MEMS Qualification Procedure for Space Applications

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9th ESA Round Table on Micro and Nano Technologies

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HTA – Heterogeneous Technology Alliance

European cooperation in microelectronics

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Outline

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   - **Advantages of using MEMS for Space Applications**
   - **Example of MEMS in Space Application**
   - **Diversity of MEMS Devices**
2. *Criteria for MEMS Classification*
   - **Correlation with Test Plan Methodology**
   - **Levels of Failure Analysis**
3. *MEMS Qualification Process*
   - *Test Plan Flow*
4. *Conclusions and Future Work*

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Advantages:

Decrease
- Size
- Weight
- Power Consumption

New functionalities

Requirement:
Assure MEMS Reliability!

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Examples of MEMS used in space

MEMS rate sensor in Cryosat-2[1]

Digital pressure sensor used in ADM-Aeolus oxygen tank[2]

[1]http://www.esa.int/Our_Activities/Technology/MEMS_Rate_Sensor_on_CryoSat-2
[2]Technology Success Stories, ESA

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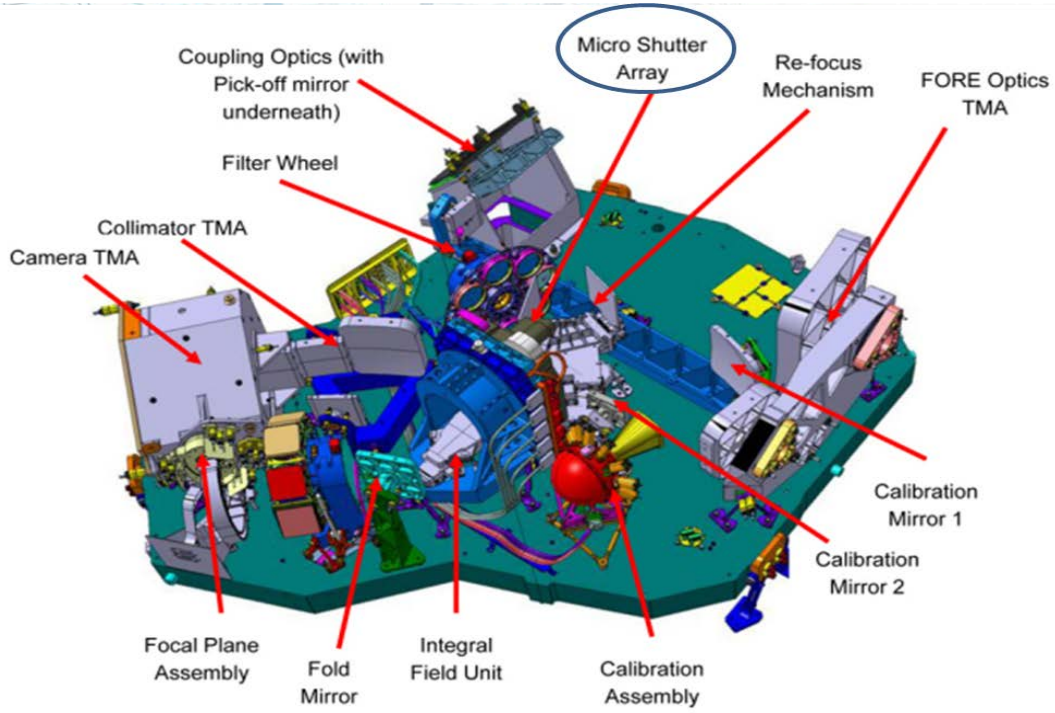
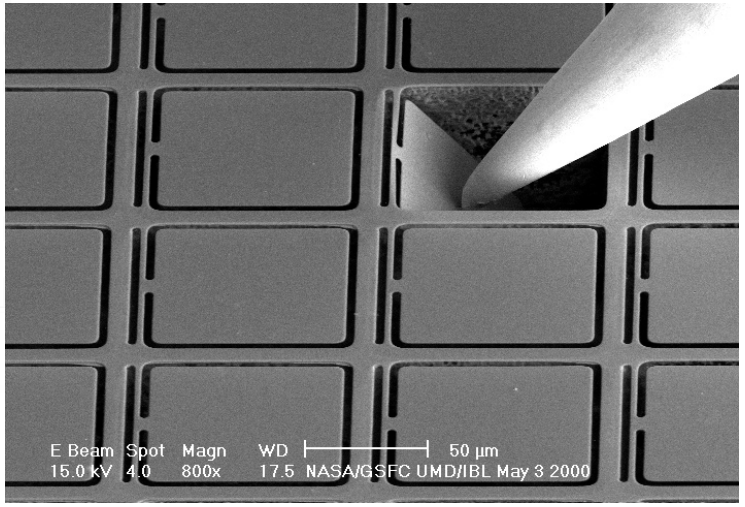
Example of MEMS in Space - Near Infra Red Spectrograph for James Webb Space Telescope

MEMS offer new functionality

MEMS have evolved in the last 10 years:
structure + testing methods





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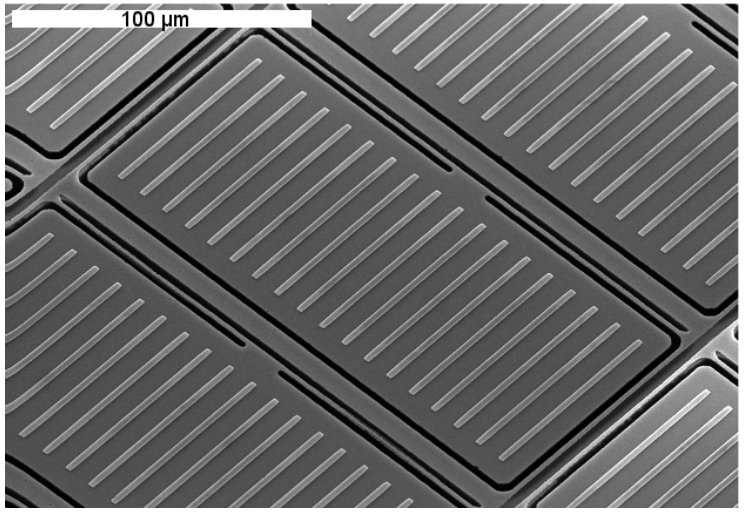

2013

http://sci.esa.int/jwst/45694-nirspec-the-near-infrared-spectrograph/

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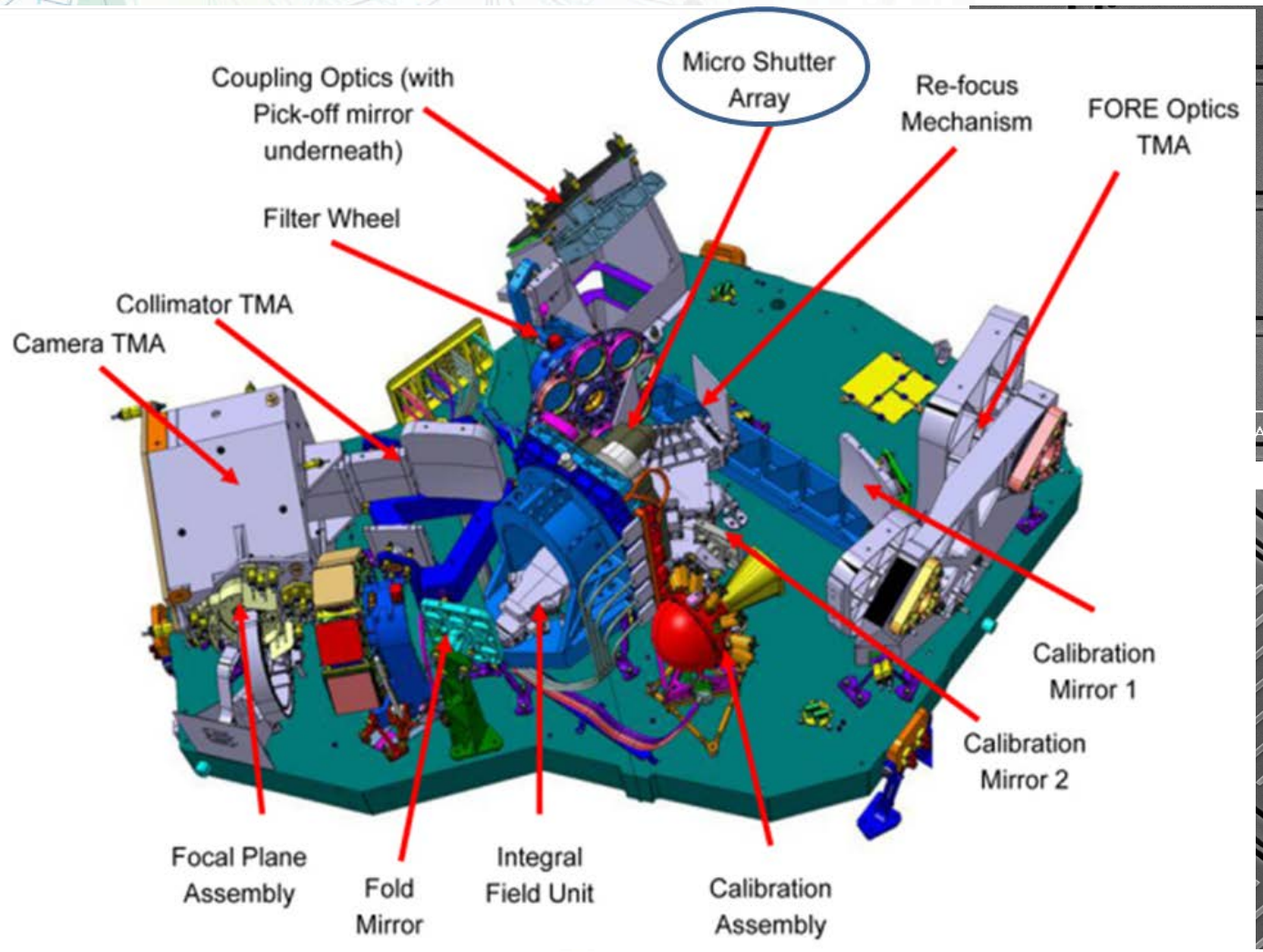

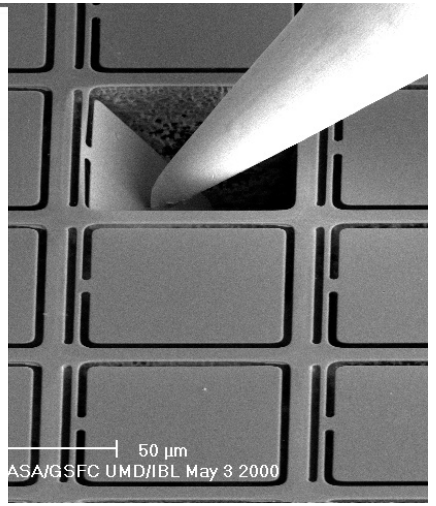

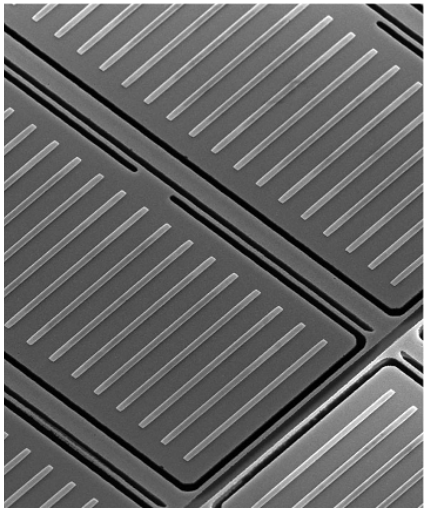

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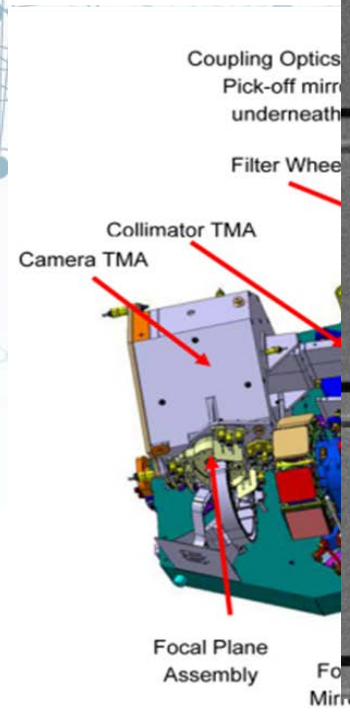
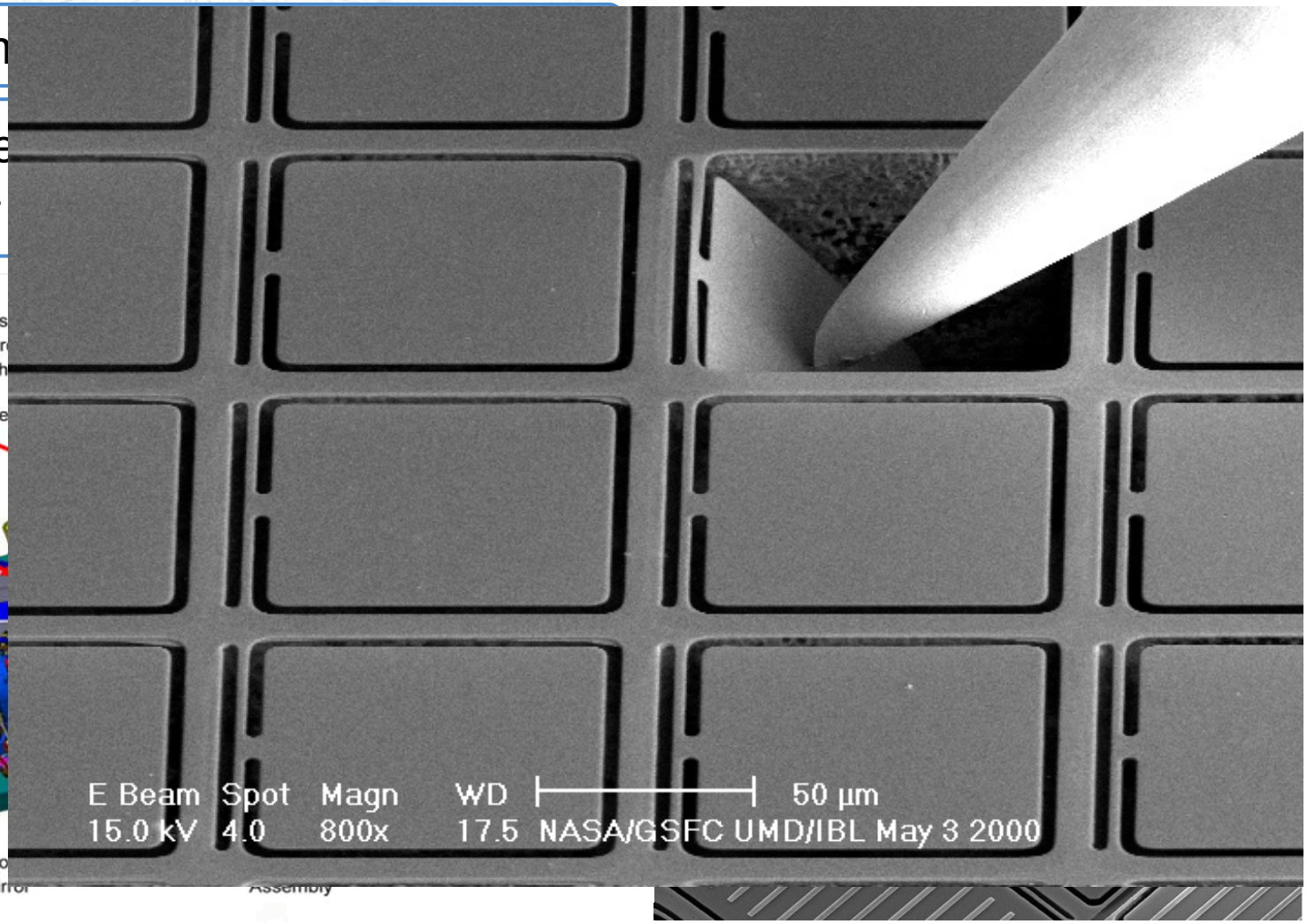
Example of MEMS in Space - Near Infra Red Spectrograph for James Webb Space Telescope

MEMS offer n

MEMS have e
structure +





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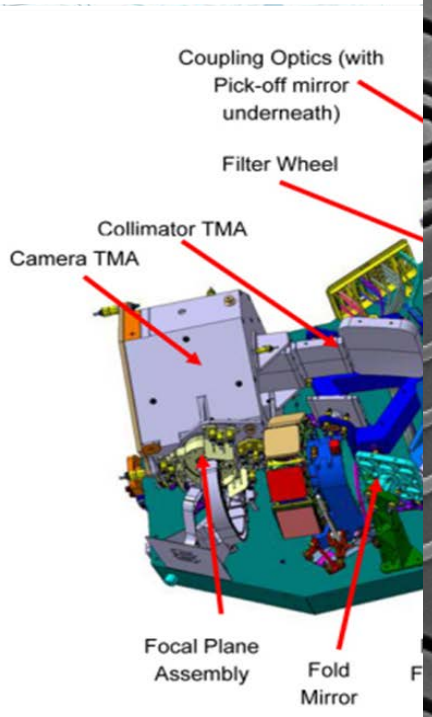
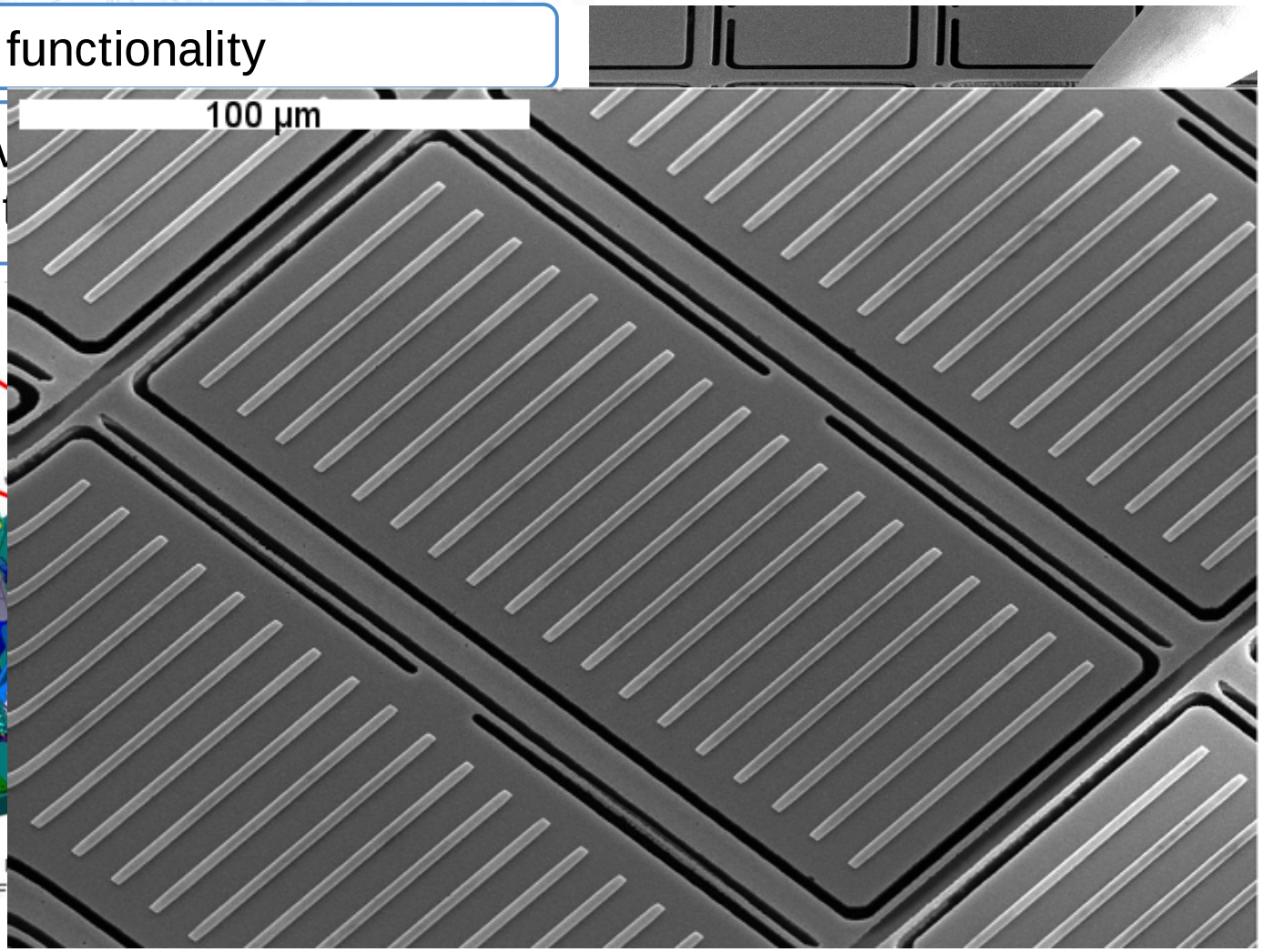
Example of MEMS in Space - Near Infra Red Spectrograph for James Webb Space Telescope

MEMS offer new functionality

MEMS have evolv
structure + test





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Diversity of MEMS Devices

Non-conventional materials
- Piezoelectric crystals
- Glass
- Polymers

Fabrication method

Moving structures

Functionality
- Mechanical
- Optical

Different critical temperatures

Different mechanical sensitivities

Different functional sensitivities

Not possible to use the same qualification methods as for the EEE components

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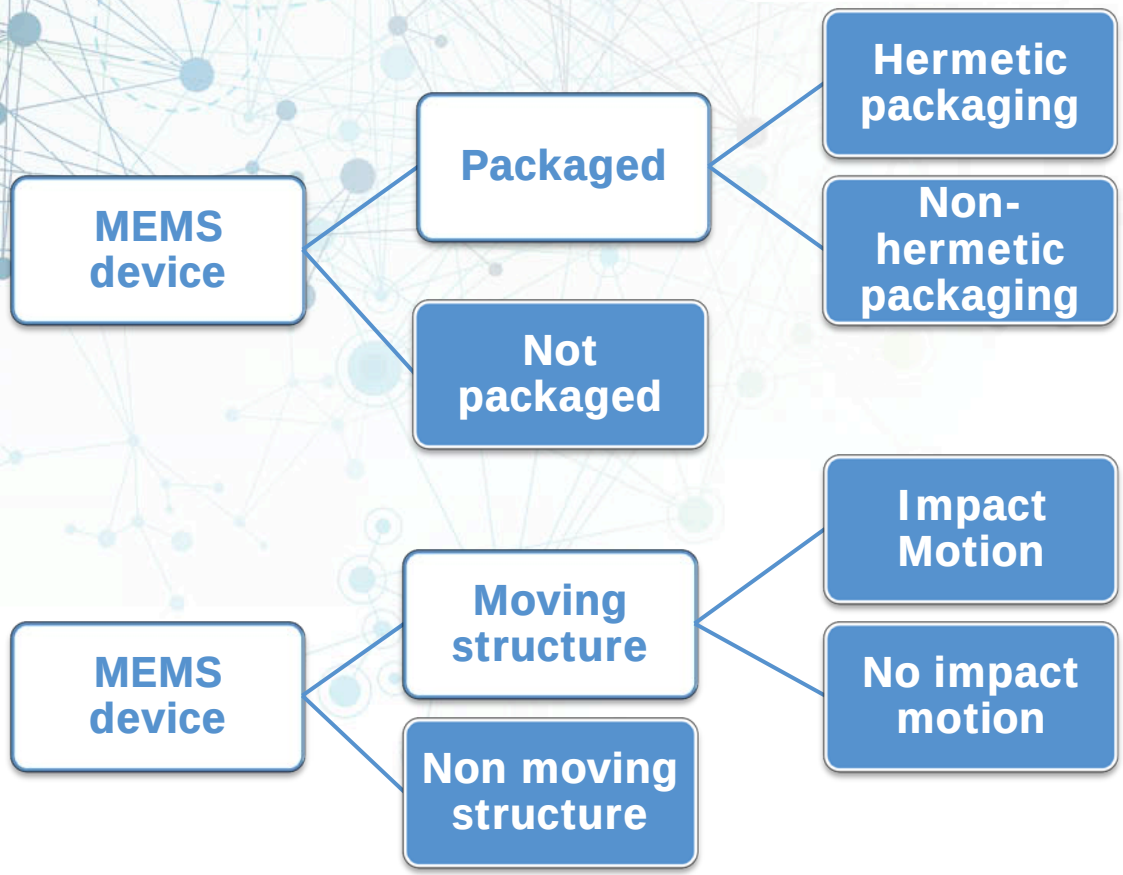
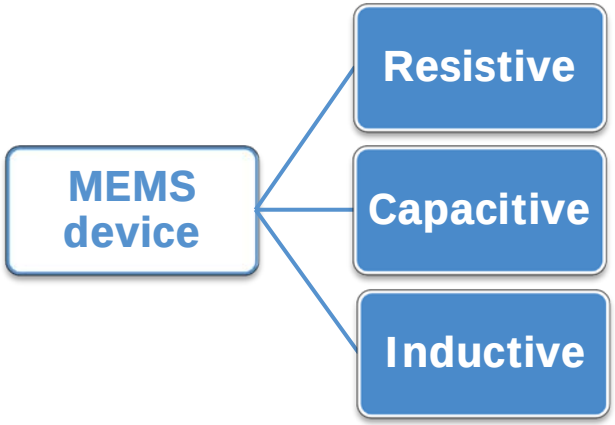
2. Criteria for MEMS Classification

- **MEMS were classified according to failure mechanisms**
- **3 Criteria were chosen:** **Package** **Movement** **Electrical**





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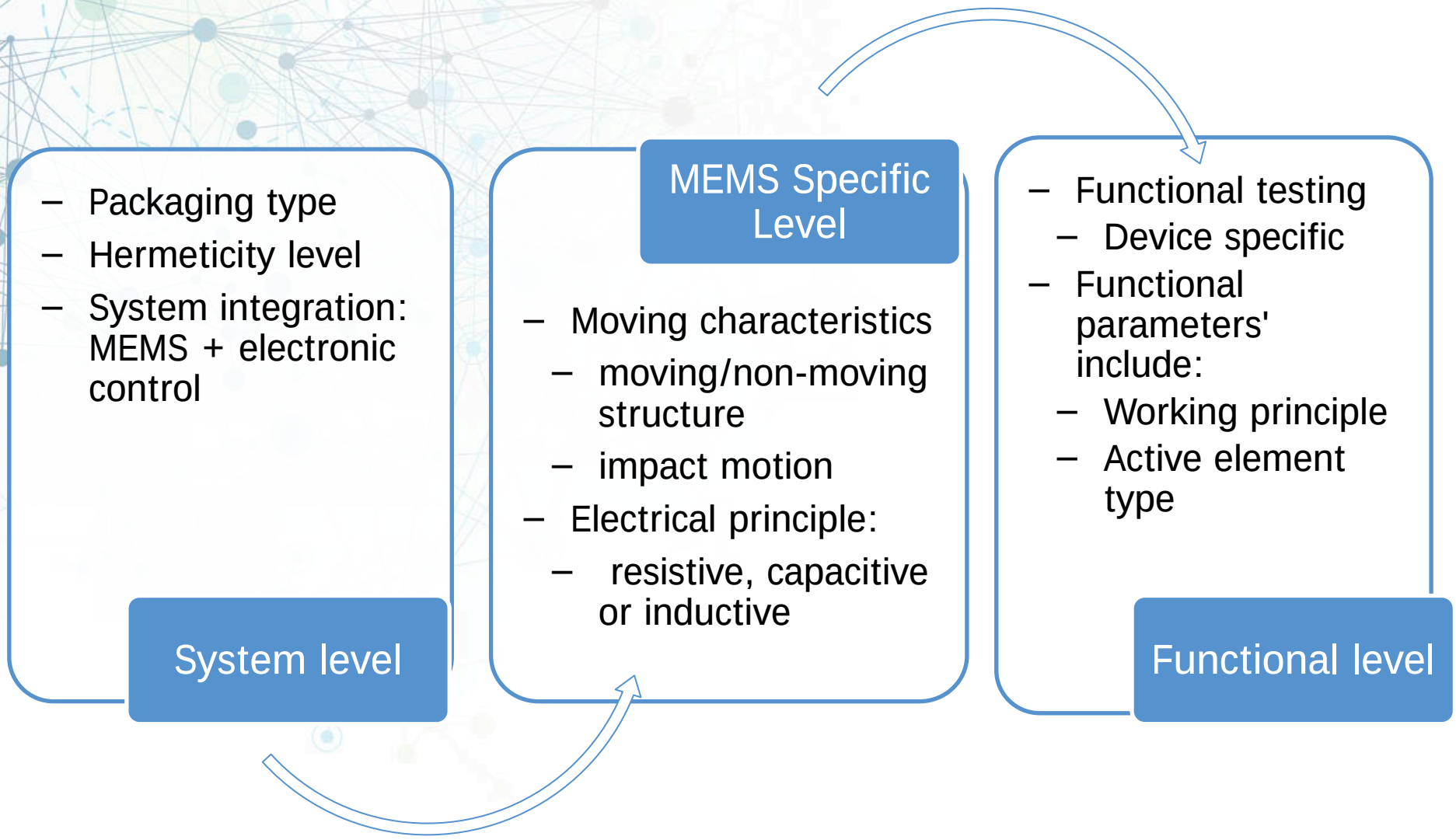
Levels of Failure Analysis



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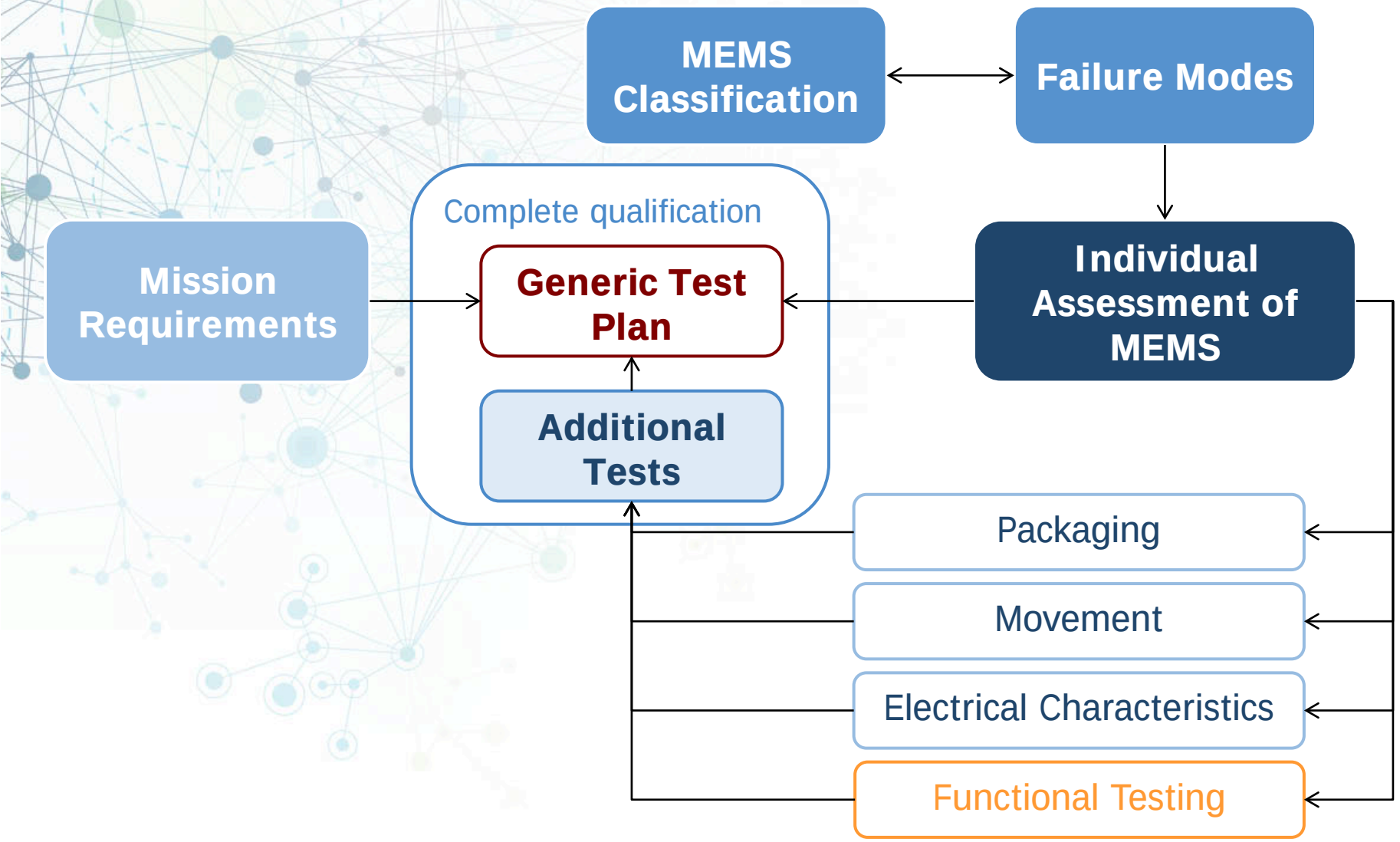
MEMS Classification and Qualification Process – Test Plan Methodology



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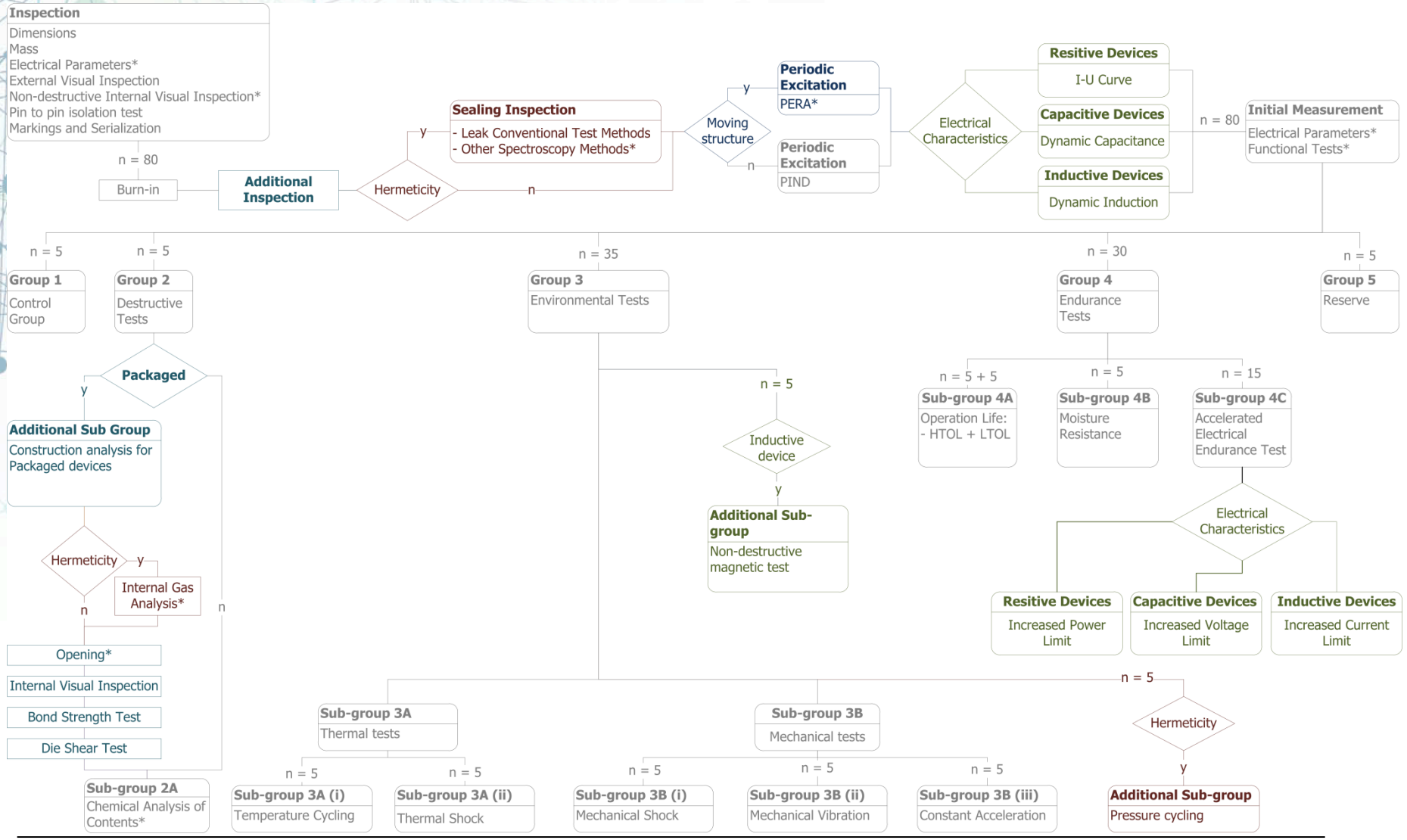
3. MEMS Qualification Process Proposed Test Plan Flow Chart



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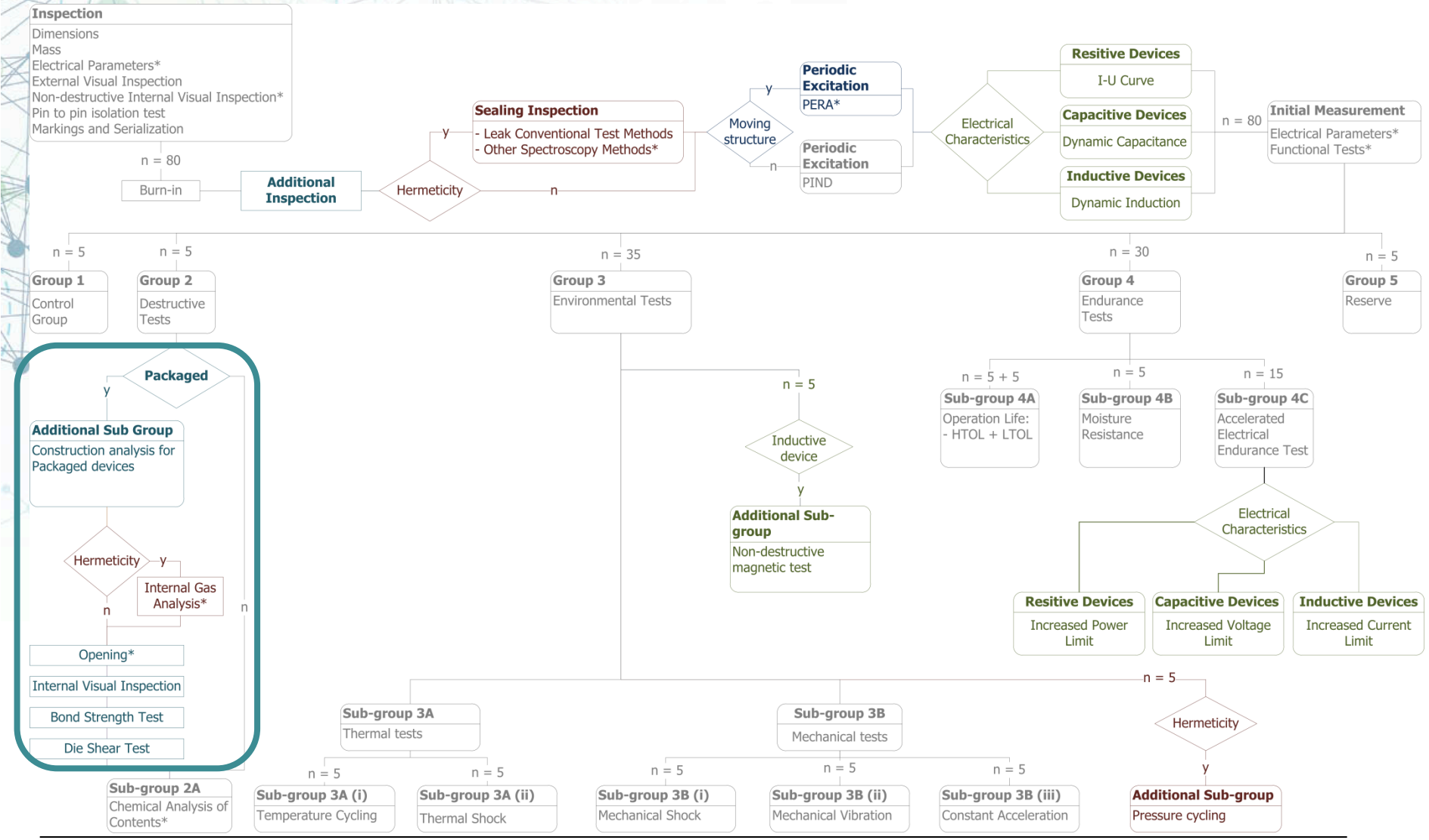
Proposed Test Plan Flow – Packaged related test methods



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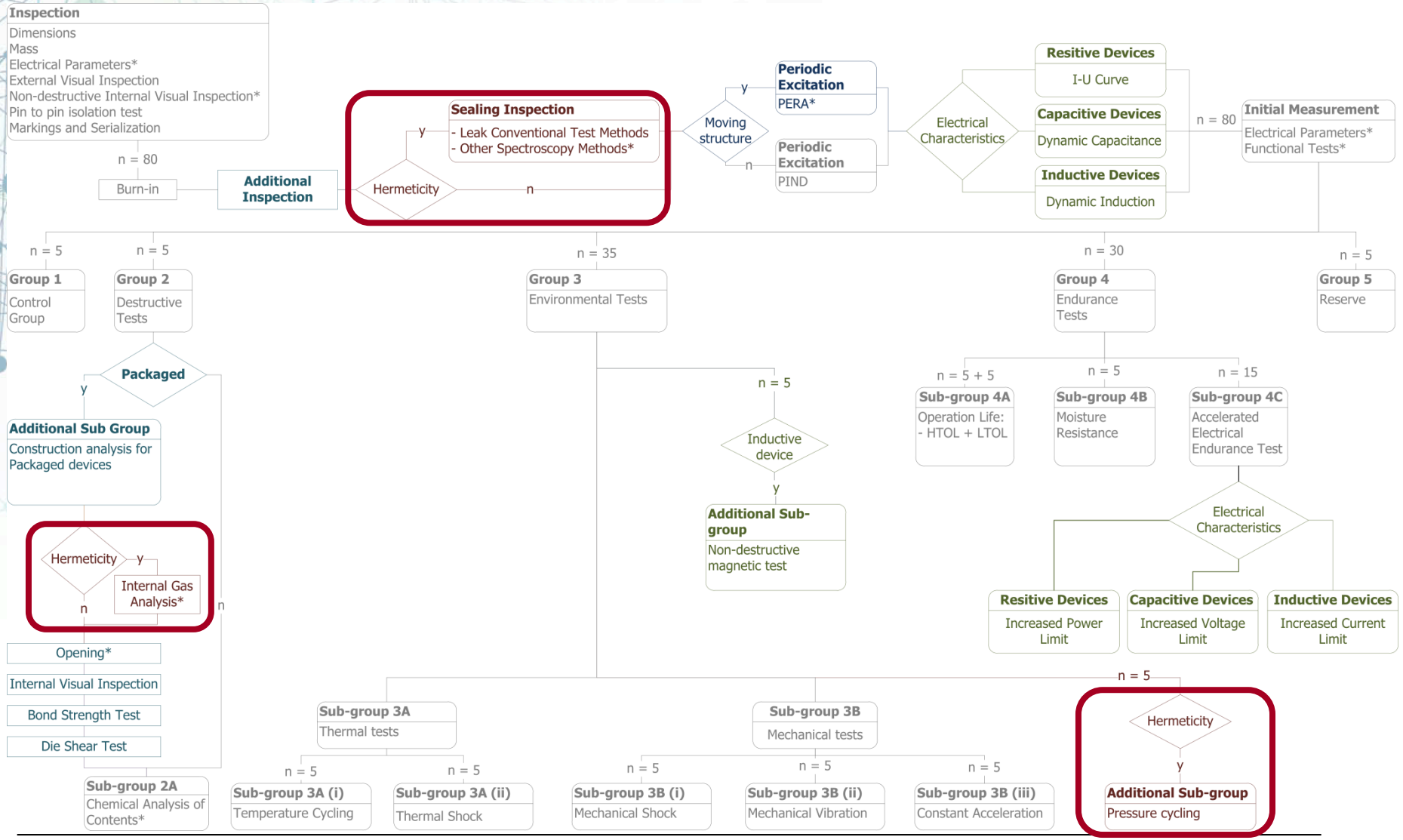
Proposed Test Plan Flow – Hermeticity related test methods



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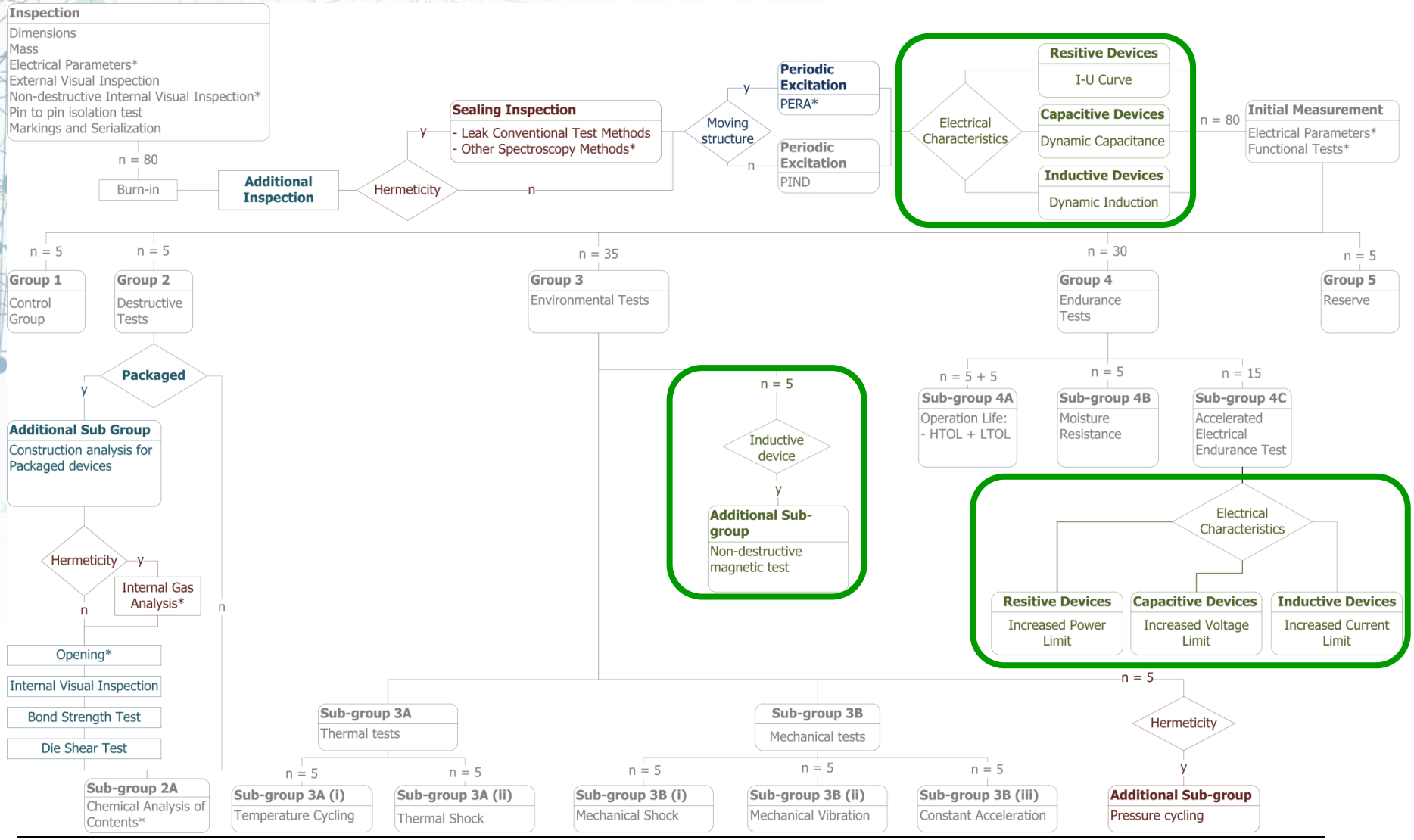
Proposed Test Plan Flow – Electrical related test methods



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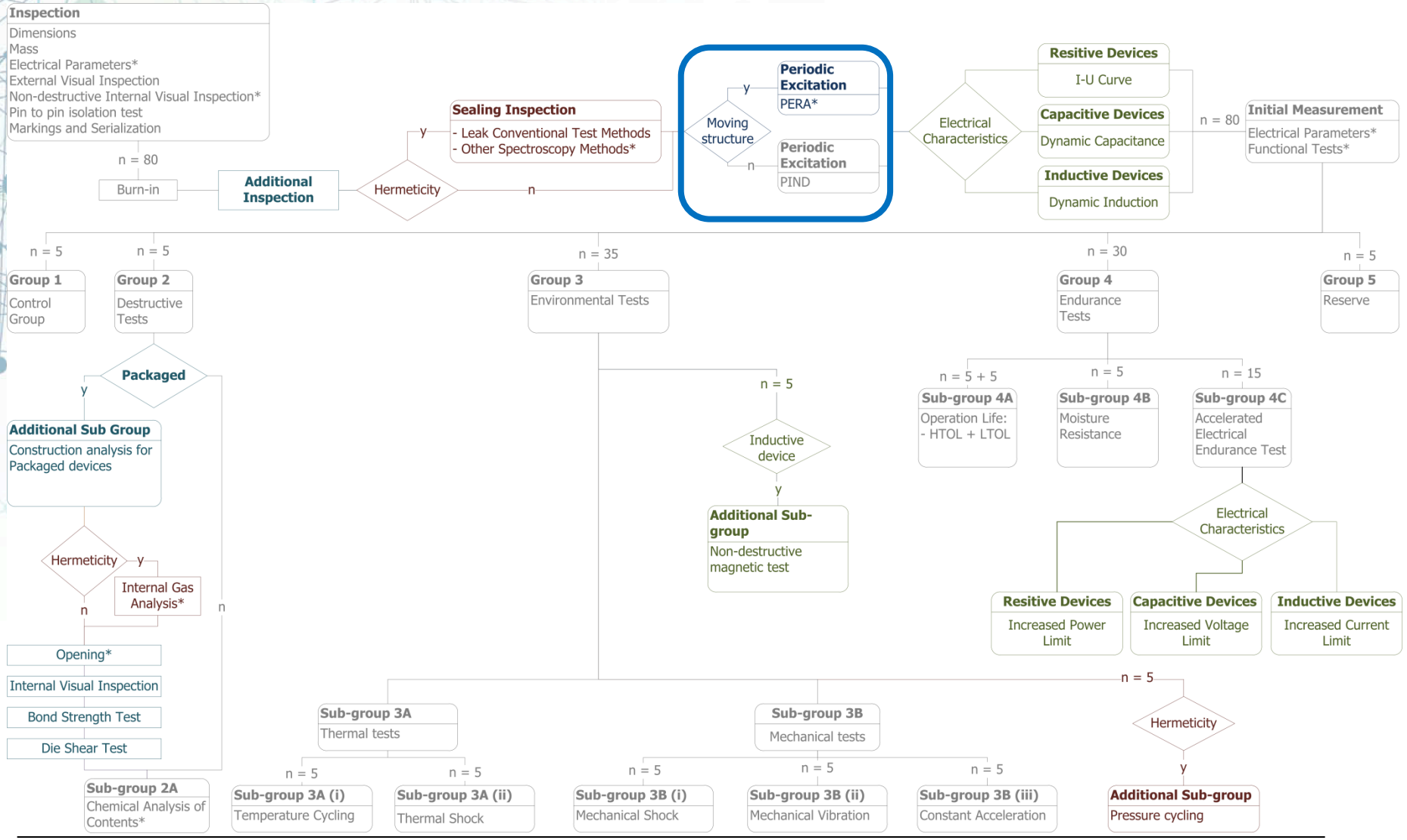
Proposed Test Plan Flow – Movement related test methods



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Qualification Step-by-Step – Inspection Phase

Inspection

Dimensions
Mass
Electrical Parameters*
External Visual Inspection
Non-destructive Internal Visual Inspection*
Pin to pin isolation test
Markings and Serialization

***Electrical Parameters**

– Depend on the MEMS device

***Non-destructive Internal Visual Inspection**

– Method and procedure will depend
  – device dimensions + materials

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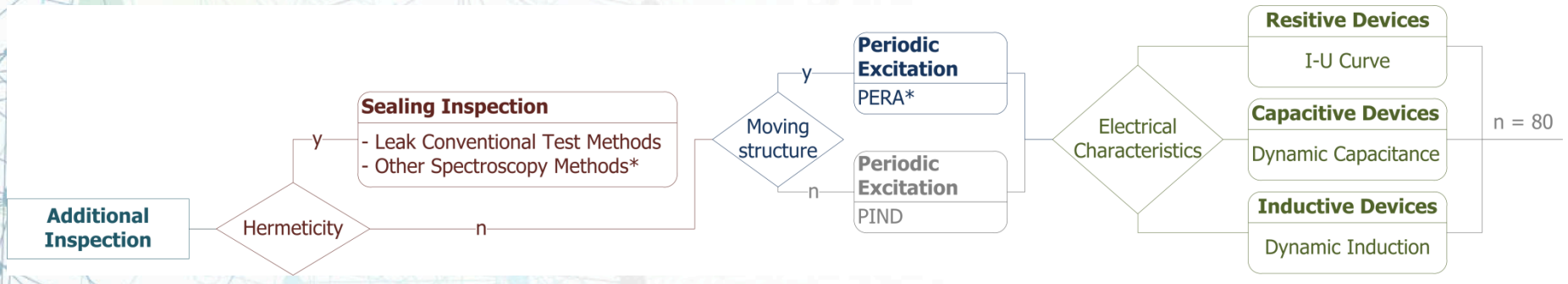
*Qualification Step-by-Step – **Additional** Inspection Phase*



*Other spectroscopy methods

- For lower leak detection limit
- Used for small cavities (wafer level packaging, *e.g.*)

*PERA Periodic Excitation Response Analysis

- Condition depend on the characteristics of the MEMS device

Dynamic measurement

- Depends on the device's electrical characteristics

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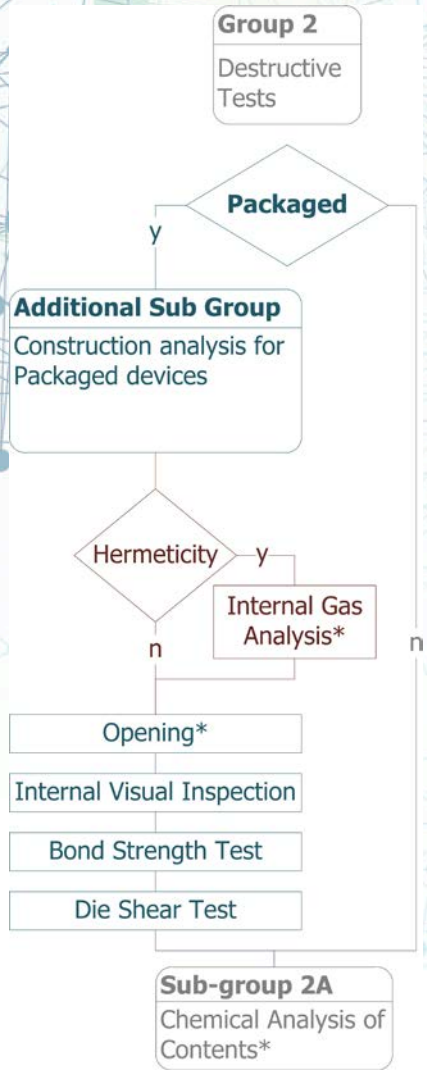
*Qualification Step-by-Step – **Destructive** Tests*



*** Internal Gas Analysis**

- Method depends on the content of the package
- Relevance depends of the MEMS sensitivity to humidity

*** Chemical Analysis of Contents**

- Method depends on the materials

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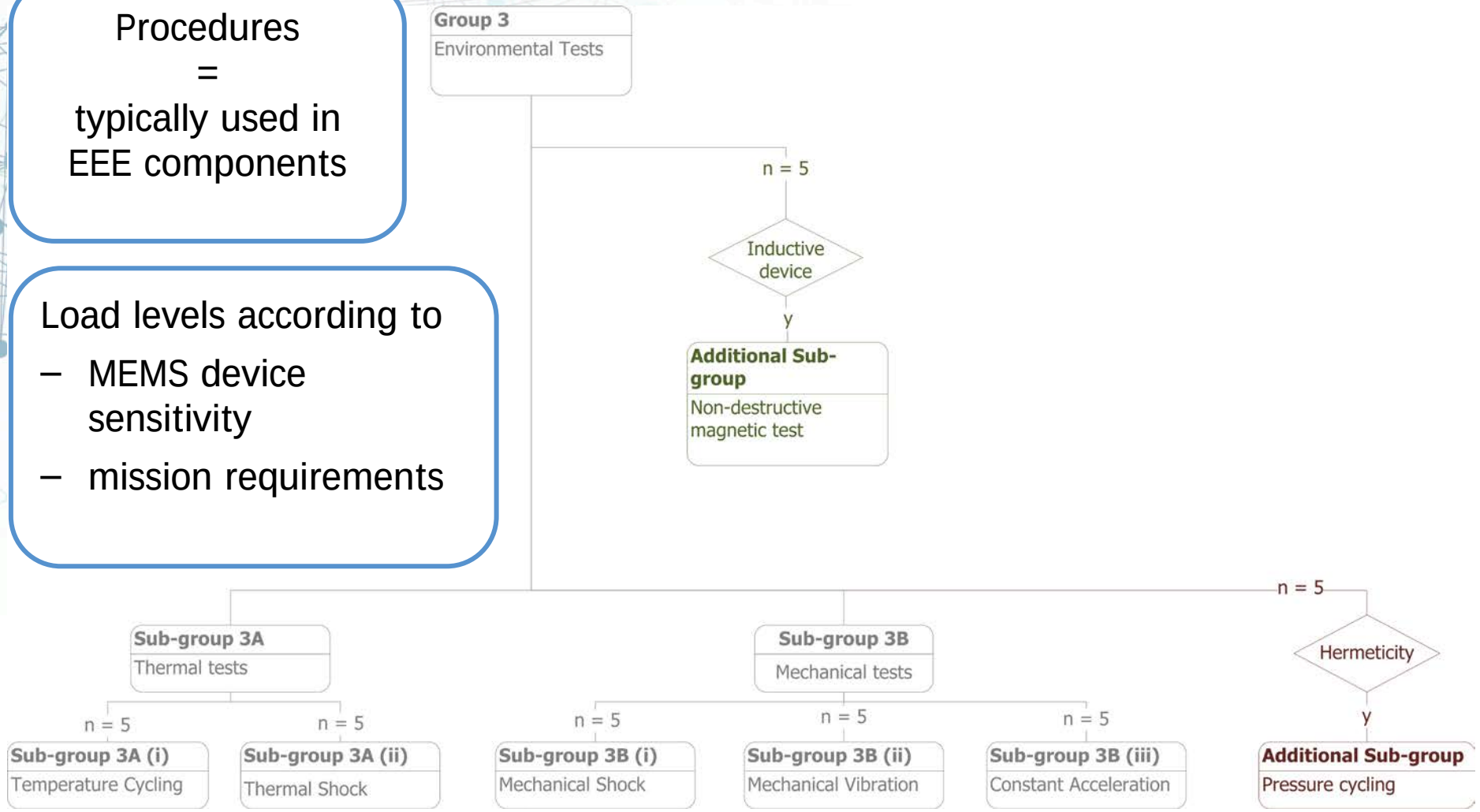
Qualification Step-by-Step – Environmental Tests

Procedures
=
typically used in
EEE components

Load levels according to

- MEMS device sensitivity
- mission requirements



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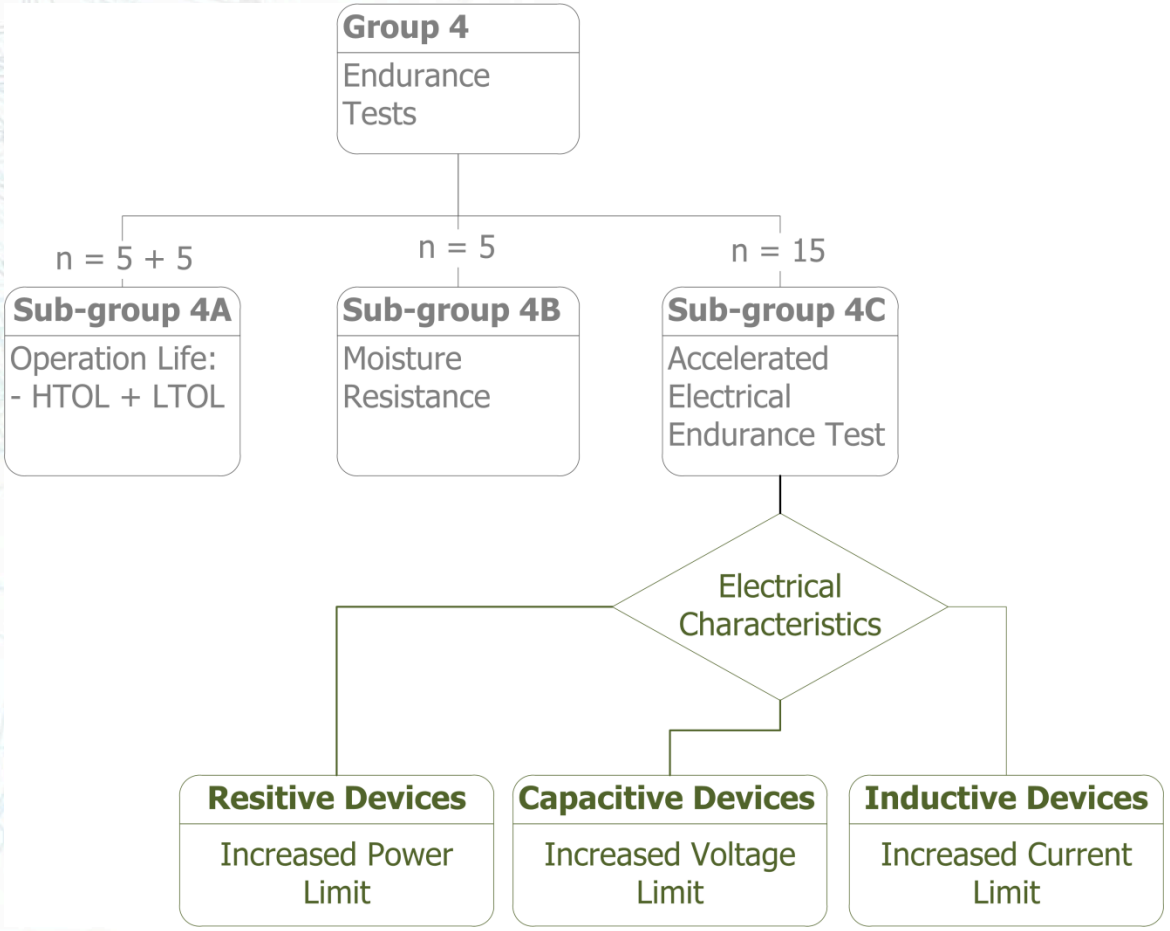
*Qualification Step-by-Step – **Endurance** Tests*

Procedures are the same typically used in EEE components

Load levels will depend on MEMS device sensitivity + mission loading



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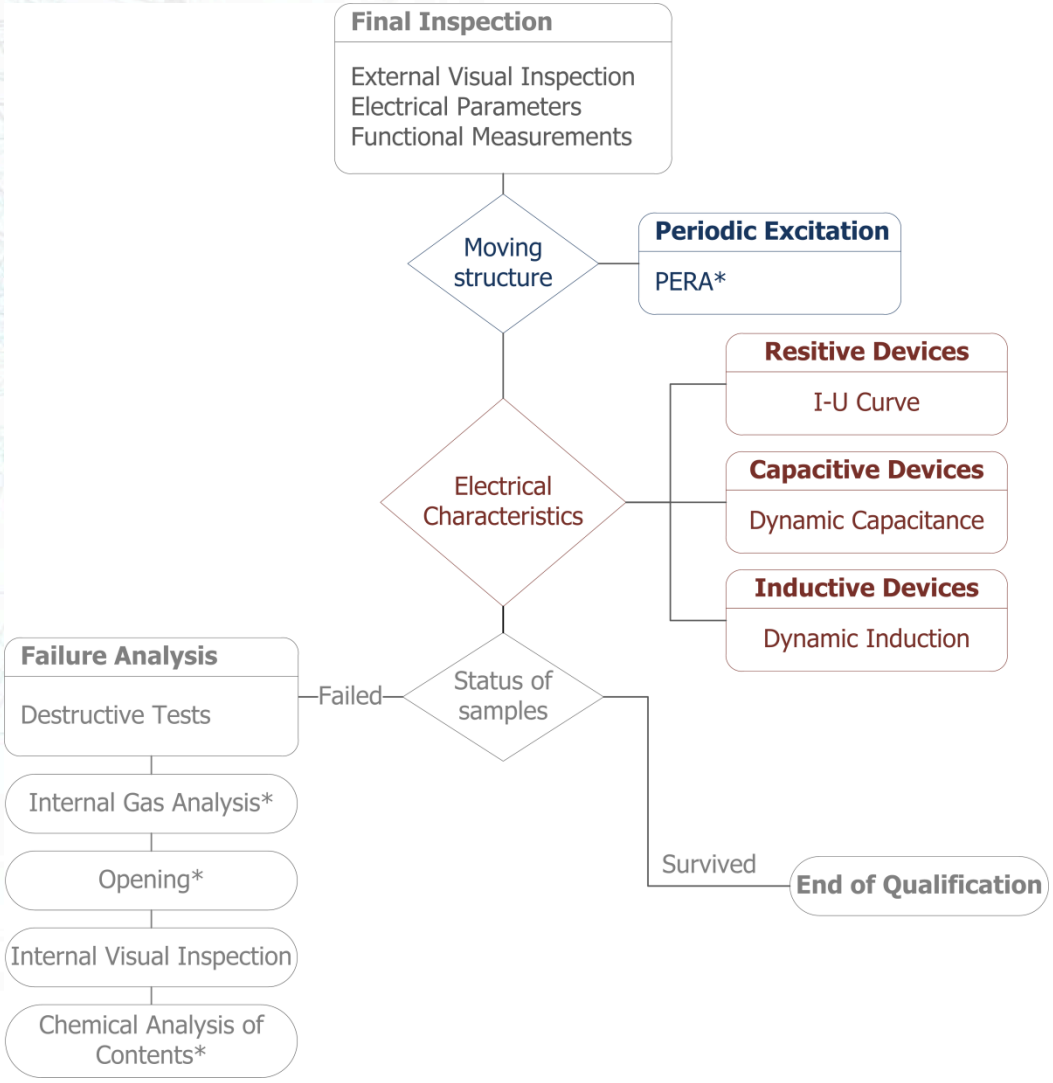
Qualification Step-by-Step – Final Inspection

Procedures
=
Inspection
+
Destructive Tests



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4. Conclusions and Future Work

Initial steps towards standard qualification method

Required feedback from industry

- Experience on materials sensitivity
- Experience on dynamic characterization of the devices

Next steps

- Validation of the qualification methodology:
  - 2 MEMS devices as case study
- Drafting of an ECSS Technical Memorandum

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Thank you for your attention!

Questions?

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