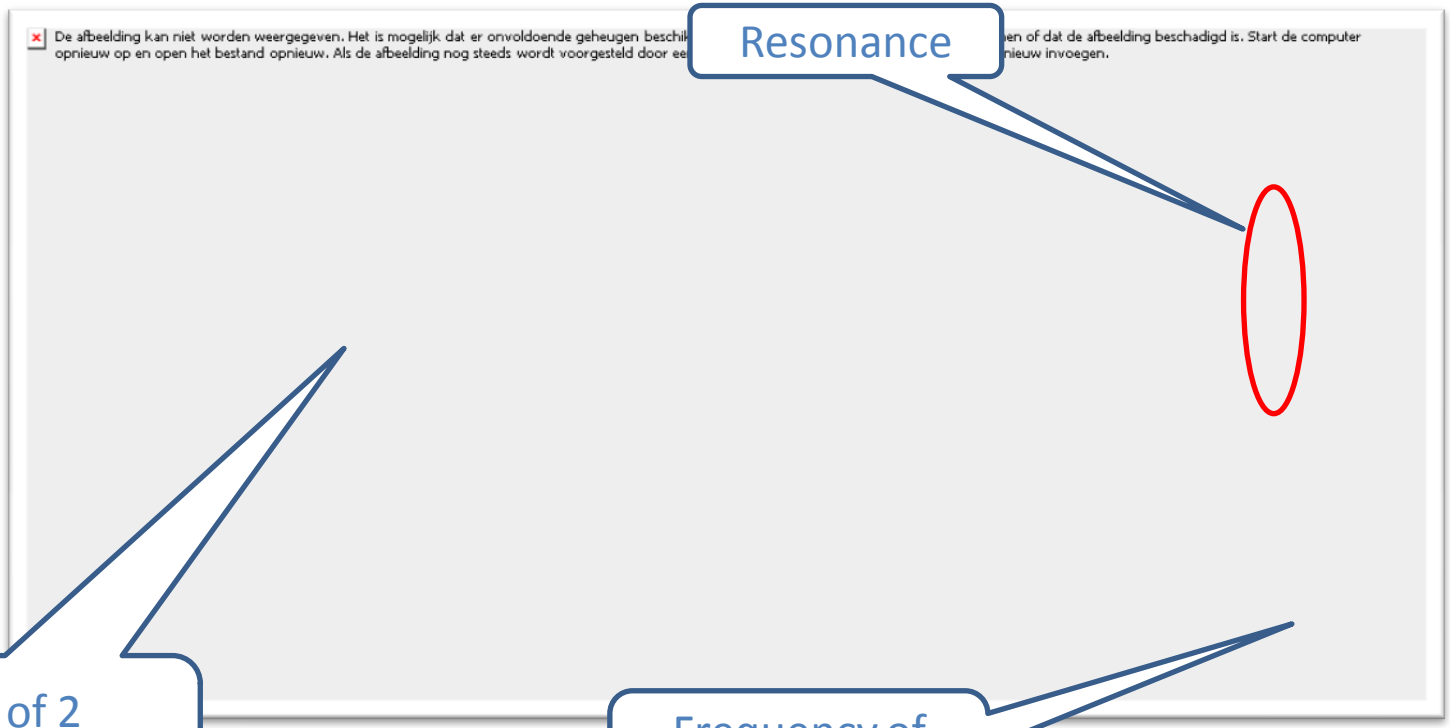


Introduction to environmental testing

1.2.- Mechanical testing

1.2.2.- Resonance search

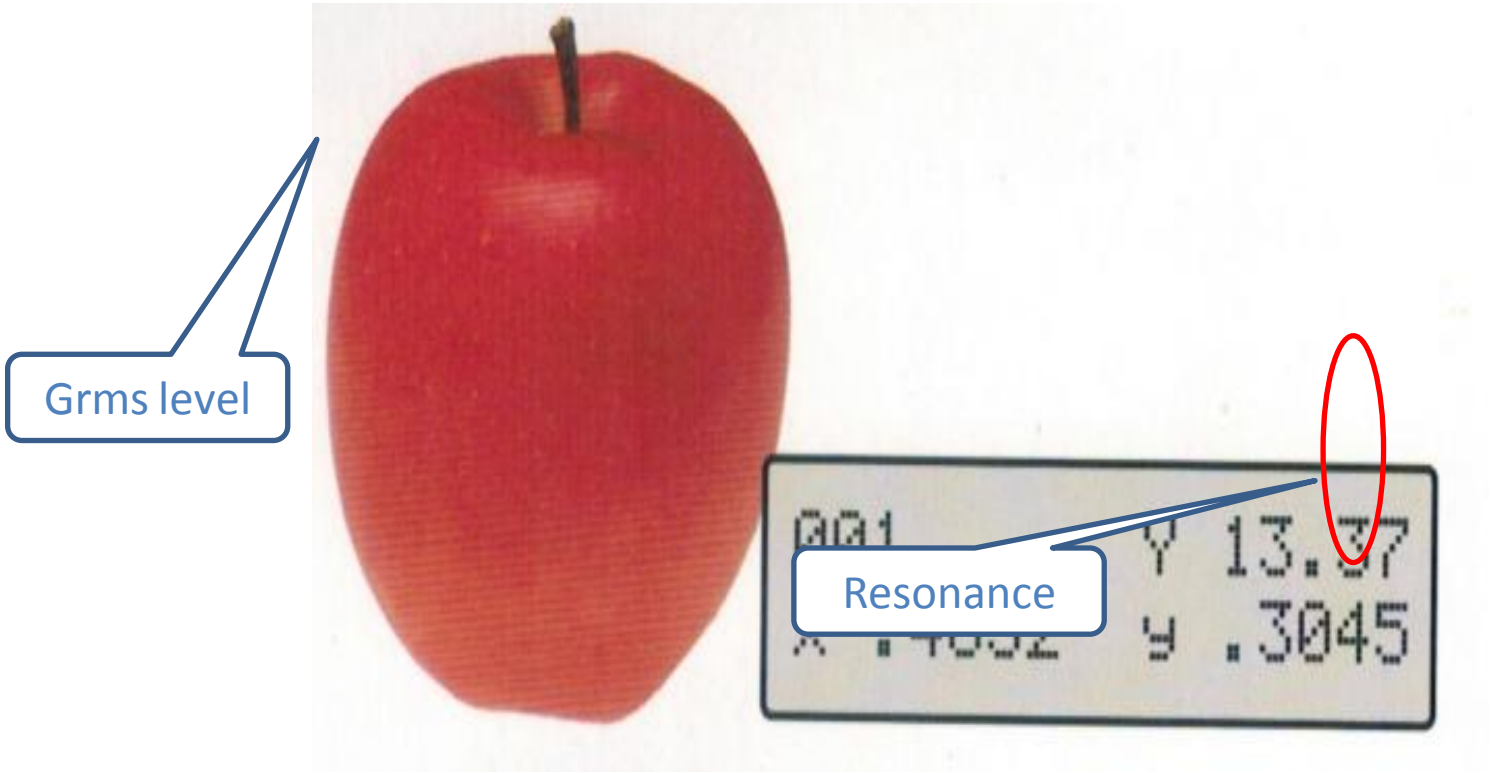
- First thing you should do. It is used as a reference for further testing.
- Use a low level input (*0.5g is fine*) and low sweep speed (*1 oct/min*).
- It is usually a sine vibration, but random is also fine.
- It defines how your Cubesat behaves to vibration vs frequency.



1.2.- Mechanical testing

1.2.3.- Random vibration

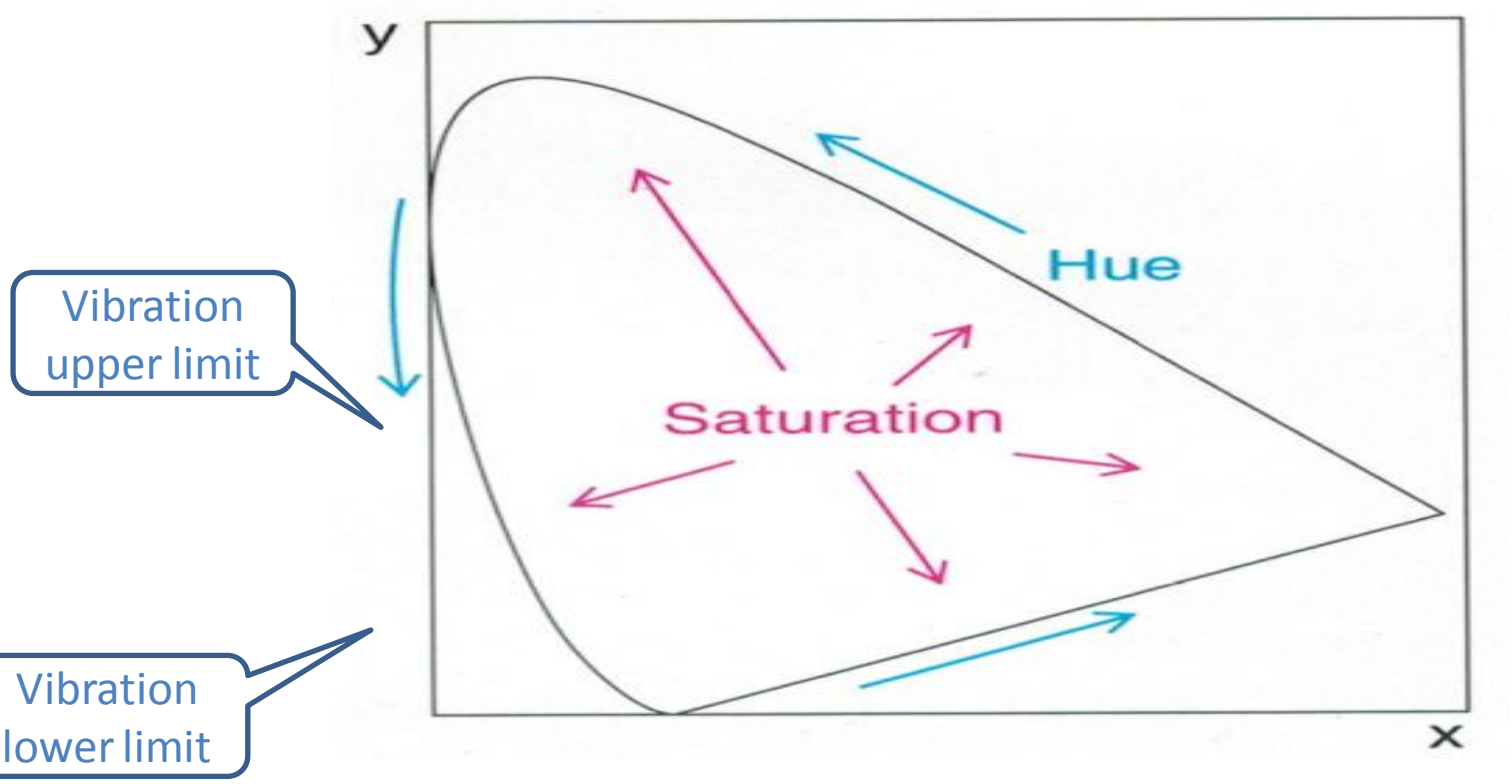
- Usually mandatory for flight acceptance.
- Really scary if you do it for the first time.
- Usually done between 20 to 2000 Hz during 60 s.
- Typical maximum Grms = 25 g



1.2.- Mechanical testing

1.2.4.- Sine vibration

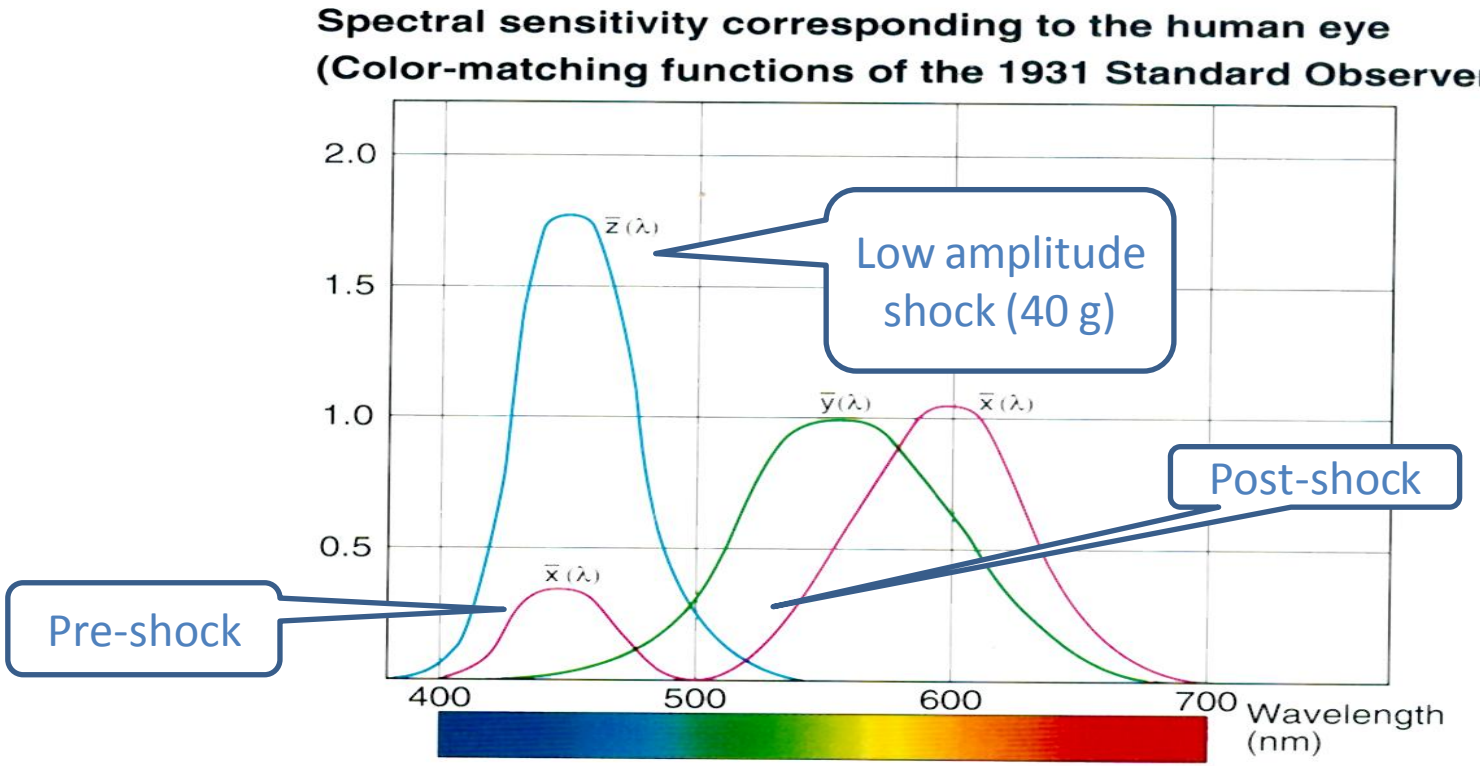
- Same principle as Resonance search.
- Higher amplitude, usually up to 20g.
- Typical sweep goes from 5 Hz to 100 Hz, 4 oct/min.
- Resonance might appear highly amplified.



1.2.- Mechanical testing

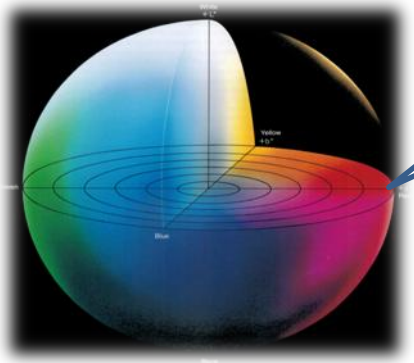
1.2.5.- Shocks

- Usually not mandatory.
- High amplitude shocks (> 100 g) difficult to setup.
- Your Cubesat will not like the idea of repeating this test.
- Consider them only under special requirements (deployment panels, heavy components).



1.2.- Mechanical testing

1.2.6.- Example: European Test Services facilities



Small Shaker

Acoustic Chamber

Multi Shaker

MPMA Facility

Hydra

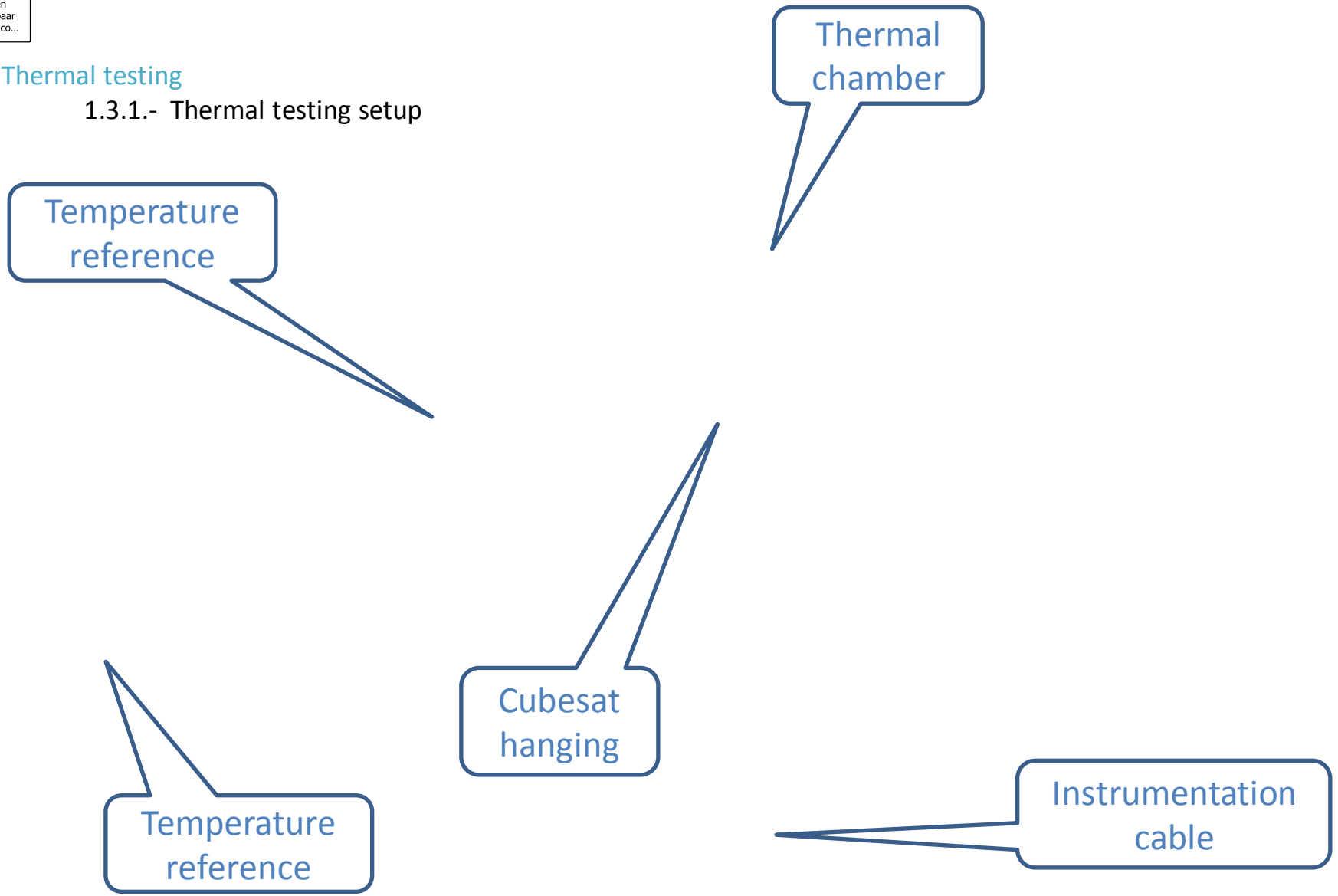
Quad Shaker

De afbeelding kan niet worden weergegeven. Het is mogelijk dat er onvoldoende geheugen beschikbaar is op de co...

Introduction to environmental testing

1.3.- Thermal testing

1.3.1.- Thermal testing setup

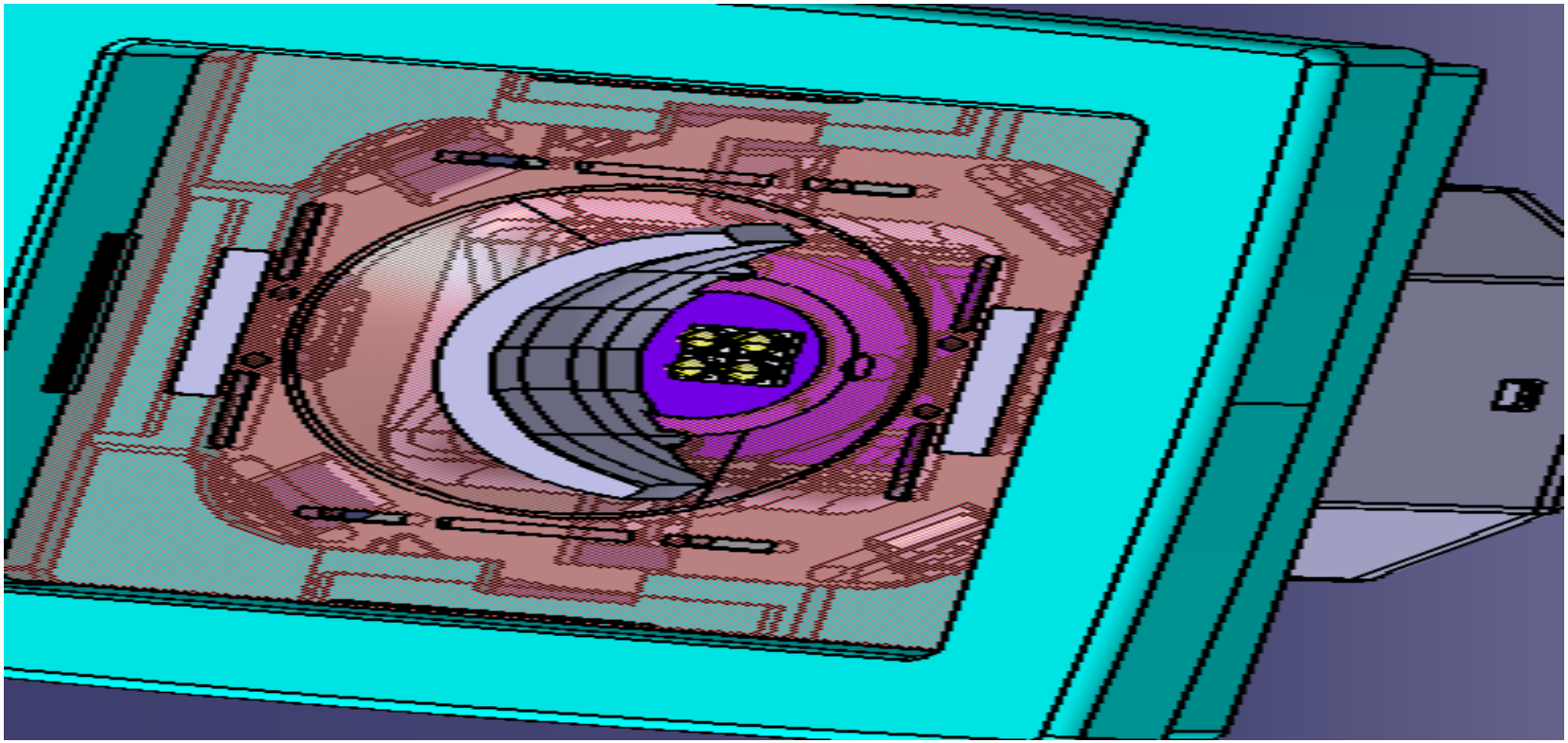


De afbeelding kan niet worden weergegeven. Het is mogelijk dat er onvoldoende geheugen beschikbaar is op de computer om de afbeelding te openen of dat de afbeelding beschadigd is. Start de computer opnieuw op en open het bestand opnieuw. Als de afbeelding nog steeds wordt voorgesteld door een rode X, kunt u de afbeelding verwijderen en opnieuw invoegen.

1.3.- Thermal testing

1.3.2.- Bake-out and Thermal vacuum cycling

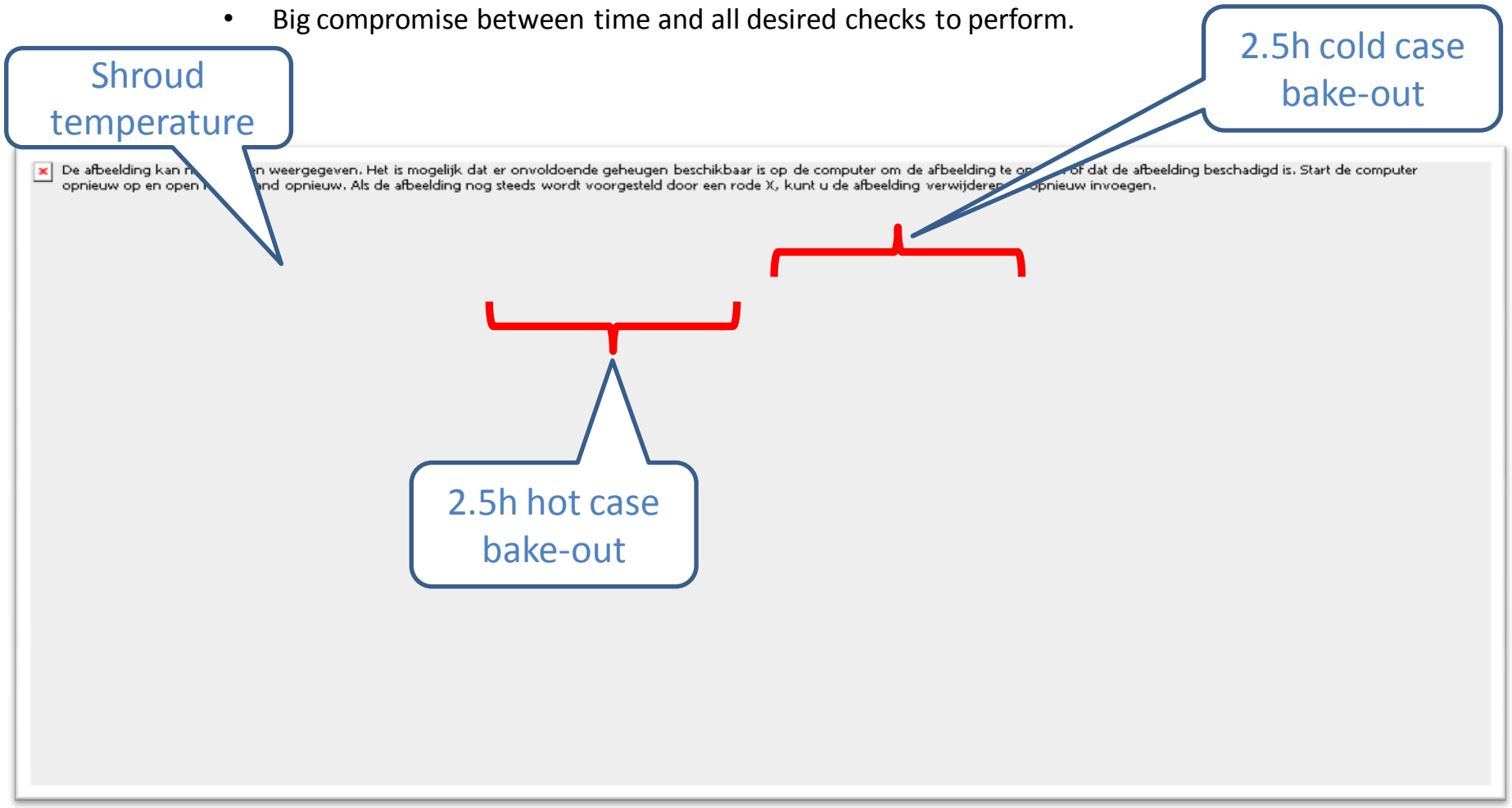
- Bake-out is used to “clean” and prepare your Cubesat for vacuum.
- Mandatory in most launchers (Dnepr, Vega, Falcon-9, etc.).
- Mostly mandatory for your Cubesat’s mission.



1.3.- Thermal testing

1.3.2.- Bake-out and Thermal vacuum cycling

- 1 Hot cycle and 1 Cold cycle should be enough to validate your hardware.
- Big compromise between time and all desired checks to perform.



1.3.- Thermal testing

1.3.3.- Ambient pressure thermal

- Thermal testing without vacuum.
- Cheaper than previous options.
- Can be really useful on early phases of the design for subsystems.
- Antenna Deployment Mechanism for Xatcobeo Cubesat:
  - More than 5 ambient pressure thermal tests during development.
  - 2 deployments under full vacuum cycling.

1.3.- Thermal testing

1.3.4.- Example: European Test Services facilities

Large Space Simulator

VTC 1.5

Phenix Chamber

1.4.- Ok, but should I do this with my Cubesat ?

Mechanical testing ?

- You must do Resonance Searches.
- You must do Random Vibration.
- You probably only need acceptance levels. Try to avoid qualification levels.
- You will probably do a vibration with a deployment mechanism as an interface:
  - You will gather few relevant data regarding your Cubesat mechanical behavior.
  - This test is “mainly” for the Launcher.

Thermal testing ?

- You might be able to do only a simple thermal vacuum cycling.
- Extremely valuable information about your Cubesat mission capabilities.
- Cubesat designers have more capabilities to influence on this test. Thermal tests can be tailored to your needs.
- This test can save you hundreds of theoretical simulations.
- This test is “mainly” for the Cubesat.

Go for a reduced mechanical on Cubesat level

Go for a full thermal on Cubesat level

Still with some budget left?

Go for mechanical testing on subsystems

Priority

Thanks for your time!
Questions?

Dario Hermida
dario.hermida@esa.int
European Test Services (ESTEC)