Fraunhofer
IPM

*Identifiying sources of residual magnetization is crucial for nanosatellite manufactures. In a magnetically shielded room, residual magnetization can be detected with high sensitivity.*

# Magnetic cleanliness
## Testing infrastructure and services

### Highly sensitive measurements in an MSR

The increased use of commercial off-the-shelf components (COTS) in New Space applications reduces costs, but also comes with risks. Minimal residual magnetizations can add up to couple to the Earth's magnetic field, perturbing satellites' attitude control and electronics. In its magnetically shielded room, Fraunhofer IPM is capable of measuring and evaluating the magnetic cleanliness of space components and assemblies with a sensitivity in the fT range.

### Staying within the magnetic budget

In our magnetically shielded room (MSR), we measure residual magnetization quickly and with high sensitivity. This helps nanosatellite manufacturers, for instance, identify critical sources of magnetization and stay within the tight magnetic budget of ~0.03 A$m^2$.

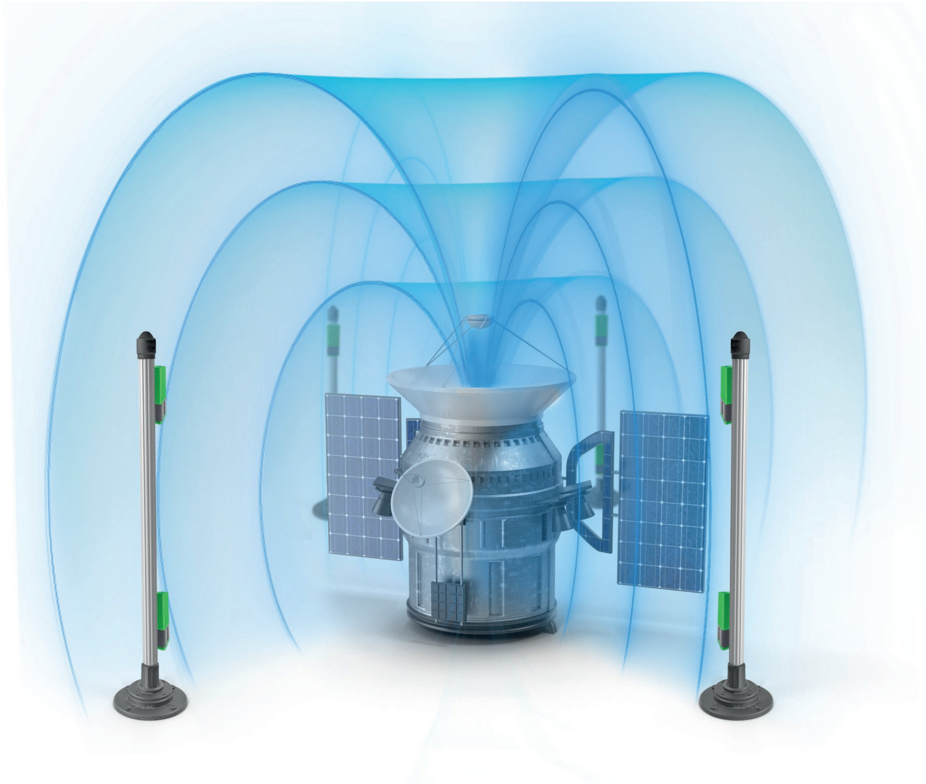
The measurement data is essential for making well-informed design decisions, reducing risks and extending the lifespan of satellite missions.

### Clear report and guidance for action

The MSR infrastructure at Fraunhofer IPM is designed to enable field zeroing with reproducible, highly homogeneous residual fields. Using highly sensitive fluxgates and quantum magnetometers (OPM), we capture 3D field maps and derive the residual magnetic moment. Depending on complexity, this value is determined as a single dipole model (SDM) or multiple dipole model (MDM). Automated rotation scans produce thousands of measurement points in a short time and robust model fits make even the smallest moments visible. The result is a clear report including moment, orientation, maps, and guidance for action.

### Our service

- Magnetic cleanliness measurements
- Localization of magnetic sources
- Advice on non-magnetic alternatives
- Customized measurements and solutions



*Estimating residual magnetization from stray-field measurements: sensitive magnetometers sample the satellite's magnetic field at multiple locations. These data are used to solve an inverse problem (e.g. regularized dipole/multipole fitting) in order to reconstruct the spacecraft's equivalent magnetic sources. The solution yields the magnitude and direction (with uncertainty) of the magnetic moment that best explains the measured field.*

## GAMAG and GAMAX integration

We cooperate with Astos Solutions to seamlessly integrate the GAMAG and GAMAX software tools into our magnetic cleanliness workflow. GAMAG uses our MSR measurement data (3D field maps) to create robust multiple dipole models (MDM) and extrapolate fields to distant positions (e. g. magnetometer positions). It also supports the design of compensation magnets as well as the verification of budget specifications and the global dipole moment. GAMAX complements this in early development phases with coil-free, fast multi-probe snapshot measurements on site. Even in uncompensated environments, we obtain reliable far-field forecasts and moment estimates for early risk and source identification. That way, we combine early screening with highly sensitive MSR detail tests – from diagnosis to compensation concept from a single source.

### Technical specifications

| | |
|---|---|
| Measurement range | ± 100 µT |
| MSR residual field (after degaussing) | < 1 nT |
| Field homogeneity | Field variation ~ 100 pT over 1 m |
| Volume | Approx. 2 m × 2 m × 2 m |
| Max. size of test sample | Approx. 80 cm length |
| Fluxgate noise density | < 10 pT/√Hz @ 1 Hz |
| OPM (quantum) noise density | < 15 fT/√Hz @ 1 Hz |

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