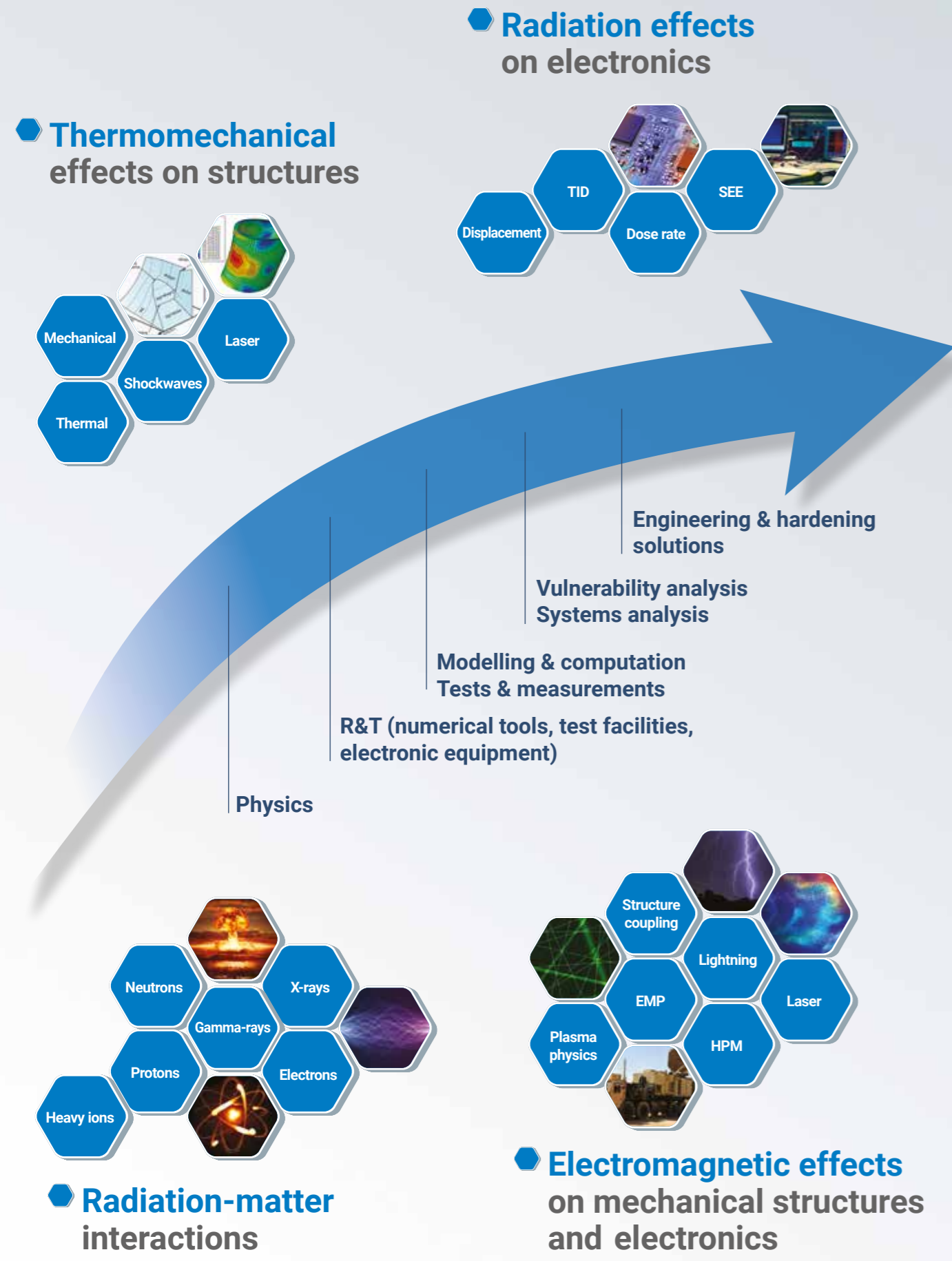


## Key skills structured around system engineering approach



## Considerable scientific and engineering experience in the field of radiation and electromagnetic harsh environments



Since 1966, **Nuclétudes**, an ArianeGroup subsidiary, has been contributing to the French nuclear deterrence efforts. In its role as a subcontractor to French prime contractors, the company bears responsibility for hardening the French strategic systems. Through this unique experience, Nuclétudes has gained an extensive expertise in:

- understanding the effects of radiations on electronic systems and on mechanical structures
- mastering their induced effects: electromagnetic waves and their coupling to systems, mechanical and thermomechanical effects on structures
- assessing the vulnerability of systems against these effects
- implementing industrial hardening solutions

Due to its outstanding know-how, Nuclétudes has extended its expertise over the years to other radiation domains (space environment, lightning) and threats (laser, high power microwaves), bringing its expertise to other industrial domains such as the space industry, aeronautics, conventional defence systems, and the nuclear industry.

### Our customers



Nuclétudes is committed to maintaining an integrated management system, certified to ISO 9001 international standards.



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## YOUR INDUSTRIAL PARTNER FOR THE PROTECTION OF SYSTEMS AND EQUIPMENT



## Radiation and electromagnetic harsh environments

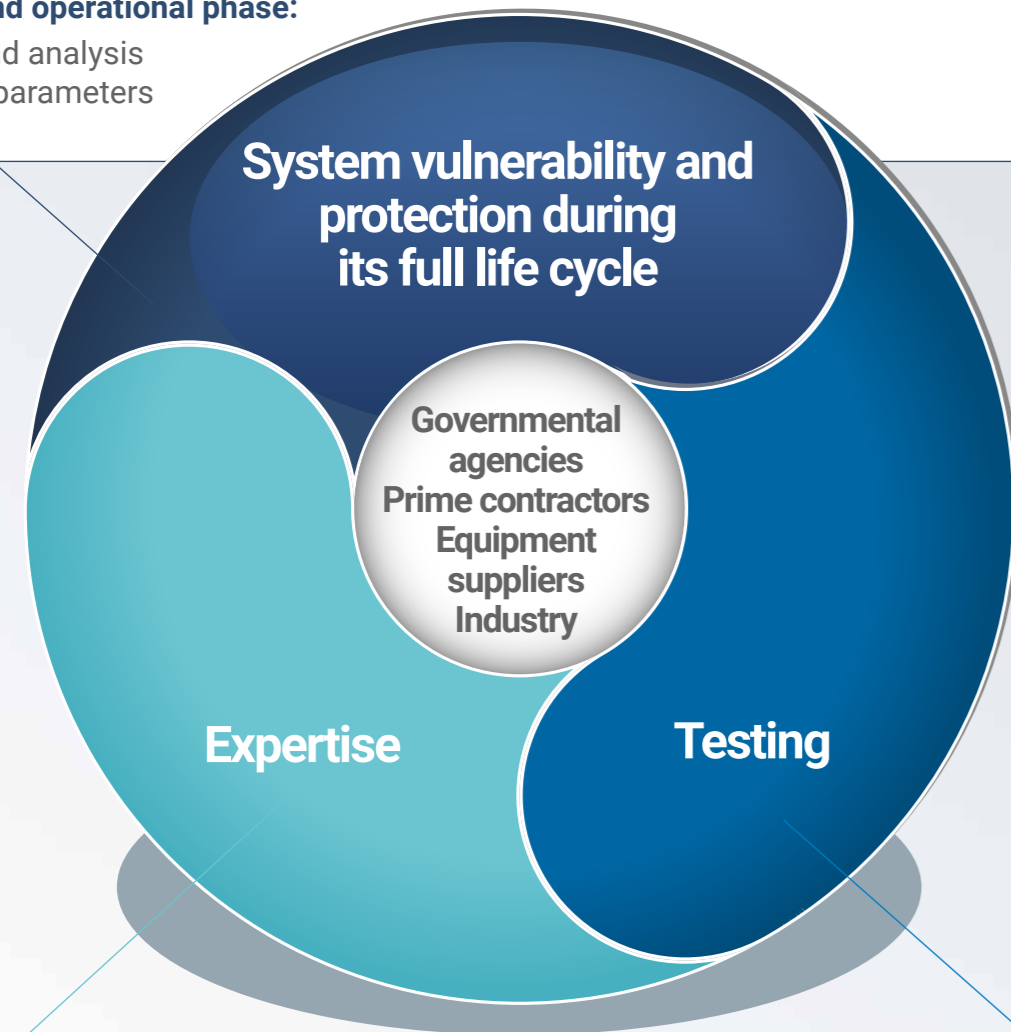
## Tailor-made engineering services

### Development phase:

Hardening requirements cascaded down to sub-system and equipment levels  
 Hardening solutions, technology selection, definition of design, and manufacturing rules  
 System and sub-systems validation and verification within radiation and electromagnetic environments

### Production and operational phase:

Monitoring and analysis of hardening parameters



Radiation & electromagnetic **environment calculation** and their **coupling** to systems

**Vulnerability analysis** of components, equipment and materials, and impact on reliability and safety

**Industrial protection solutions** against radiation & electromagnetic environments

**Electronic architecture expertise**

**Tests at the component, electronic board, or equipment levels**

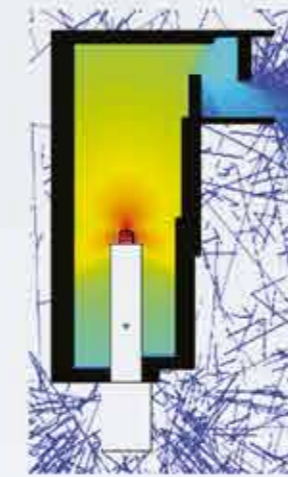
**We offer what you need:**

- Test design, planning, and execution
- Sample preparation, definition and manufacturing of testing tools
- Analysis of test results

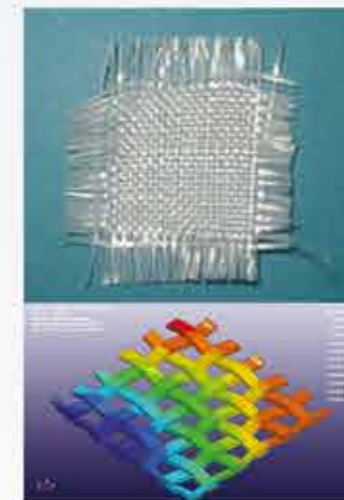
## Technical excellence secured by a significant R&T activity

R&T is central to our strategy to continually improve our expertise and as such we are developing:

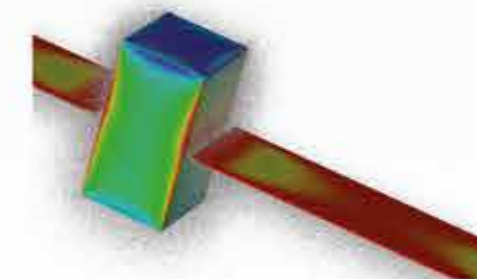
- Numerical simulation tools in Electromagnetics
- Engineering tools
- Models for material behaviour and damage for complex materials submitted to thermomechanical shocks
- Methods and tools adapted to the development of new component technologies
- Experimental techniques



Radiation protection dimensioning of an infrastructure



3D material deformation (mesoscopic model)



Electron plasma evolution and surface current



The dual culture of modelling and testing has been in our teams' DNA since the establishment of the company.

We have our own computing centre and test facilities ( in electromagnetics, radiation and thermomechanics ).

## A unique testing capability

### Our test facilities

| Total Ionizing Dose (TID) testing  |   |  |
|--|---|--|
| <b>Co<sup>60</sup> source</b>  | From 30 to 3600 rad(Si)/hr                                    | Component and equipment levels   |
| Dose rate testing  |   |  |
| <b>Flash X-ray facility</b>  | Up to 10 <sup>11</sup> rad(Si)/s                              | Component and equipment testing for upset, latch-up, and burn-out  |
| Thermomechanical shock testing   |   |  |
| <b>Electron beam gun</b>   | 40 to 400 J/cm <sup>2</sup>                                   | Material characterization, material behaviour and damage modelling, and equations of state validation      |
| Electromagnetic testing  |   |  |
| <b>Mode-stirred reverberation chamber</b>                                | 400 MHz to 6 GHz<br>1 kV/m                                    | Radiated field susceptibility tests on equipment<br>Shielding effectiveness of cables and electronic boxes |
| <b>NEMP simulator</b>  | Up to 50 kV/m   | NEMP susceptibility tests on sub-systems   |
| <b>Transient generators</b>  | Lightning, NEMP...  | Susceptibility tests on equipment  |
| <b>High Power Microwave generator</b>                                    | 50 kW class magnetron @ 3 GHz and 9 GHz                       | High power radiated field susceptibility tests on equipment  |
| <b>Transfer impedance measurement bench</b>                              |   | Characterization of the shielding effectiveness of cables and connectors                                   |
| <b>Flash X-Ray facility</b>  | 10 <sup>-5</sup> to some 10 <sup>-4</sup> cal/cm <sup>2</sup> | Antennas, cables and electronic boxes responses  |
| Our electronic lab   |   |  |
| <b>Electronic board prototyping</b>                                      |   |  |
| Testing devices for analog and digital components, and electronic boards |   |  |
| <b>Laser test bench (fault injection)</b>                                |   |  |

Our testing teams can be readily deployed to various test facilities worldwide:

### Thermomechanical shock testing

Test benches GEPI and DEMETER (CEA/Gramat) – Laser test facility (DGA/TA, Mines ParisTech)

### Neutron displacement damage, single event effects (neutrons, heavy ions, protons) testing

in France (CEA Saclay, CEA-DIF, GENEPI2) and abroad (Belgium, Italy, Finland, USA, Canada,...)

