IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Utilization of UAV Based Radiation Monitoring Technology for Radiological Mapping

IAEA Activities

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Organizational Structure

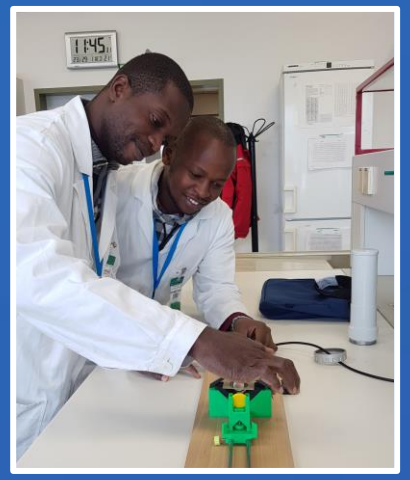
Nuclear Science and Instrumentation Laboratory

IAEA, International Atomic Energy Agency

NAPC, Department of Nuclear Sciences and Applications

Physic Section

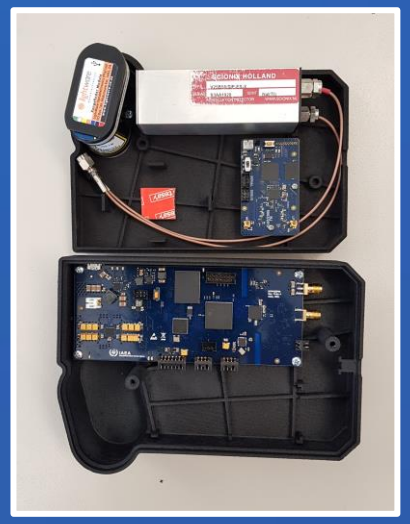
NSIL Activities



Trainings

Missions

Expertise



Development

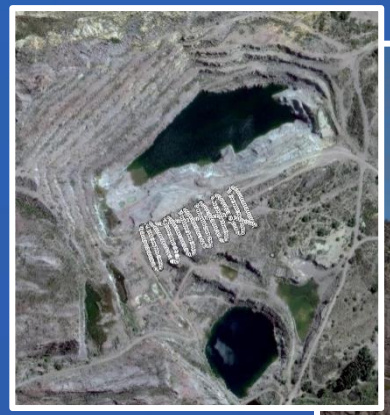
Capacity Building

Nuclear Science and Instrumentation Laboratory

Helps Member States (MSs) to develop, operate and maintain various nuclear instrumentation and spectrometry techniques in support of a wide range of applications such as health care, food, agriculture, environment, forensics, cultural heritage, and materials science.

NSIL Projects - UAV Based Radiological Mapping

Project with Fukushima Prefecture, Japan 2018



Measurement Mission - San Rafael Argentina 2016

UAV Expert Mission Brazil 2018

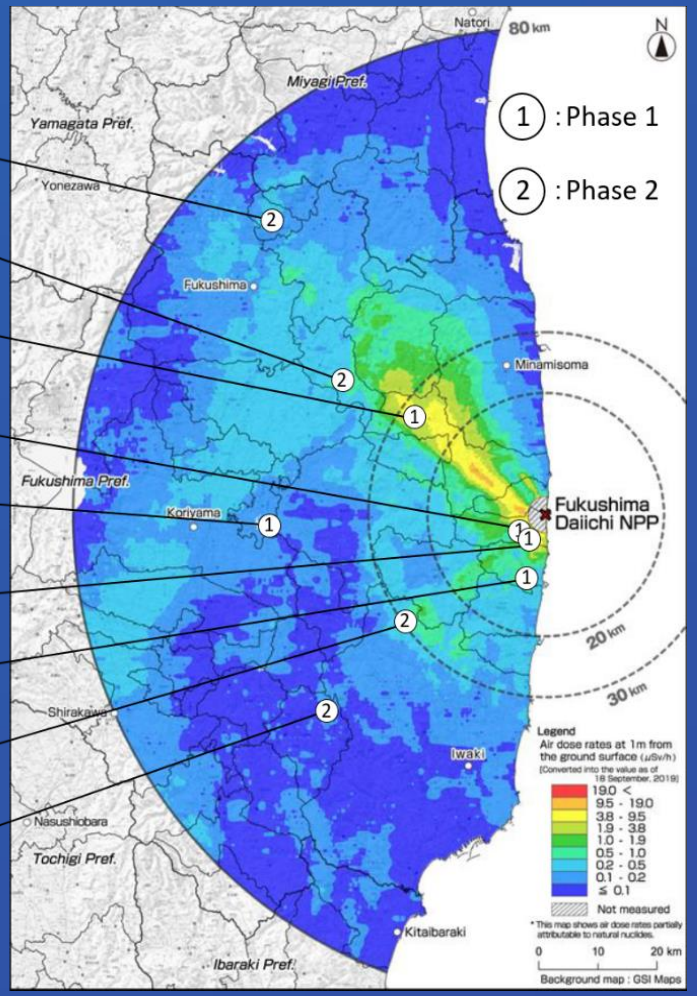
Project with Fukushima Prefecture 2012-2020

Rapid Environmental Mapping with UAV

UAV (Aibotix) based system and its instrumentation components delivered to the Fukushima Prefecture.

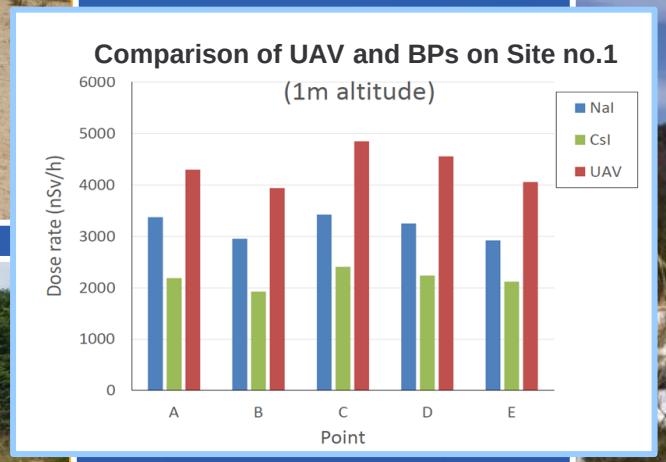
- Site no. 1
- Site no. 2
- Site no. 3
- Site no. 4
- Site no. 5
- Site no. 6
- Site no. 7
- Site no. 8
- Site no. 9

Monitored Sites



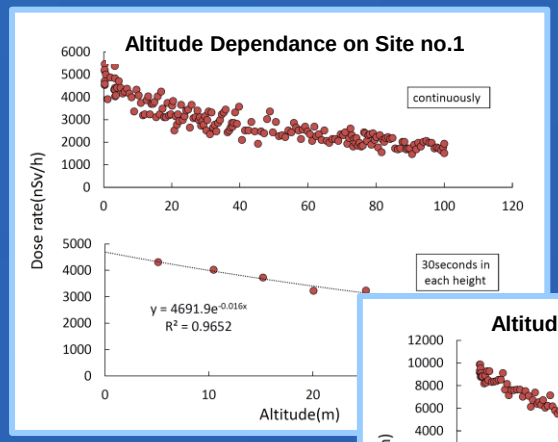
Project with FP – Verification of Methodology

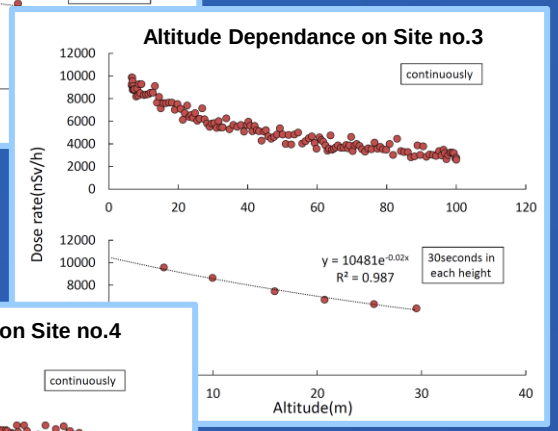
Comparison of UAV and Ground Measurement

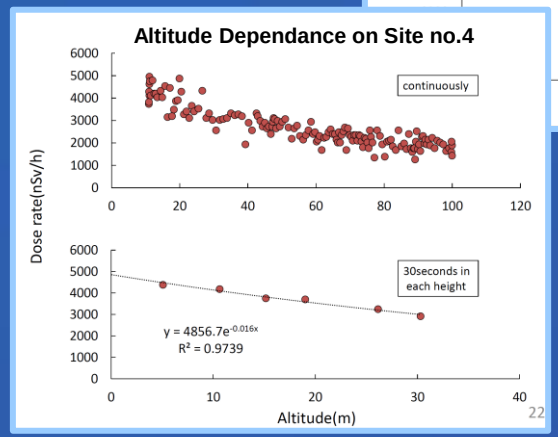


Developed Methodology for Measurement Verification of Dose Rate Compatibility (UAV vs Ground Instruments) on Site

Project with FP – Altitude Correction



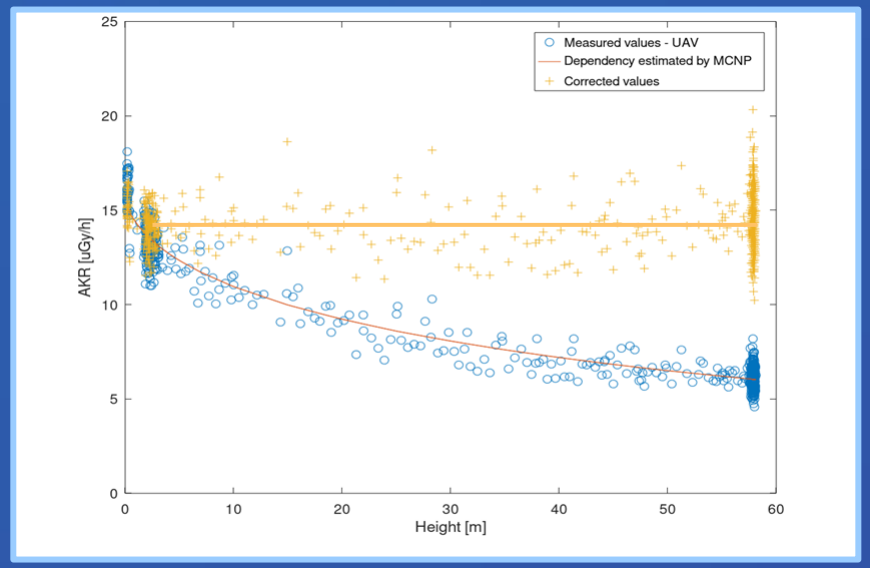




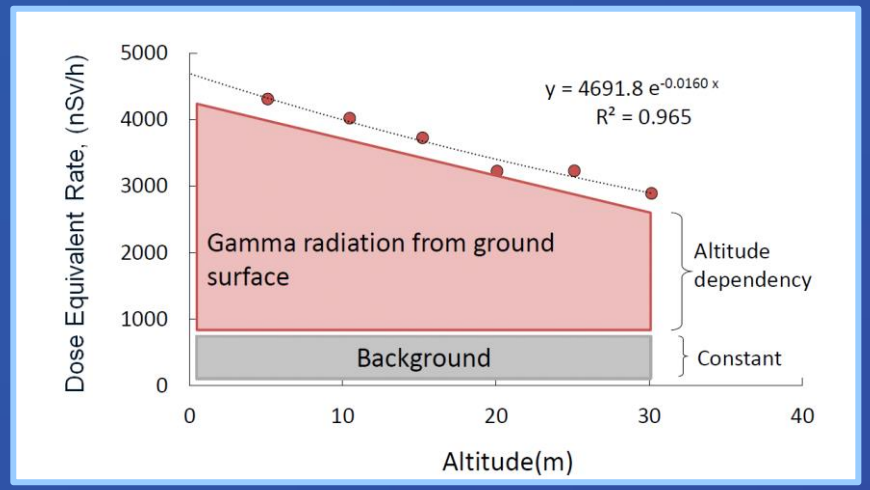
Experimental Data for Altitude Correction

Different Level of Contamination

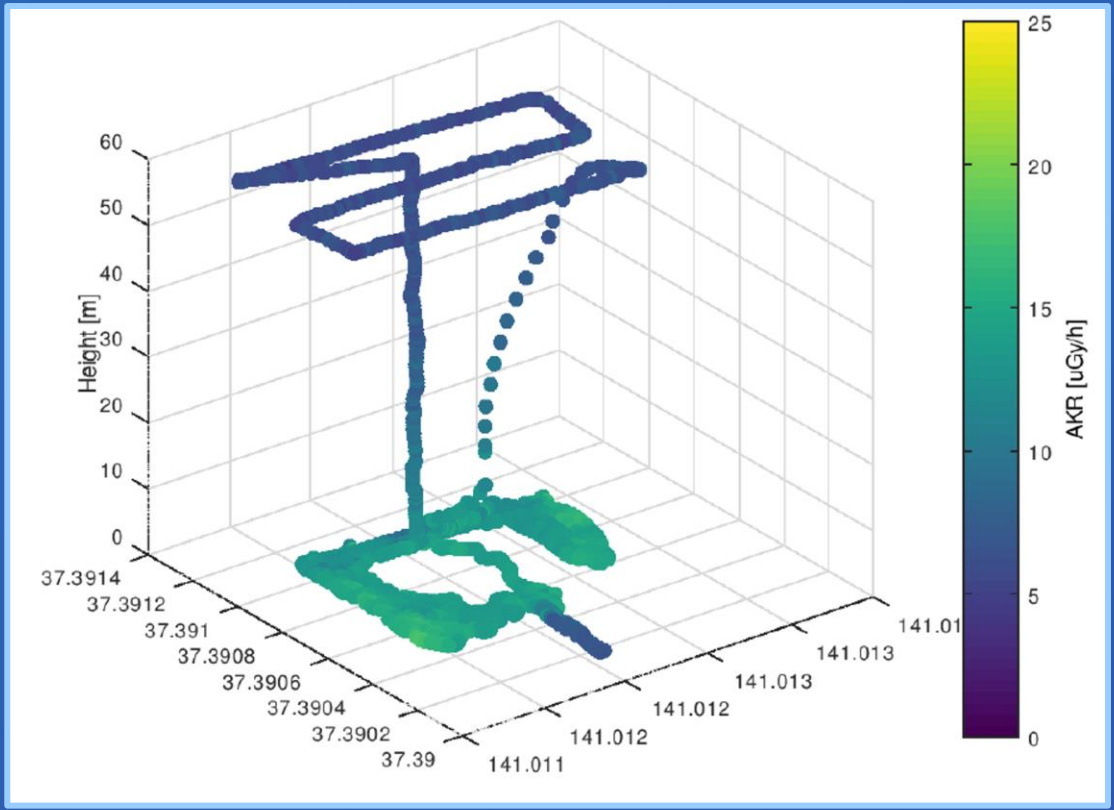
MCNP Modeling



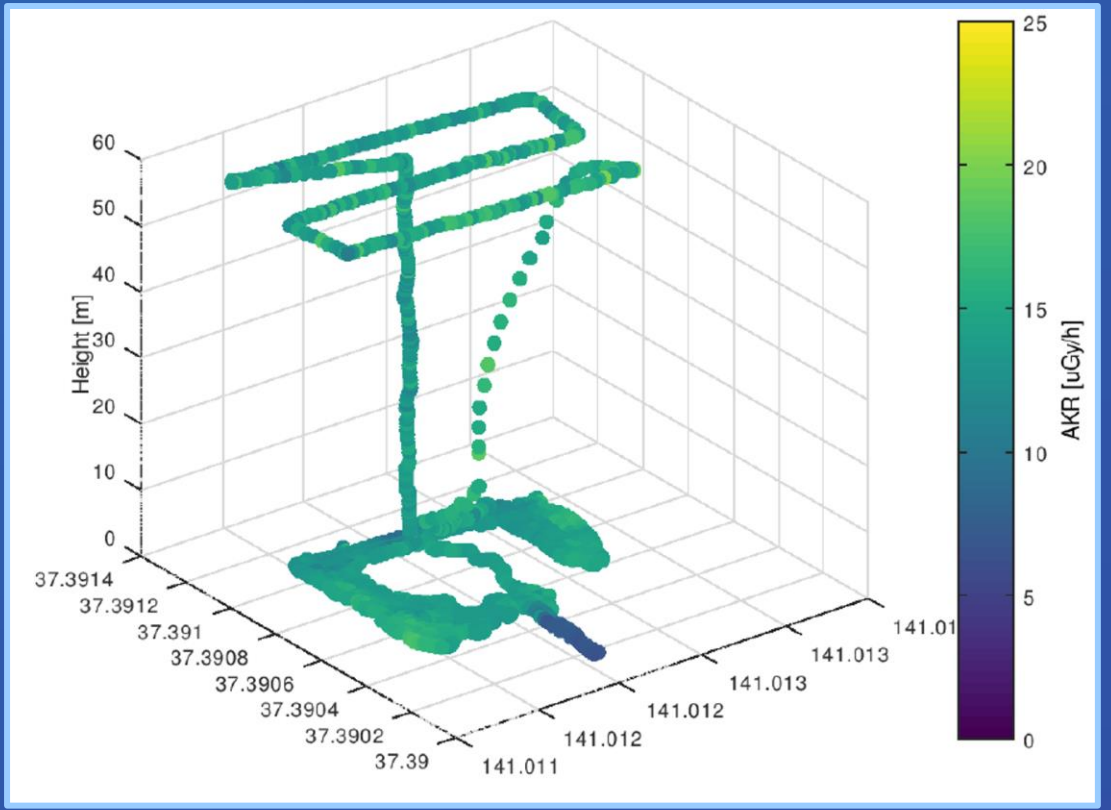
Final Model for Altitude Correction



Project with FP – Altitude Correction

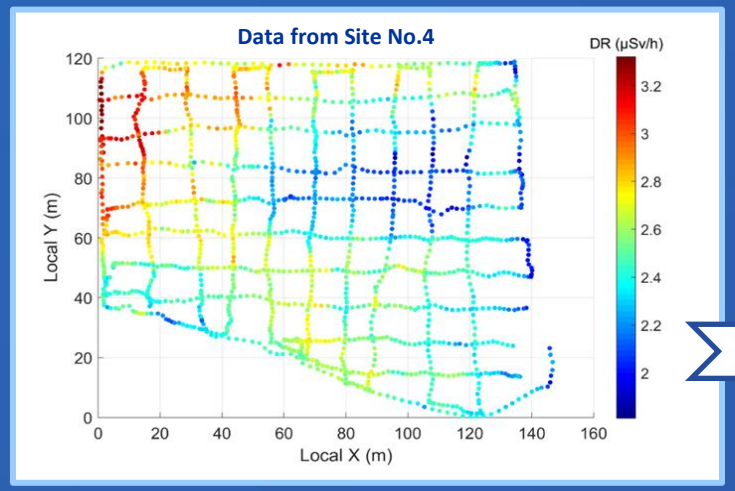


Data from Ground and UAV Measurement
(Raw-Non Corrected)



Data from Ground and UAV Measurement
(Corrected by MCNP to 1m Above Ground)

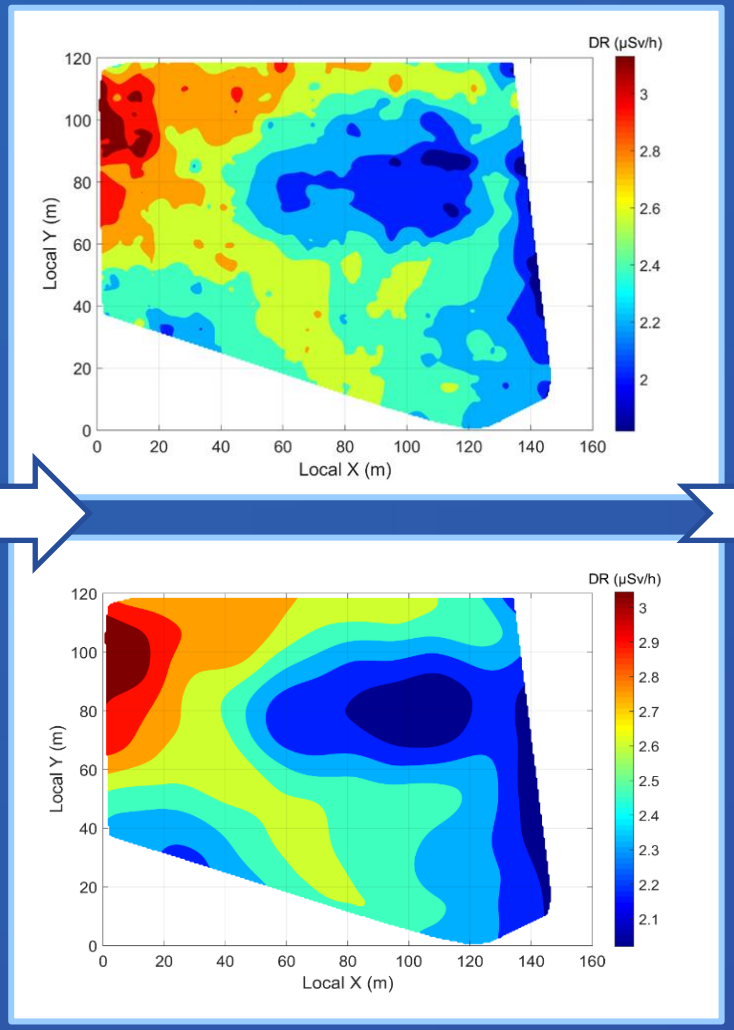
Project FP – Data Interpolation



Raw data from survey.

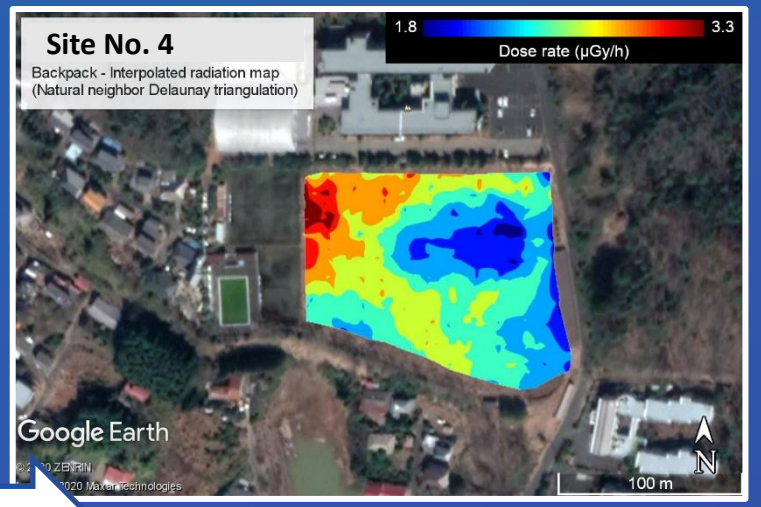
Method Optimization for Data Interpolation and Radiological Map Creation

Natural Neighbour Delaunay Triangulation



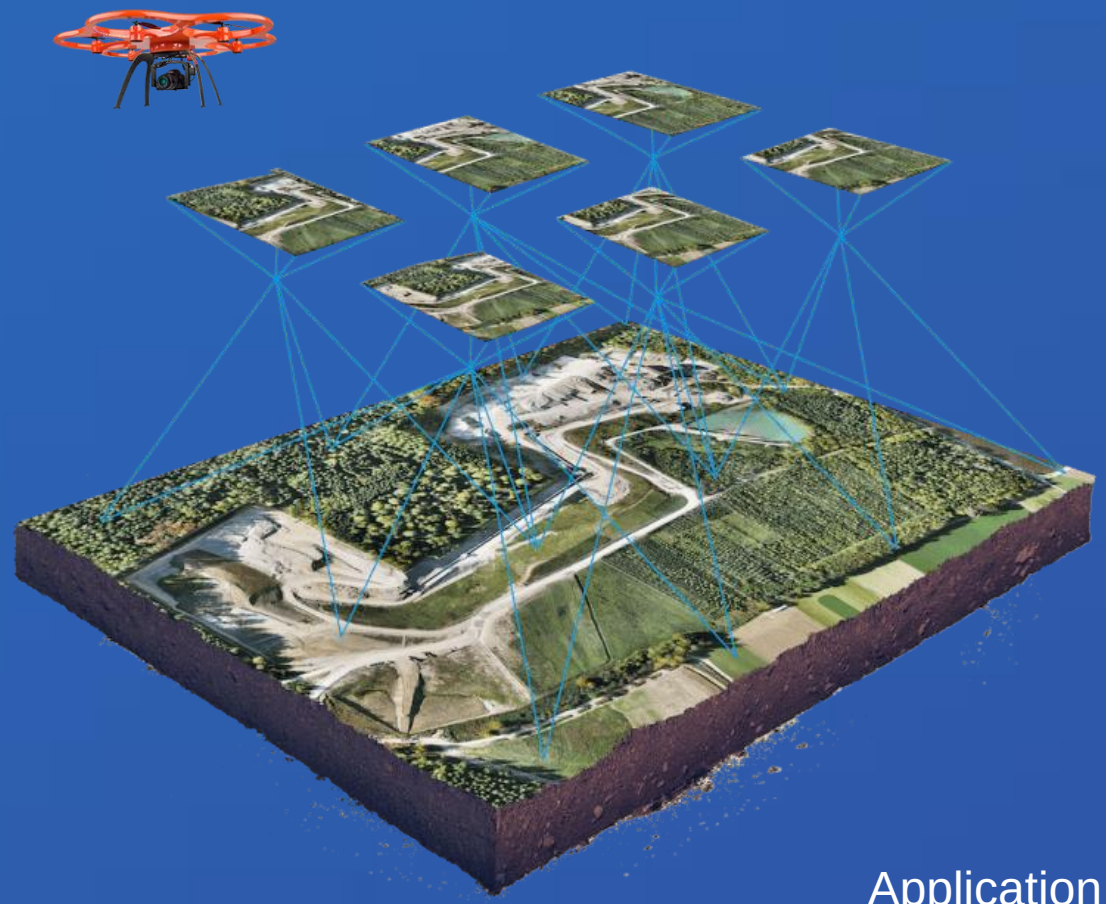
Thin-plate Spline Interpolation

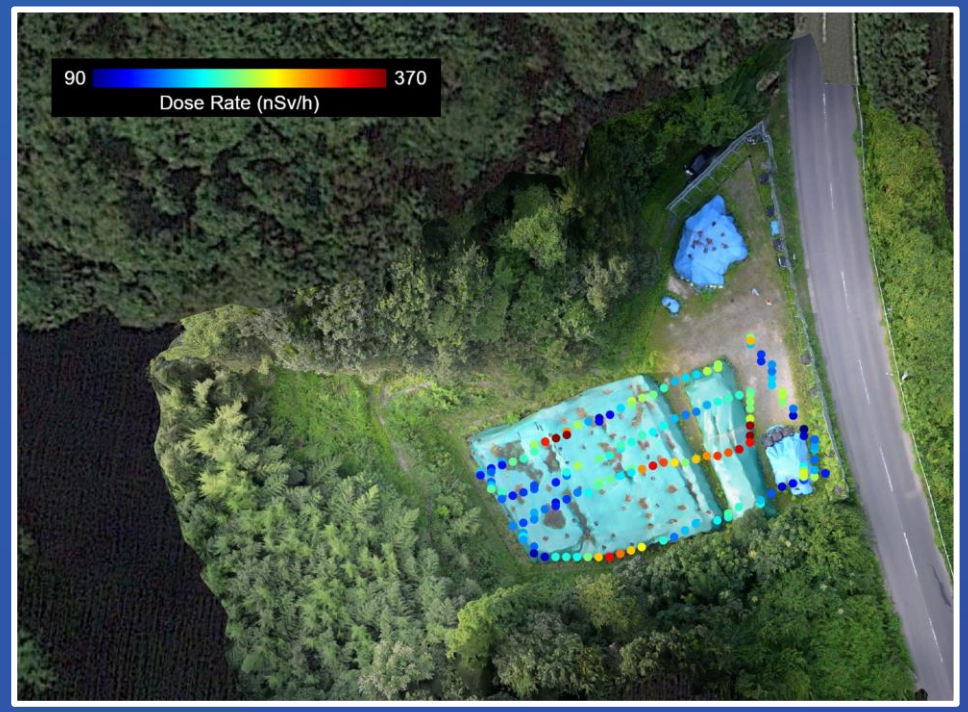
Final Dose Rate Color Scale Map



Final Isodoses Map

Project with FP - Implementation of Photogrammetry for UAV Radiological Mapping

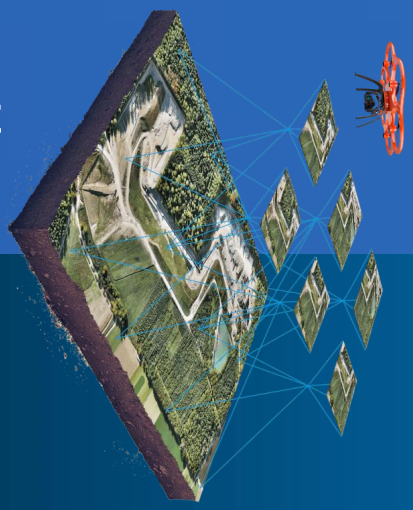




Application of UAV Photogrammetry for Radiological Mapping

3D Photogrammetry

Results of Monitoring - FP Project
Temporary Waste Storage Site



NSIL Current Development in UAV Based Technology

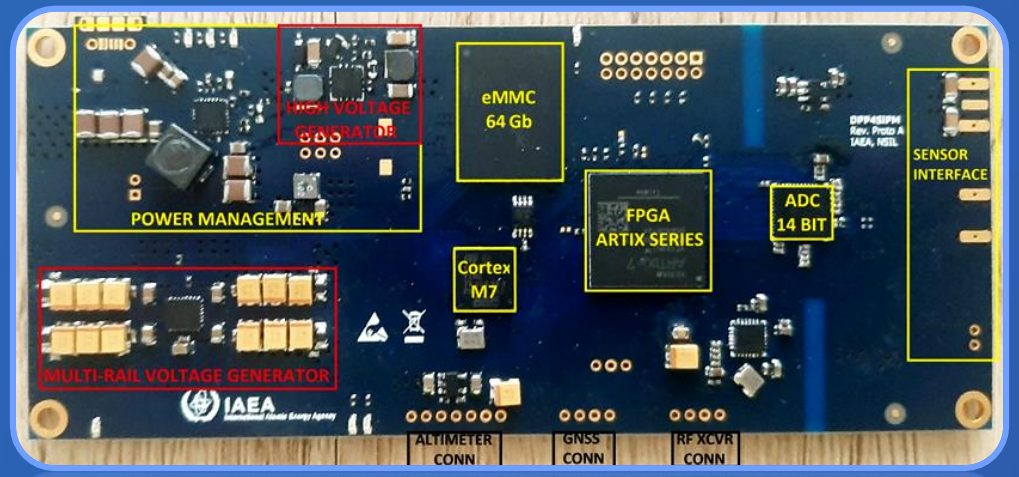
Testing of Commercially Available Systems

UAV DJI Matrice 210 V2 equipped by commercial GS module 1x1” SiPM NaI(Tl)

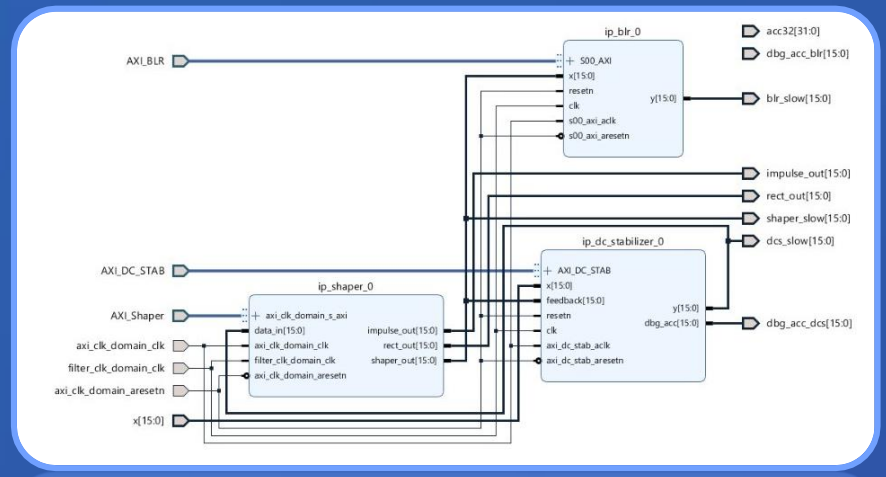
Testing of NSIL Developed Systems

UAV DJI Matrice 210 V2 equipped by experimental GS module 2x2” NaI(Tl) & 1.5x1.5” SiPM CeBr3

NSIL Current Development in UAV Based Technology



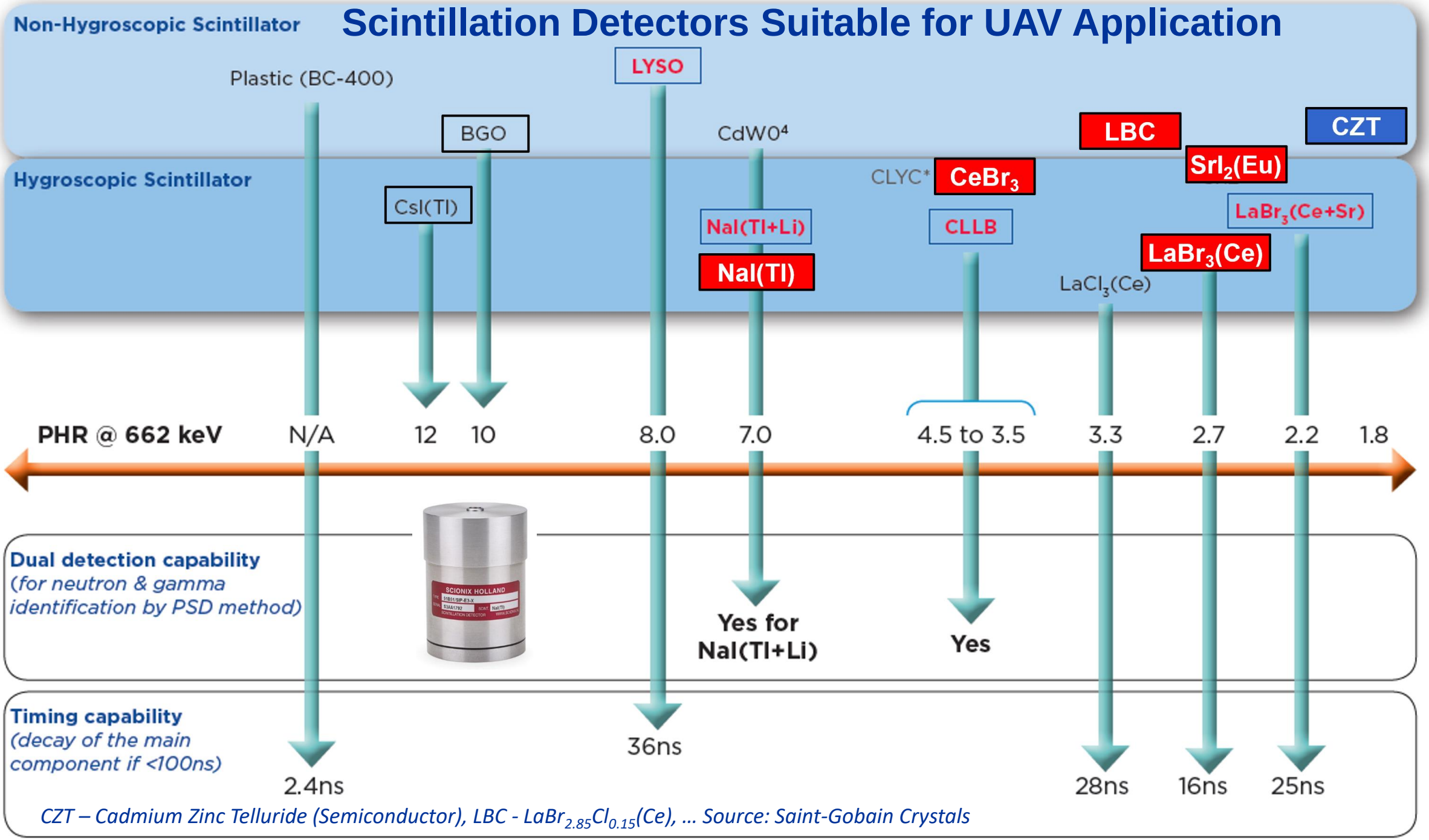
Digital Pulse Processor for UAV (MCA)



New Firmware for DPP

New Type of SiPM Detectors

Scintillation Detectors Suitable for UAV Application



CZT – Cadmium Zinc Telluride (Semiconductor), LBC - $LaBr_{2.85}Cl_{0.15}(Ce)$, … Source: Saint-Gobain Crystals

NSIL Current Development in UAV Based Technology

Digital Pulse Processor for UAV (MCA)

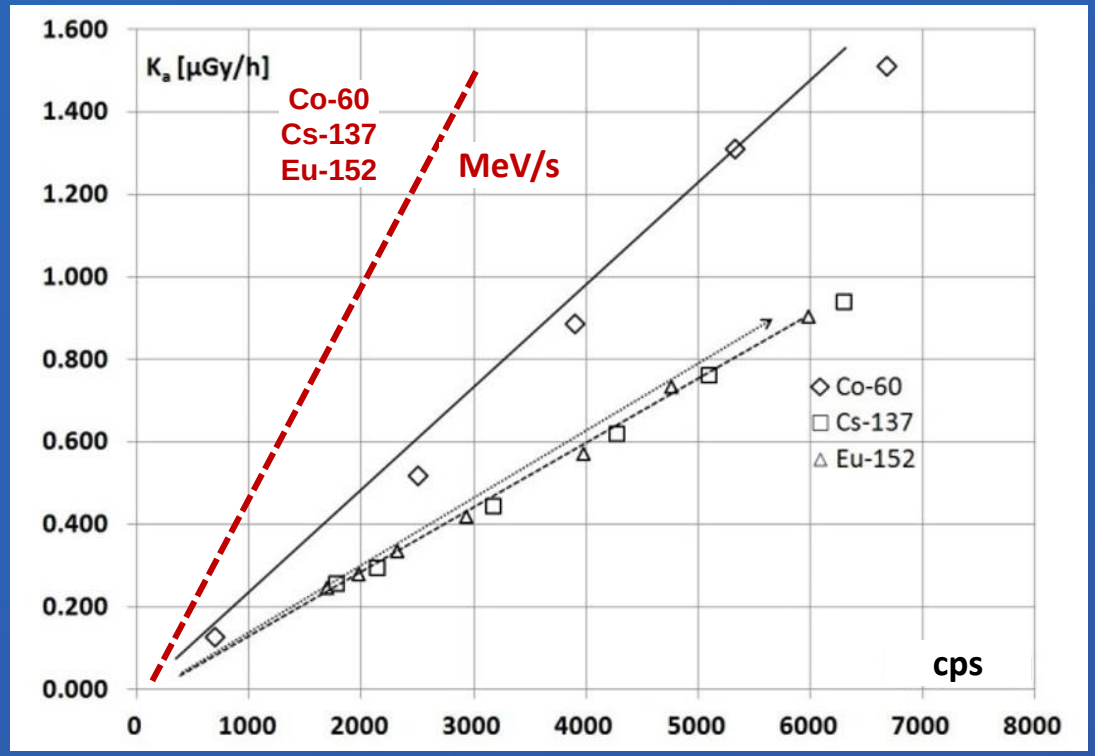
+ GNSS Antenna, Laser Altimeter,
RF Communication, …

Application of DPP Module on UAV

Data Format
SW for Ground Base Station

NSIL Current Development in UAV Based Technology

UAV System Calibration to Dose Rate Measurement

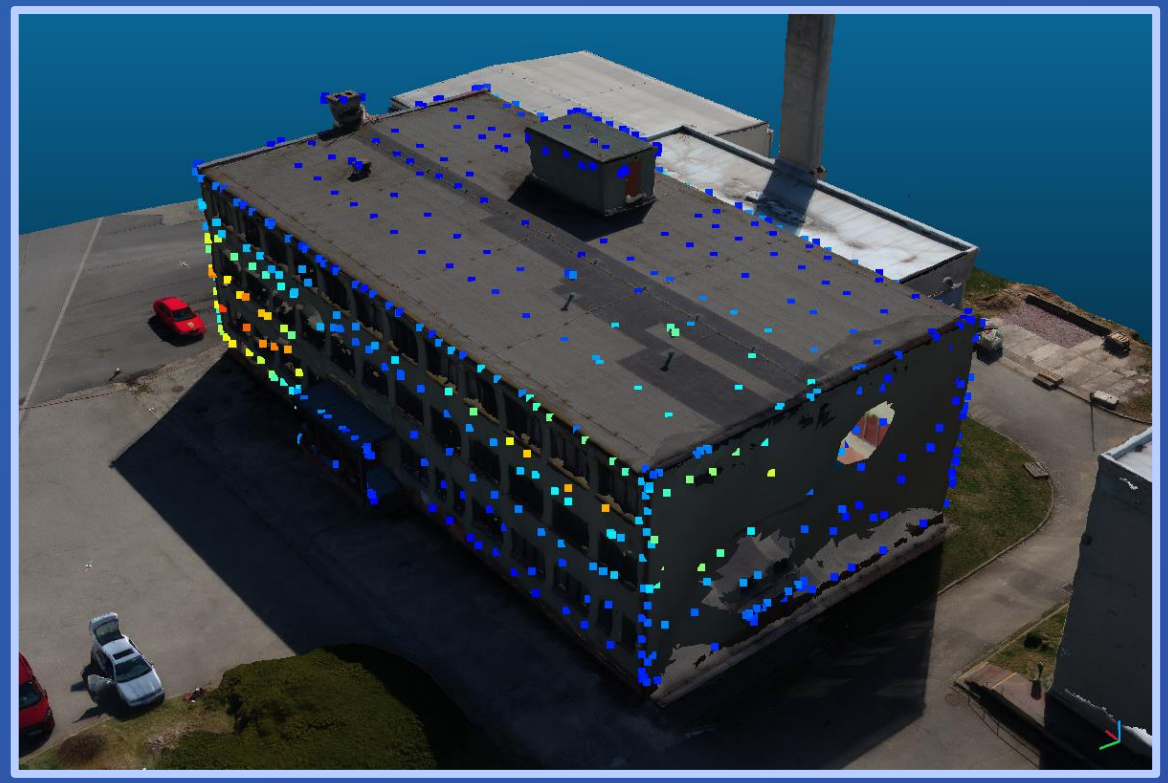


Calibration example of air kerma rate versus total cps for ^{137}Cs, ^{60}Co and ^{152}Eu measured with NaI(Tl) detector.

$$E_{ma} = \frac{\sum_{i=j}^{n} E_a \times N(E_a)}{t}$$

E_{ma} is the relative absorption energy rate in MeV/s, t is the live (real) time, j is the initial channel number and n is the final channel number and $N(E_a)$ is the number of counts with an energy E_a in the interval E_a, $E_a + dE_a$ in a channel over the measuring time t.

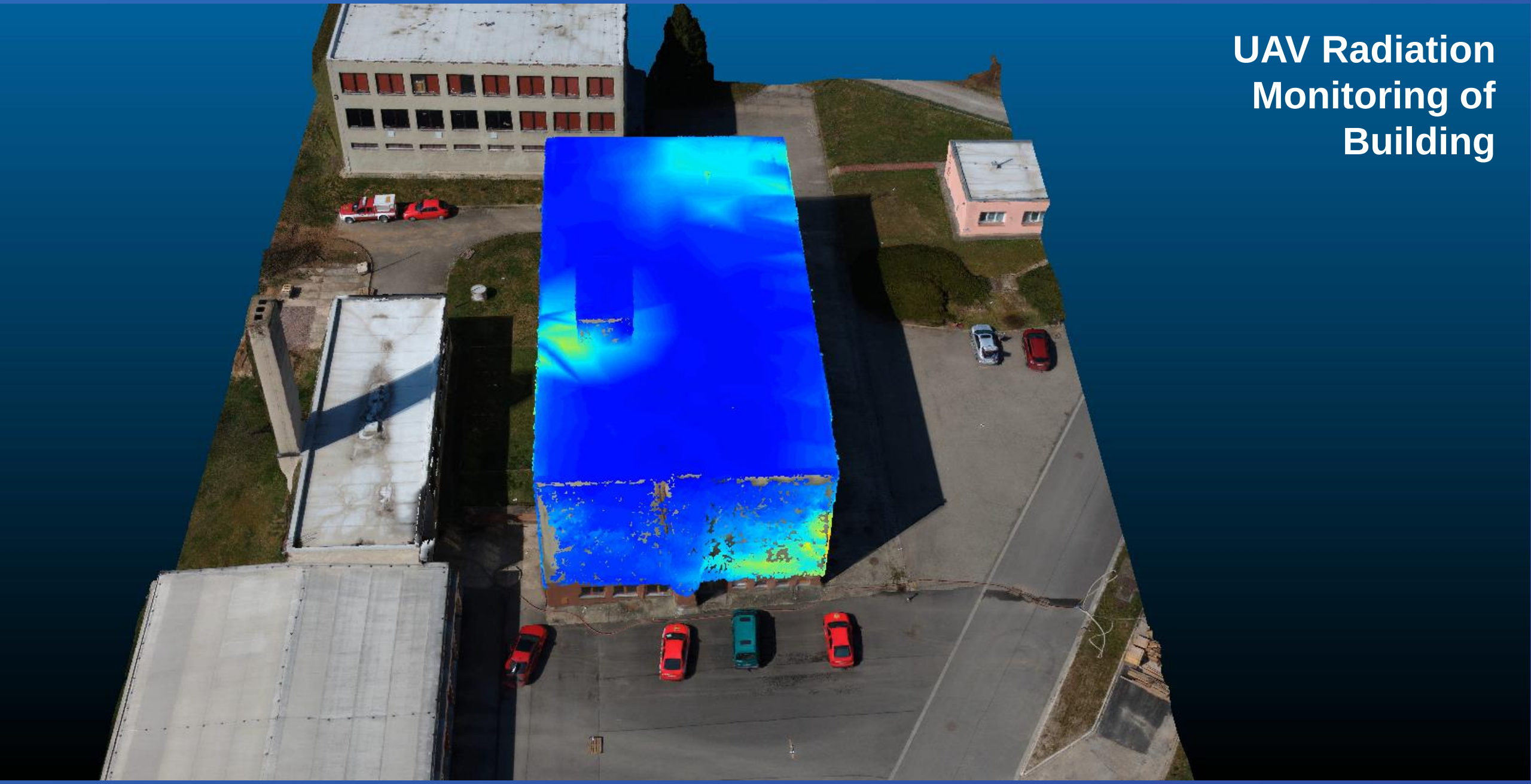
Radiological Mapping of Objects/Buildings



0.1 1.0 10

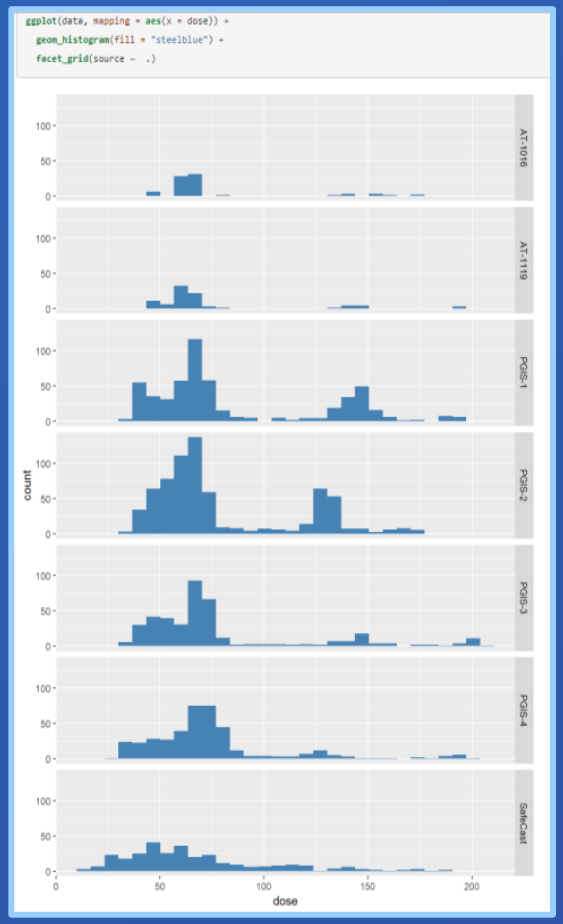
µSv/h (in log10 scale)

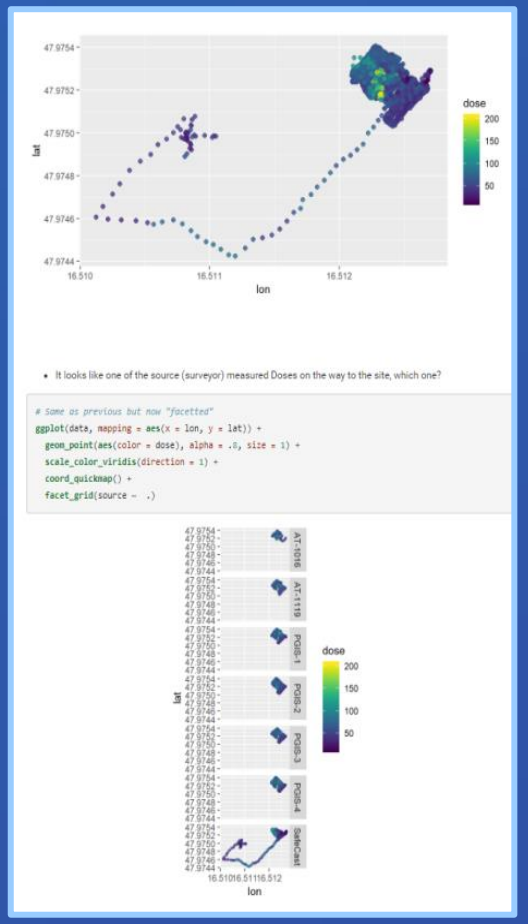
UAV Radiation Monitoring of Building

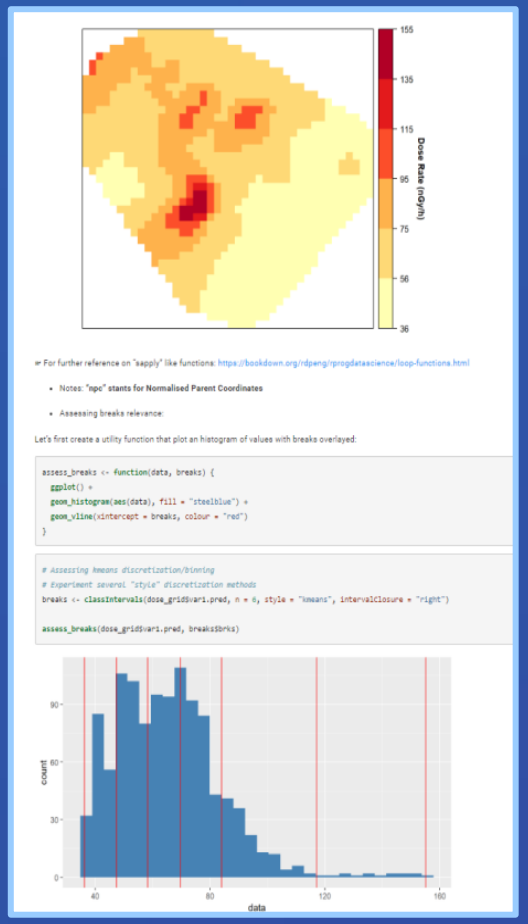


NSIL Current Development – R-Tool

R-based tool developed by NSIL (open source)
Data QC/QA, interpolation, variance analysis, iso-doses & color scale map creation, …







Classification of UAV Detection Systems with Regard to IAEA Relevant Areas of Application

Small
needed payload <2 kg

Typical Areas of IAEA Interest

- Environmental
- Nuclear Security
- Waste & Remediation
- Radiation Protection
- Water & Agriculture
- Nuclear Sciences & Applications
- Others …

Medium
needed payload <10 kg

Large
needed payload >10 kg

Large RAD UAV Systems

- **Advantages**: Large Area Capabilities, High Payload, Long Durability of Operation, High Resistance, Long Distance Data Transmission, High Detection Sensitivity, Application HPGe & Large Scintillation Detectors, Sensitive Gamma Spectroscopy & RN Identification, Real Time Analyse (Stripping/NPA Method), …
- **Limitations:** Total Weight, High Price, Preparation Time/Transport, Operator and Pilot Navigation, Professional Licence, Special Mounting for Modules & Auxiliary Sensors, Aviation Certification, Issue with Temporary Landing, …
- **Potential Application:** Environmental Monitoring, Remediation Survey, Search for Uncontrolled Rad Sources, Large Areas with Contamination, Geophysics, HPGe Gamma Spectroscopy, Emergency Action after Nuclear Accidents, Delimitation of Evacuation Zones, …

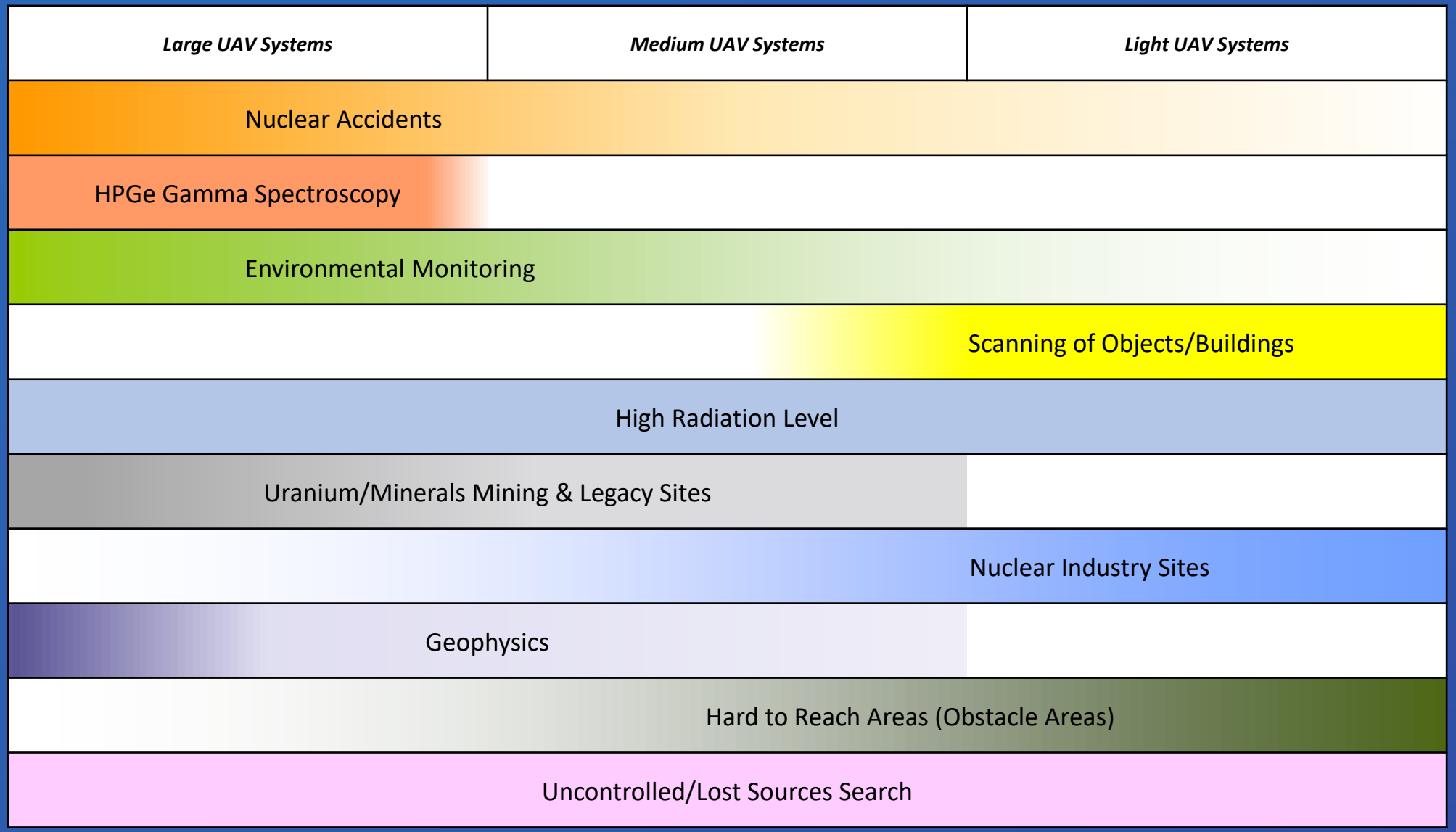
Medium RAD UAV Systems

- **Advantages**: Monitoring of Medium Size Areas, Operability & Flexibility of Field Deployment, Effective Ratio Cost /Performance, Good Environmental Resistance, Application of Typical Radiation Detectors, Real Time Data Transmission, Lower Level Altitude Operation, Autonomous Operation and UAV Independence, …
- **Limitations**: Limited Durability, Preparation Time, Operator for Ground Station, Licenced Pilot, Aircraft Transportation of Batteries, Operation “Line-the-Sight” Distance, Engines Maintenance …
- **Potential Application:** Dose Rate Mapping, Survey in Radiation Accident, Search for Uncontrolled Rad Sources on Small Areas, Simultaneous Application of Photogrammetry or Lidar, High Dose Rate Areas, Autonomous Operation in Emergency …

Small RAD UAV Systems

- **Advantages**: Lower System Price, Wider Available on Market, Effective for Monitoring of Small Areas and Low Altitudes, Monitoring of Spots with High Dose Rate Level, Easier Operation in Obstacle Area, Quick Preparation, Easy Transportation, Easier License, …
- **Limitations**: Lower Detection Sensitivity and Flight Durability, Lower Payload, Limited Real-Time Data Processing and Transmission, Environmental Resistance, …
- **Potential Application:** Initial System, Demonstration of UAV Based Rad. Mapping Technology, Monitoring of Hot Spots & Areas with High Dose Rate Level, Operation on Small Areas, Monitoring of Objects & Buildings, Security/Emergency Monitoring, …

Effective Use of UAV Systems for Various Areas of Application



Thank you for attention …