Precision on earth.
Reliability in space.
RUAG Space.

Together ahead. RUAG

The (technical) Challenge of Radiation Monitors in Space (Industry View)

RUAG Schweiz AG

RUAG Space

CHIPP - Château de Bossy, 2015-06-30

Reto Muff, Manager Engineering, BU-OE&I

RUAG Space at a Glance

- Leading European space product supplier to the industry
- Eight sites in four countries (Switzerland, Sweden, Finland, Austria)
- US office in Denver, Colorado
- 1158 employees (end 2014)
- Total revenues (2014): 322 mCHF
- Headquarters: Zurich (CH)

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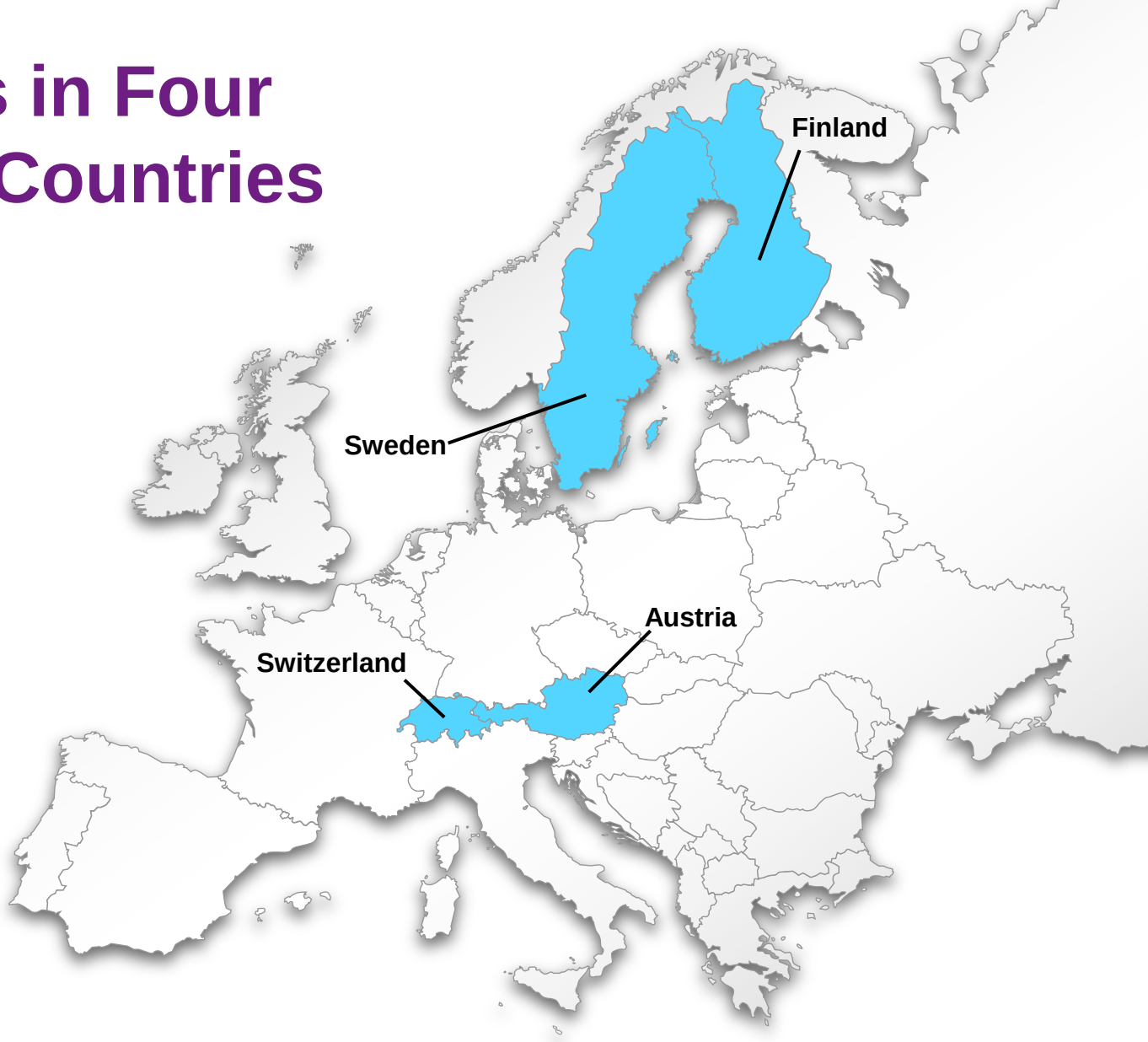
Eight Sites in Four European Countries

Switzerland
Zurich, Emmen, Nyon

Sweden
Gothenburg, Linköping

Austria
Vienna, Berndorf

Finland
Tampere



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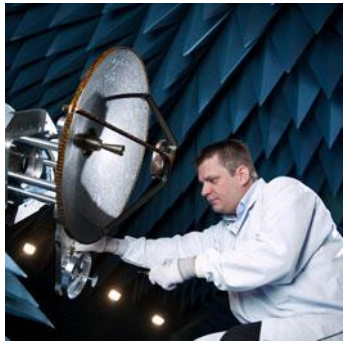
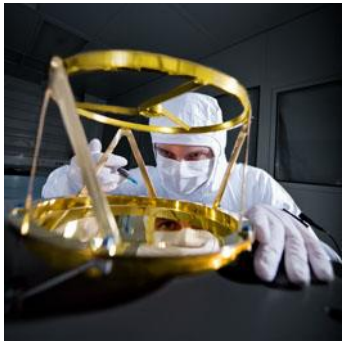
RUAG Space Product Portfolio

Launcher Structures & Separation Systems	Satellite Structures, Mechanisms & Mech. Equipment	Digital Electronics for Satellites and Launchers	Satellite Communication Equipment	Satellite Instruments
				
■ Launcher Fairings & Structures ■ Payload Adapters & Separation Systems ■ Sounding Rocket Guidance	■ Satellite Structures ■ Satellite Mechanisms ■ Slip Rings ■ Mechanical Ground Support Equipment ■ Thermal Systems	■ Satellite & Launcher Computers ■ Navigation Receivers & Signal Processing	■ Receivers & Converters ■ Antennas ■ Optical Communication	■ Satellite Instruments

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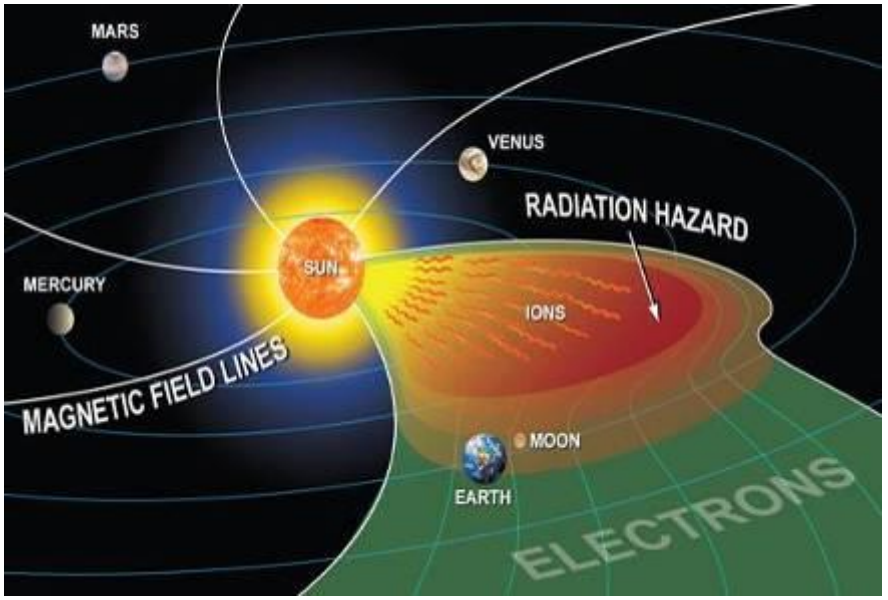
Because scientists need accurate data.
Our instruments collect them.
Together
ahead.
RUAG

… and we need the scientists to define the right sensors!

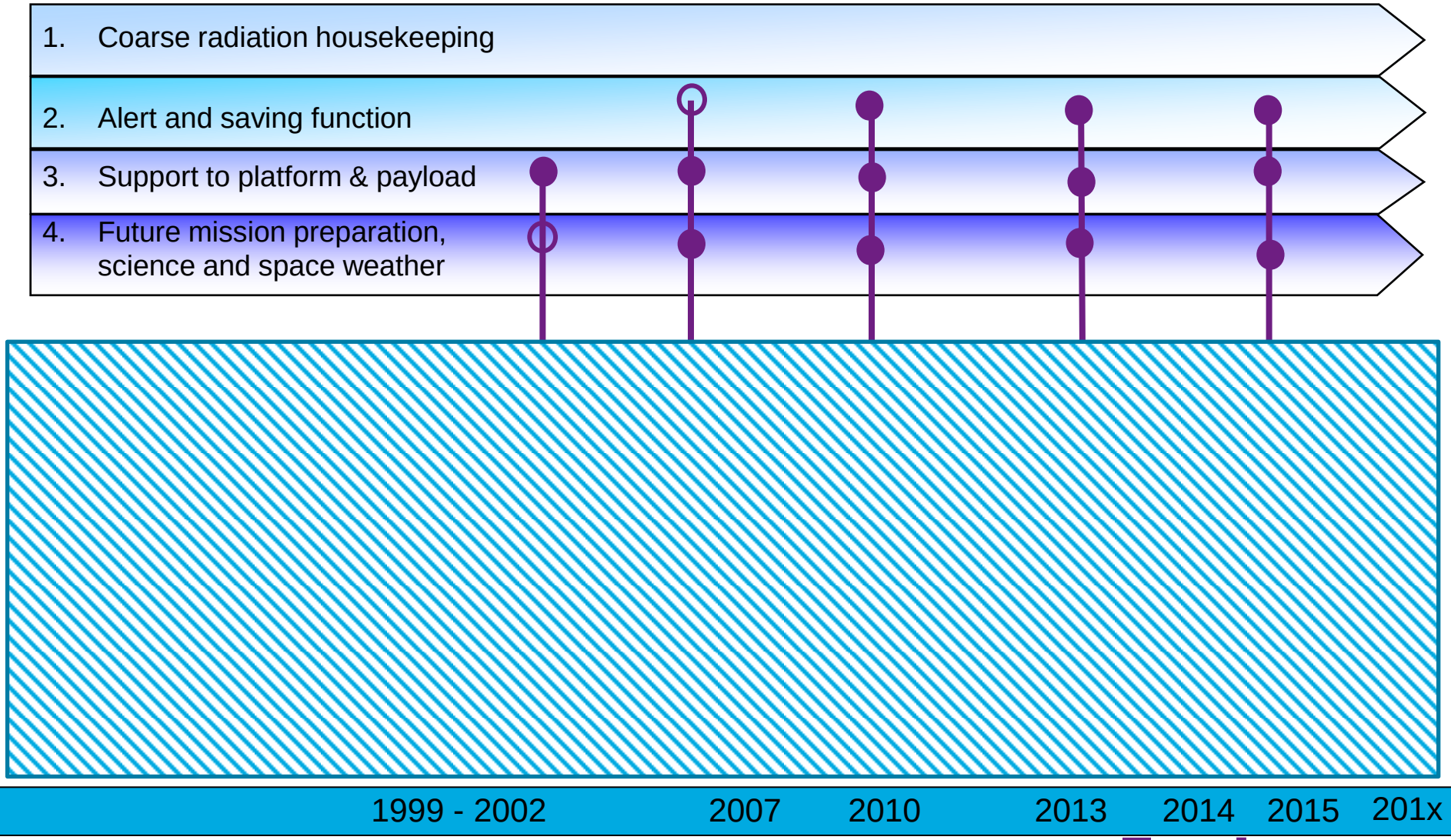
Scientific Instruments

- Scientific instruments
- Opto-electronic subsystems
  - proximity/front-end electronics
  - mirrors, telescopes, etalons, spectrometers
  - detector modules
  - focal planes
  - thermal engineering for observation instruments.
- Radiation Monitors
- Micro-Bioreactors

Radiation Monitors



ESA's categorization for RM



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For me, it all started at Christmas 2006…

… with an eMail from my new employer with ITT documents to read …

Galileo Industries SpA ° Via G.V.Bona 85 °
I-00156 Roma - Italy

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Tel.: +39 06 4151-284
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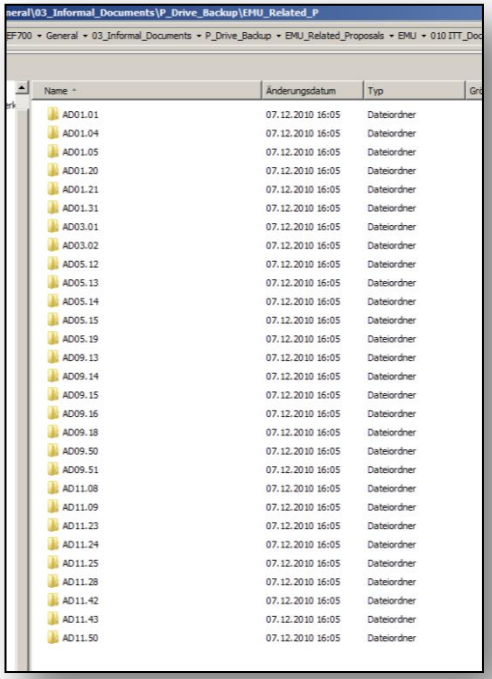
15 December 2006

Invitation to Tender ("ITT") Space Segment Avionics N-3 Procurement: Environmental Measurement Unit (EMU) for Phases C/D/E1 of the Galileo Development and In Orbit Validation Phase (IOV)

ITT ref.: GAL-ITT-U-EMU-0001

List of 1st level AD's:



plus all the ECSS standards….

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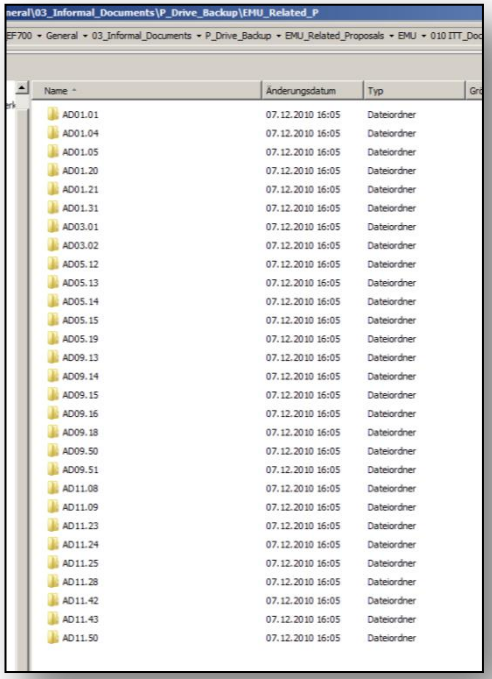

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→ I was shocked….

plus all the ECSS standards….

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The proposal

- 6 Week tiime to deliver proposal
- Challenging performance requirements (see next slides)
- Some teaming boundary conditions / restrictions
- Heritage as key requirement
- Recurring units
- Stringent cost targets

Challenges

- 1st trouble for the monitor start at T-0 and ends just a few minutes later → the launch
  - Non-ops
  - High mechanical loads, vibration, acustic noise, depressurization, thermal gradient
  - High shock at stage and fairing separation by pyrotechnics
- In orbit environment
  - Here it gets quiet, but …
  - Large temperature gradients, limited (thermal) protection
  - Continuous thermal cycling → stress in many ways
  - Radiation…. → obviously !!
- Very limited on-board resources
  - Power
  - Mass ←→ volume
  - Mostly no thermal control

Challenges

- No access for repair / maintenance but long mission time
- Very long lead times, mainly for EEE
- Very limited set of «approved» components
  Conservative mounting
- Compatibility requirements (→ ESCC)
  - Connectors → size!
  - EMC
  - Material properties (eg. outgasing

  NGRM: approx. 2000 tracked requirements

What we did …

- EMU (Galileo)
  - Protons, Electrones, Heavy Ions, TID
  - 8 W
  - 3.5 kg
  - 3 lt
  - 15 years in MEO
  - Galileo safety and RAMS requirements

→ We suffered and delivered

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→ We suffered and delivered

- While in full EMU qualification → next monitor ITT / spec came out

- NGRM
  - 1 W
  - 1 kg
  - 1 lt
  - rest the same (just lower budget)

→ What and how to do??

NGRM

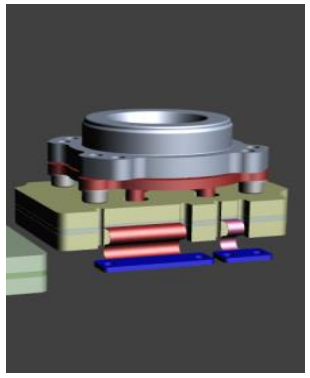
- Custom read-out ASIC
- Silicon / diode based detectors
  → size, power

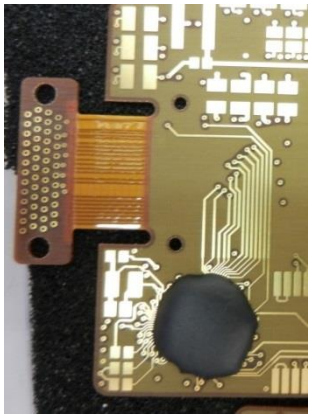
- Die bonding
- COB technology
  → footprint
  → mass

- Special rigi-flex PCB

- External sensor port to allow non-standard measurements
- Changeable S/C interface

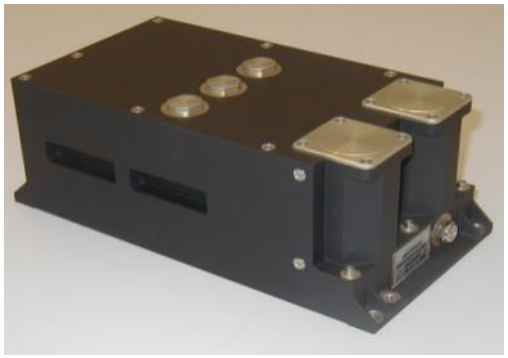
→ Lots of qualification effort





Radiation Monitor Heritage

- SREM, EREM (1999 – 2002)
  - Standard Monitor for ESA
  - Flying on 8 mission, incl. Giove (Galileo pre-cursor) & Rosetta
  - http://srem.web.psi.ch
- GSEM (2005 – 2007)
  - Study for future Radiation Monitor concepts (→ eg NGRM)
- EMU (2009 – 2013)
  - Tailored to Galileo needs / specifications, especially Charging Sensor
  - Selected (by ESA) Galileo satellites will be equipped with EMU
  - EMU units for 2 Japanese GEO missions delivered in August 2013 and in Orbit since Oct. 2014
- NGRM (2013 – now)
  - SREM successor
  - Low resource requirement
  - Generic
  - Quali in 3Q15
  - IOD on EDRS-C



Product Roadmap

1. Coarse radiation housekeeping
2. Alert and saving function
3. Support to platform & payload
4. Future mission preparation, science and space weather

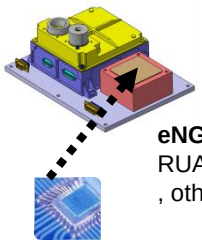
Radiation Monitors

SREM
RUAG & PSI

GSEM (study)
RUAG, Uni Geneva & PSI

Galileo EMU
SEDA Himawari
RUAG, Qinetiq

NGRM
RUAG, PSI, EREMS

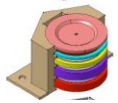


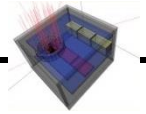
eNGRM
RUAG, PSI , others

Add-on detectors

Sensor/ASIC Development

PSI,
LEED sensor





GM-I
RO ASIC

1999 - 2002 | 2007 | 2010 | 2013 | 2014 | 2015 | 201x

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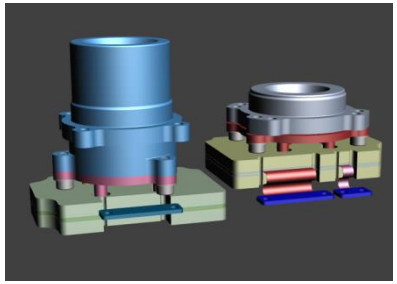
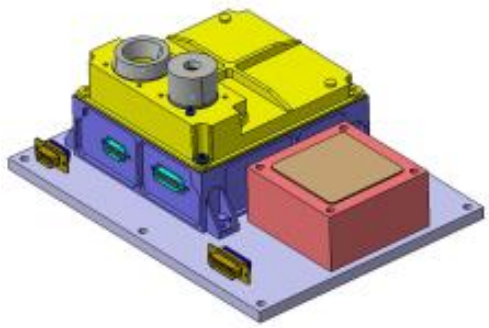
Radiation Monitor Outlook

- Recurring Units
  - MTG 6 units
  - Other 6 units for ESA in discussion
  - Interest in US and Asia
  - Upcoming ESA missions

- Detector Kit for Embedded Monitors
  - Core Kit
  - Relay on S/C on-board resources



- Act as instrument Host for non-standard external sensors
  - Qualified, standard based and “no-worry interface” towards Space Craft (firewall)
  - Allows buffering of data
  - Standardized serial interface to external sensor
  - User definable protocoll



- Miniaturization