# Goddard Procedural Requirements (GPR)

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| **DIRECTIVE NO.** | GPR 1860.3B | **APPROVED BY Signature:** | *Original signed by Arthur F. Obenschain for* |
| **EFFECTIVE DATE:** | June 17, 2011 | **NAME:** | Robert Strain |
| **EXPIRATION DATE:** | June 17, 2016 | **TITLE:** | Director |

**COMPLIANCE IS MANDATORY**

**Responsible Office:** 350/Occupational Safety & Health Division

**Title:** Radio Frequency Radiation Protection

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# PREFACE

## P.1 PURPOSE

This directive describes the Goddard Space Flight Center (GSFC) Radiation Protection Program (RPP) for Radio Frequency (RF) radiation, which contains guidance on administrative and procedural requirements. Other types of radiation are addressed in other documents.

## P.2 APPLICABILITY

This directive is applicable to all GSFC civil servants, facilities, and activities, including all permanent and temporary sites. This directive shall also apply to all GSFC tenant organizations, contractors, grantees, clubs and other persons operating on GSFC property as required by law and as directed by contractual, grant, and agreement documents.

## P.3 AUTHORITIES

a. NPR 1800.1, NASA Occupational Health Program Procedures

## P.4 APPLICABLE DOCUMENTS

a. 21 CFR Part 1010 – Federal Performance Standard for Electronic Products
b. Institute of Electrical and Electronics Engineers (IEEE) for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz (IEEE C95.1)
c. RF Warning Sign American National Standards Institute (ANSI C95.2)
d. NPR 1800.1, NASA Occupational Health Program Procedures
e. NPR 8715.3, NASA General Safety Program Requirements
f. GSFC 23-6RF, Request for Non-Ionizing Radiation Safety Committee Action – Non-Ionizing Radiation Source (RF/EMF) Use Approval
g. GSFC 23-28RF, Request for Non-Ionizing Radiation Safety Committee Action – RF/Microwave Source Questionnaire
h. GSFC 23-35RF, Request for Non-Ionizing Radiation Safety Committee Action – RF/EMF Source - Personnel Approval

## P.5 CANCELLATION

GPR 1860.3A, Radio-Frequency Radiation Safety

## P.6 SAFETY

Safety requirements and numerous safety-related procedures are identified throughout this directive. Specific requirements applicable to procedures resulting from this GPR are described where appropriate.

## P.7 TRAINING

Training requirements are specified in Section 2.2. Each individual's specific training is identified on their GSFC 23-35RF when submitted for approval.

## P.8 RECORDS

| Record Title | Record Custodian | Retention/Schedule |
|---|---|---|
| GSFC 23-6RF *Request For Non-Ionizing Radiation Safety Committee Action – Non-Ionizing Radiation Source Use Approval* | RPO keeps original; users maintain duplicate sets. | NRRS 8/38<br>Transfer to Federal Records Center when 6 years old. Destroy when 75 years old. |
| GSFC 23-28RF *Request For Non-Ionizing Radiation Safety Committee Action – RF/Microwave Source Questionnaire* | RPO | NRRS 8/38 |
| GSFC 23-35RF *Request For Non-Ionizing Radiation Safety Committee Action – RF/EMF Source Personnel Approval* | RPO keeps original; users maintain duplicate sets. | NRRS 1/130<br>Records are kept for 3 years. If employee does not wish to be renewed for the position at the end of 3-year period, the record is removed and placed in an inactive file. Records are retained at GSFC until destroyed. Destroy when 75 years old. |
| RF radiation safety operating procedures | RPO keeps original; users maintain duplicate sets. | NRRS 8/38 |
| Records of personnel experience and training | Supervisors | NRRS 1/130 |
| Records of inspections and evaluations of facilities, equipment, location, and inventory | RPO or designee | NRRS 8/38 |
| Records of equipment and facilities, including model numbers, serial numbers, and calibration requirements | User organization, as part of their Radiation Safety Operating procedures | NRRS 8/38 |
| Hazard analysis reports | RPO | NRRS 8/38 |
| Reports of violations | RPO | NRRS 8/38 |

**NRRS - NASA Records Retention Schedules (NPR 1441.1)*

## P.9 MEASUREMENT/VERIFICATION

Metrics will be reported quarterly to the Non-Ionizing Radiation Safety Committee (NIRSC) by the Radiation Safety Officer (RSO) and shall include:

a. The number of new RF operation approvals;
b. The number of harmful employee exposures; and
c. The number of RF incidents.

## PROCEDURES

In this document, a requirement is identified by "shall," a good practice by "should," permission by "may" or "can," expectation by "will," and descriptive material by "is."

## 1.0 GSFC RADIATION PROTECTION PROGRAM

### 1.1 Introduction

The goal of the Goddard Space Flight Center (GSFC) Radiation Protection Program (RPP) is to provide a safe and healthful environment for all persons associated with the Center, including users of RF radiation sources and devices, Radiation Protection Office (RPO) staff, students, and visitors. Attainment of this goal requires the cooperation and commitment of all persons involved.

Custodians, approved users, and supervisors are directly responsible for maintaining an atmosphere that promotes full compliance with this directive.

Everyone involved with the use of RF radiation producing devices in any way shall be familiar with the provisions of this directive.

### 1.2 RF radiation safety responsibilities

#### 1.2.1 Non-Ionizing Radiation Safety Committee (NIRSC)

The NIRSC is responsible for the development of non-ionizing radiation policies and procedures regarding the safe use of these types of radiation in locations where GSFC operates. The NIRSC will consist of a Chair, Radiation Safety Officer (RSO), Radiation Frequency Safety Officer (RFSO), representatives of management, and members from divisions on the Center that work with or use RF radiation-producing sources and devices, including a representative from Wallops Flight Facility. NIRSC shall:

a. Meet at least quarterly, and as often as necessary to accomplish its responsibilities;
b. Ensure that non-ionizing radiation sources used at GSFC or under GSFC programs are managed so as to minimize the health and safety risks to Government and contractor employees and the public;
c. Ensure that GSFC and other Federal regulations, professional standards, and sound health physics practices are met;
d. Approve category 3 or higher RF operations and, if necessary, prescribe conditions and requirements to minimize radiation hazards by reviewing the RF safety plan submitted with a GSFC 23-6RF;
e. Approve the qualifications of personnel as responsible users and custodians of RF radiation producing devices by reviewing their completed GSFC 23-35RF;
f. Approve safe operating procedures; and
g. Suspend any approval not in compliance with GSFC's RPP.

#### 1.2.2 Radiation Safety Officer (RSO)

The RSO has administrative responsibility for the Center's RPP and is supported by the Radiation Protection Office (RPO) staff, which includes the RFSO. The RSO shall:

a. Ensure maintenance of records associated with all RF sources and/or devices reviewed and maintained by the RPO; and
b. Provide notification to the NASA Senior Environmental Health Officer (SEHO) regarding any unintended personnel RF exposure.

### 1.2.3 Radiation Protection Office (RPO)

The RPO staff provides a wide range of specific radiation protection services such as RF hazard analysis, laboratory and/or RF site surveys, maintenance of records, consultation on the safe use of RF radiation sources and devices, and training.

### 1.2.4 Radio Frequency Safety Officer (RFSO)

The RFSO is responsible for ensuring that all operations using RF devices meet the requirements of this GPR and report any issues or concerns to the RSO. The RFSO can also be the Center's Laser Safety Officer (LSO). The RFSO shall:

a. Review all applications for use of RF radiation producing devices and sources, including location, and procedures;
b. Recommend approval or disapproval (to the RSO and NIRSC) of applications for the use of RF radiation sources and devices;
c. Suspend any activity they determine to be a threat to health or property; and
d. Investigate overexposures, accidents, and other deviations from approved radiation safety practice, and implementing corrective actions as necessary.

### 1.2.5 Occupational Safety & Health (OS&H) Division

OS&H is responsible for oversight of safety programs at GSFC facilities in matters specific to the health and safety of personnel. The Chief, OS&H shall ensure a qualified individual is assigned as the RFSO and that there are adequate contractual personnel available to support the RPP.

### 1.2.6 Management

GSFC line management has primary responsibility for the RF radiation safety of personnel working under their jurisdiction and shall:

a. Designate custodians of RF radiation-producing sources and devices;
b. Ensure that RF radiation sources and/or devices are used only by individuals approved by the NIRSC and that all procedures and requirements are met; and
c. Ensure that RF custodians and users have adequate education, training, and experience for the responsibilities of a custodian or user.

### 1.2.7 Custodians

Custodians are responsible for ensuring that personnel using RF radiation sources and devices under their authorization are trained in safe-use practices, are familiar with the terms of the authorization and are complying with Center policies and applicable regulations. The custodian will normally be the

principal investigator of a research project or the member responsible for a field exercise in which RF radiation producing sources and/or devices are used. The RF custodian must also be an approved user.

### 1.2.8 Approved Users

Employees that have been approved by the NIRSC to be users of RF radiation producing sources and/or devices at the GSFC shall be responsible for knowing and observing all applicable RF radiation safety regulations.

All unsafe conditions or operations involving RF radiation sources or devices shall be immediately stopped and reported by the user to their custodian and the RFSO. Users should also feel free to raise any safety concerns to their management, the RSO or the NIRSC.

## 1.3 Wallops Flight Facility (WFF) Safety Office

WFF safety office will designate a Wallops RFSO who shall:

a. Provide review and preliminary approval for RF activities at or managed by WFF; and
b. Provide a list of preliminary approvals that have been granted at the quarterly NIRSC meetings.

The WFF safety office will be the office of record for all documents and use programs to assure compliance with NIRSC requirements relating to RF radiation safety at WFF or WFF operations.

### 1.3.1 Wallops RFSO

The Wallops RFSO shall:

a. Act as liaison officer to GSFC's RPP to ensure compliance with the applicable regulatory agencies' requirements relative to all RF radiation related activities that are conducted on the Wallops campus;
b. Provide technical guidance and evaluation to Wallops organizations on RF radiation-related matters and act as the functional representative on the NIRSC;
c. Audit the recordkeeping systems of the RPP pertinent to applicable requirements for registrations and reports specific to the RF operations on the Wallops campus;
d. Assume technical control, initiate investigations, and direct corrective actions in RF radiation incidents and emergencies at Wallops and coordinate mishap reporting and investigation requirements;
e. Review and submit interim approvals to the NIRSC's Chair, subject to subsequent NIRSC ratification;
f. Perform onsite surveillance, inspections, surveys, or monitoring of RF radiation uses and users, as required;
g. Provide health and safety analysis of planned RF systems; and
h. Survey RF systems with a designated RF exclusion area annually.

# 2.0 RADIO FREQUENCY RADIATION AUTHORIZATION

All approved users, custodians, and uses of RF radiation sources or devices require approval by the NIRSC. All authorizations are subject to conditions in the references listed in P.4 and this GPR and the conditions imposed by the NIRSC. Violations of the approved conditions regarding users, uses, or location may result in revocation or termination of the authorization.

### 2.1 Obtaining authorization to be an approved user and/or custodian of RF radiation sources or devices

The procedure for obtaining authorization is as follows:

a. A proposed individual will complete a GSFC 23-35RF, listing their training and experience working with RF sources and/or devices, a listing of the sources and/or devices they will be using, and listing of the custodian for the sources and/or devices. NOTE: Proposed users shall only be allowed to work for up to 30 days under the supervision of a currently approved user until formal NIRSC approval has been granted;
b. Submit the form to their appropriate manager/supervisor for concurrence. If satisfied with the request, the manager/supervisor shall forward the request to the RPO for NIRSC approval;
c. The RPO shall review the request to ensure that the individual has the education, training, and experience necessary to handle the RF radiation sources or devices requested;
d. The NIRSC shall approve or disapprove the request and the RPO will notify the individual by providing a copy of the approved or disapproved GSFC 23-35RF; and
e. NIRSC approval shall be renewed every 3 years. Interim approval for a request may be granted by the NIRSC Chair between NIRSC meetings and then finalized at the next NIRSC meeting.

Civil service and contract employees are allowed to be either an approved user or custodian of RF sources or devices at GSFC or GSFC-approved locations. GSFC civil servants, contractors and other personnel operating offsite under GSFC authorization are subject to all provisions of Goddard's RPP, but are also responsible for ensuring all local regulations are being met.

### 2.2 Personnel training requirements

Personnel completing a GSFC 23-35RF are required to list the RF radiation safety training they have received. Additional specific training may be required of each individual based on the characteristics of the RF source or device they are seeking authorization to use. All personnel requiring access to controlled environments shall be appropriately trained in safe work practices for controlling or mitigating personal exposures.

Persons applying to become RF custodians or authorized users of RF radiation sources and/or devices shall have sufficient training and education to understand and be familiar with the following:

a. Introduction to RF sources and RF safety
    1) importance of an RFSO
    2) examples of RF sources
    3) definitions/ units
    4) electromagnetic spectrum
    5) basic physics of electromagnetic exposure
    6) differences between ionizing and non-ionizing radiation

7) rationale/importance for complying with RF standards
8) importance of avoiding areas designated as restricted

b. RF generators, transmission lines, wave propagation
1) types of generators/amplifiers, e.g., klystrons, magnetrons, traveling-wave-tubes (TWTs)
2) types of transmission lines and their uses, e.g., coax, parallel line, twin lead, twisted pair, waveguides etc.
3) RF wave propagation, i.e., guided/unguided, free-space radiation, absorption, reflection, ground waves, sky waves etc.

c. Antennas
1) transmitting/receiving
2) antenna types - directional/omni-directional/array
3) resonant: single element/ multi-element
4) antenna patterns
5) antenna gain (directivity), beam widths
6) locations of antennas, e.g., towers, atop of buildings/vehicles, etc.
7) parasitic re-radiators
8) areas to avoid

d. Biological effects/hazards
1) interaction with body
2) potential hazards, i.e. overheating, RF shock/burn, hot spots
3) penetration depth, resonance
4) susceptible parts of the body
5) ancillary hazards, e.g., electric shock/electrocution

e. Standards, basis of standards/regulations
1) units: specific absorption rate (SAR), currents, electric fields (volts/meter), magnetic fields (amps/meter), power density (milliwatts per square centimeter), etc.
2) whole-body exposure/local exposure
3) safety factors incorporated in standards
4) quantitative exposure limits, dependence on frequency
5) spatial averaging for determining compliance
6) time averaging in determining compliance
7) induced current/contact current limits
8) pregnant workers (note no difference in guidelines if applicable)

f. Elements of a safety/protection program having RF exposure
1) RFSO (main contact for RF safety)
2) documentation/record keeping

3) inventory of sources
4) training of employees and documentation
5) control procedures to prevent overexposure
6) administrative (signs, alarms, indicative barriers, etc.)
7) engineering (elevation/azimuth interlocks, sector blanking, software controls, fences, barricades etc.)
8) Reporting procedures in case of overexposure/point of contact in case of overexposure

g. Procedures to be observed for suspected overexposures
   1) whom to contact
   2) medical exams to be performed
   3) evaluation of incident, i.e., circumstances, type of system, average power levels, exposure time duration
   4) proximity of person(s) to radiating source, whole-body or local (partial) body exposure, etc.
   5) procedures to prevent reoccurrences

h. RF signs, alarms, barricades
   1) types of signs (Notice, Caution, Warning, Danger)
   2) meanings of each and when to use

i. Site evaluation
   1) types/numbers of sources
   2) location of antennas and proximity to personnel
   3) identifying potentially hazardous/restricted areas, where to post RF signs, etc.

j. Medical implant concerns
   1) defibrillators/pacemaker wearers
   2) metallic implants
   3) possible effects, e.g., electromagnetic interference (EMI), shocks, burns
   4) importance of guidance from physician or manufacturer on avoiding EMI

### 2.3 Personnel experience requirements

Experience in working with hazardous RF radiation sources or devices is crucial. A person shall have previous experience in operating RF radiation sources or devices. Experience for this requirement can include that obtained from universities, former employment, and work supervised by a custodian (who is responsible for keeping records of this experience).

This experience shall be documented on the individual's GSFC 23-35RF.

#### 2.3.1 Supervision of inexperienced RF radiation workers

Completing RF radiation safety training does not ensure that inexperienced workers are competent to use RF sources or devices without supervision. Inexperienced personnel needing to use RF radiation producing sources or devices will submit a GSFC 23-35RF. Block #5 shall be marked YES for "direct

supervision during all operations." The custodian will ensure that inexperienced workers are directly supervised during RF radiation use until such time that the custodian is comfortable that the worker can handle sources or devices of radiation safely and competently. Once the custodian is comfortable with this worker's experience a request should be submitted in writing to the RPO to have the original GSFC 23-35RF modified to change Block #5 to NO. This request will include the dates that the worker was supervised.

### 2.4 Obtaining authorization to use RF radiation sources or devices

Requests for approval to use RF radiation **sources or devices** are initiated by submitting a GSFC 23-28RF (which is a description of the device/source) and if necessary a GSFC 23-6RF (which describes the who/what/where/why of using the source) to the RPO. A GSFC 23-28RF should be submitted first for a hazard evaluation. Based on the level of hazard a GSFC 23-6RF may be required by the RFSO.

Requests shall be submitted by the approved user or custodian to the RPO **at least** 2 weeks prior to the need date to guarantee processing. Complicated projects, extremely hazardous operations, offsite activities, and flight activities should be coordinated with the RPO in early planning stages to ensure that there is no impact to mission schedules.

Approvals are only valid for a maximum of **3 years** and may contain conditions that restrict the use of the RF source/device for specific purposes at GSFC and approved off-site locations.

The procedure for obtaining authorization is as follows:

a. For new sources or devices; the originator shall prepare the GSFC 23-28RF describing the RF radiation sources or devices involved and identifying their radiating characteristics. For RF sources or devices previously approved by the NIRSC, the originator should list the assigned Docket Number(s) in the appropriate section of the GSFC 23-6RF or in the RF safety plan;
b. The originator shall prepare the GSFC 23-6RF describing the intended use of the source or device along with safety procedures, showing that the source or device can be properly used with minimum exposure to personnel or damage to property. All operations will be in compliance with GSFC and other applicable regulations. The location and availability of proper equipment (including model numbers, serial numbers, and calibration requirements as applicable) and facilities should be included in the procedures;
c. The originator submits the above forms to the RFSO for NIRSC approval;
d. When the RFSO receives the request an evaluation to determine the adequacy of the equipment, facilities, and location of the particular use of the RF radiation source or device is conducted. Operating procedures and source handling techniques shall be discussed and evaluated. On the basis of the evaluation, the RFSO may impose additional conditions to ensure safe operation. Any additional conditions or explanation of non-approval should accompany the request;
e. In some cases, the RFSO may require the applicant to submit a safety analysis that indicates probability of a serious incident, its consequences, and mitigation. The RFSO shall determine this requirement on a case-by-case basis;

f. The NIRSC shall approve or disapprove the request for use of RF radiation sources and/or devices, and the RPO will notify the originator by providing a copy of the approved or disapproved GSFC 23-6RF. The NIRSC may also impose additional requirements; and
g. The procedures approved in the request become the conditions under which the custodian and his/her personnel are approved to use RF source/device. Any subsequent change in procedure regarding its use or additional approved users shall be reviewed and approved in writing by the RSO prior to instituting the change.

### 2.5 Facilities/Site evaluation

The review of RF radiation source and/or device use requests shall include an evaluation by the RFSO of the adequacy of the proposed facilities/site. Depending on the type of device or source and the complexity of the proposed procedures, the following should be considered:

a. Isolation from general laboratories and public areas;
b. Availability of radiation detection instrumentation; and
c. Ability to control the RF radiation area

### 2.6 Inspection and inventory requirements

Facility/site location inspections shall be performed annually by the RFSO (or designee) to ensure compliance with the approved GSFC 23-6RF. Source inventory will be completed (at a minimum) annually by the RPO staff and source inventory, in the same manner, will be required to be verified by the custodian annually. The possible loss of any source should be immediately reported to the RSO.

### 2.7 Obtaining approval to purchase RF radiation sources or devices

The individual requesting the source or device shall be an approved user. Requests shall be submitted to the RPO at least 2 weeks prior to the date the purchase needs to be authorized to guarantee all processing is complete. The request should be submitted on a GSFC 23-28RF to the appropriate branch head (or higher authority) for concurrence. If satisfied with the request, the branch head (or higher) forwards the request to the RPO.

#### 2.7.1 Radiation Protection Office (RPO) review

The RPO shall review the order request to determine the following:

a. The requestor has been approved to use the type of RF source or device being ordered. The name of the custodian should be clearly indicated on the order;
b. The RPO shall perform a RF hazard analysis to ensure no limits will be exceeded by this request; and
c. The custodian has no unresolved items of safety noncompliance, including responses to survey reports and training notices.

When the above criteria are met, the order will be approved and the requestor will be notified to place the order. If the above criteria are not met, the custodian shall be notified by telephone or email to expedite provision of the necessary information.

### 2.8 Amendments to authorizations

a. A memo to the RFSO shall be submitted for any additional RF radiation sources or devices to be added to their operation; and
b. A custodian who needs to use RF radiation sources or devices in a manner other than that already approved shall submit a new GSFC 23-6RF describing the new use to the RFSO for NIRSC approval.

### 2.9 Record keeping

A copy of all forms that have received NIRSC approval shall be maintained in the custodian's radiation safety records. The original forms are kept at the RPO.

### 2.10 Approval for onsite movement of RF sources or devices

GSFC 23-6RF shall be submitted for all actions involving movement of RF sources or devices on Center (loans, shipments, different users, etc.) from building to building or the movement of a source inside the same building.

### 2.11 Approval for use of an RF source or device offsite

Approval from the NIRSC shall be obtained to use GSFC-owned or -operated RF sources or devices at a temporary job site. The user organization is responsible for generating a GSFC 23-6RF, which requires approval by the NIRSC at least 6 months prior to offsite use.

Timely submittal of these documents is recommended as obtaining some approvals can be time-consuming, and additional time may be necessary for correction of procedural discrepancies.

## 3.0 PROGRAM EXEMPTIONS

A variety of commercially available consumer, business, and industrial application RF radiation devices are exempted from the authorization requirements of the GSFC RPP because of their common usage and negligible potential for hazardous exposure under conditions of normal use. However, such exemption is valid only when certain conditions are met. The conditions listed below shall be met for exempted items. Individuals should consult with the GSFC RFSO or the WFF RFSO, if there is a question regarding applicability of program exemption to their particular situation or requirement.

### 3.1 Exempted item categories

The following general categories of radio frequency/microwave radiation devices are exempted:

a. Voice communication devices, which include walkie-talkies, car phones and all cellular phones;
b. Speed monitoring devices (radar guns);
c. Automotive radar detectors;
d. Microwave ovens designed/used for heating/cooking food;

e. RF/microwave radiation devices designed for and operated in a completely enclosed configuration where no open-air transmission is possible, this includes the EMI test chambers located in building 7/10/15 complex;
f. RF radiation devices designed to operate in a hard-lined, closed loop configuration where no open air transmission is possible; and
g. Devices or systems which have been shown by documented (GSFC 23-28RF) worst case analysis that they are incapable of emitting radiation levels greater than 20 percent of current applicable maximum permissible exposures levels.

### 3.2 Basis for exemption of sources

Exemptions are valid for the general categories of equipment, instruments, and systems identified by paragraph 3.1 of this section provided that:

a. The individual item is maintained in its original design configuration and utilized for its originally intended use over the useful life of the item;
b. The design and manufacture of the item is in accordance with the specifications of the federal performance standard for electronic products (Title 21, CFR, Part 1010);
c. The item is operated in accordance with the manufacturer's recommended operating procedures; and
d. Maintenance, service, or repair activities which could expose personnel to accessible levels of radiation equal to or greater than the levels described or implied in IEEE C95.1 shall be performed only by appropriately authorized and qualified personnel.

### 3.3 General precautions for exempted items

#### 3.3.1 Associated hazards

Exemption of radiation devices from the authorization requirements of the GSFC RPP shall not be construed to exempt the user from other safety requirements relating to potential hazards associated with operation of the item, such as, electrical hazards, etc.

#### 3.3.2 ALARA

Notwithstanding the negligible potential non-ionizing radiation hazard characteristically represented by exempted sources, users shall avoid the following by using As Low As Reasonably Achievable (ALARA) principals:

a. Close or prolonged exposure to emissions of devices; and
b. Intra-beam exposure conditions of any duration.

## 4.0 RADIATION PROTECTION CONTROLS FOR RF RADIATION SYSTEMS

### 4.1 General Considerations

a. Radiation protection controls shall be devised to reduce the possibility of exposure of personnel to hazardous levels of RF radiation and to other hazards associated with the operation of RF devices during normal operation and maintenance;
b. For all uses of RF systems, it is recommended the minimum level of RF radiation required for the application be utilized;
c. RF transmitter beam height shall be maintained at a level not to intercept occupied facilities or structures and/or personnel within the identified hazard distance;
d. Engineering control measures (items incorporated into the RF system installation by design) shall be given primary consideration for limiting access to RF radiation; and
e. If engineering controls are impractical or inadequate, administrative and procedural controls and personal protective equipment shall be used to limit access to RF radiation.

### 4.2 Applicability of control measures

a. The purpose of control measures is to limit the possibility of exposure of personnel to hazardous levels of RF radiation and to associated hazards;
b. Whenever the application of any one or more control measures reduces the possible exposure to a level at or below the applicable Maximum Permissible Exposure (MPE) limit, the application of additional controls for the same purpose is not required;
c. Control measures described by this GPR and the applicable GSFC use authorization(s) shall apply at all times when an RF source or device is in its operational and maintenance modes; and
d. If, during periods of service to an RF system, the calculated level of accessible radiation exceeds the applicable MPE, the appropriate control measures shall be instituted on a temporary basis by the custodian/user until servicing is complete.

### 4.3 Substitution of alternate control measures

Engineering control measures described by paragraph 4.1 may, upon review and approval by the GSFC RFSO and NIRSC, be replaced by procedural, administrative, or other alternate engineering controls that provide equivalent protection.

### 4.4 Engineering controls

#### 4.4.1 Service access panels

a. Access panels to high voltage cabinets for RF systems are intended to be opened only by service personnel. These cabinets are designed to limit exposure to the radiation generated from the high-voltages and to prevent direct access to high-voltage components. These panels shall either:
   (1) Be equipped with an interlock; or
   (2) Require a tool for removal and have an appropriate warning label on the panel.
b. If the interlock can be bypassed or defeated, a warning label shall be located on or near the interlock.

#### 4.4.2 Antenna stops

Mechanical, electrical, or software antenna azimuth and elevation stops shall be utilized to inhibit movement of the transmitting antenna beyond established azimuth and elevation guidelines.

### 4.4.3 Antenna activation warning systems

When required by the provisions of the applicable GSFC 23-6RF Use Authorization, a rotating light shall be installed near the antenna site and activated when the RF system is transmitting. A sign explaining the purpose of the rotating light will be posted adjacent to the light. Antennas that have a rotating or movement component should be equipped with a light to warn persons in the area that the antenna will be in motion.

## 4.5 Administrative and procedural controls

Administrative and procedural controls are methods or instructions that specify rules, or work practices, or both, that implement or supplement engineering controls and which may specify the use of personal protective equipment (PPE).

### 4.5.1 Written procedures

Written operating, maintenance, service, and emergency procedures shall be provided and maintained with the RF system for reference by operator, maintenance, and service personnel.

### 4.5.2 Output emission limitations

The RF system custodian shall take such action as is necessary and approved by the RFSO/RSO to reduce levels of accessible power to that which is commensurate with the required application.

### 4.5.3 Education and training

Operators, maintenance, or service personnel should have education and training commensurate with the level of potential hazard. All personnel required to enter or work in controlled environments shall be appropriately trained in safe work practices for controlling or mitigating personal exposures.

### 4.5.4 Authorized personnel

RF systems with accessible emission levels exceeding the appropriate MPE shall be operated, maintained, and serviced by qualified and trained personnel approved by the NIRSC.

### 4.5.5 RF area identification and control

#### 4.5.5.1 Radio Frequency Control Area (RFCA)

a. The area shall be posted with the appropriate warning sign(s) as described by ANSI C95.2;
b. The area shall be operated by and under the control of NIRSC approved operator personnel;

c. Untrained and unauthorized personnel shall be excluded from the RFCA at all points where the appropriate MPE is exceeded;
d. Radiating antennas shall not be positioned in such a manner as to intercept occupied facilities/structures and/or personnel within the identified hazard zone;
e. The RF beam path shall not exceed the established elevation and azimuth restrictions;
f. The RF beam path shall be terminated when possible; and
g. When the RF/microwave system is not being used, it shall be disabled in a manner to prevent unauthorized use.

### 4.5.6 RF warning signs and labels

RF warning signs and labels shall be utilized as described in section 4.8 and the ANSI C95.2, American National Standard Radio Frequency Radiation Hazard Warning Symbol.

#### 4.5.6.1 Inclusion of pertinent information

The inclusion and choice of warning information or precautionary instructions shall follow the guidelines of section 4.8 and the ANSI C95.2, unless otherwise specified by the GSFC 23-6RF use authorization.

#### 4.5.6.2 Display of RF signs and labels

All signs and labels shall be conspicuously displayed in locations where they will best serve to warn unauthorized personnel. The backs of doors cannot be used since the door may be propped open and hide the access warning signs.

### 4.5.7 Suspected overexposure to RF radiation

If it is suspected that someone has been overexposed to RF radiation (greater than the limits specified in ANSI C95.1), the custodian will instruct the individual to be screened by their primary medical provider to document any effects from the exposure. The custodian or operator of the system shall immediately notify the RFSO/RSO of the suspected overexposure and document the conditions leading up to the incident.

## 4.6 Associated hazards

In some RF/microwave applications, other associated hazards may require consideration. Associated hazards shall be evaluated and appropriate control measures taken by the RF user organization. Examples of associated hazards are provided here for consideration by the user organization.
a. High-voltage sources and wiring shall be shielded;
b. High-voltage equipment may produce x-radiation and require shielding;
c. All electrical equipment shall be properly grounded; and
d. Persons working with high-voltage energized equipment shall be trained in cardiopulmonary resuscitation.

### 4.7 Medical surveillance requirements

There currently are no routine medical surveillance requirements for users of extremely low frequency, radiofrequency, and microwave radiation systems. Suspected overexposures shall be immediately referred to the health unit (Greenbelt/WFF site) or local medical provider (off site) for evaluation.

### 4.8 RF categories and warning sign requirements

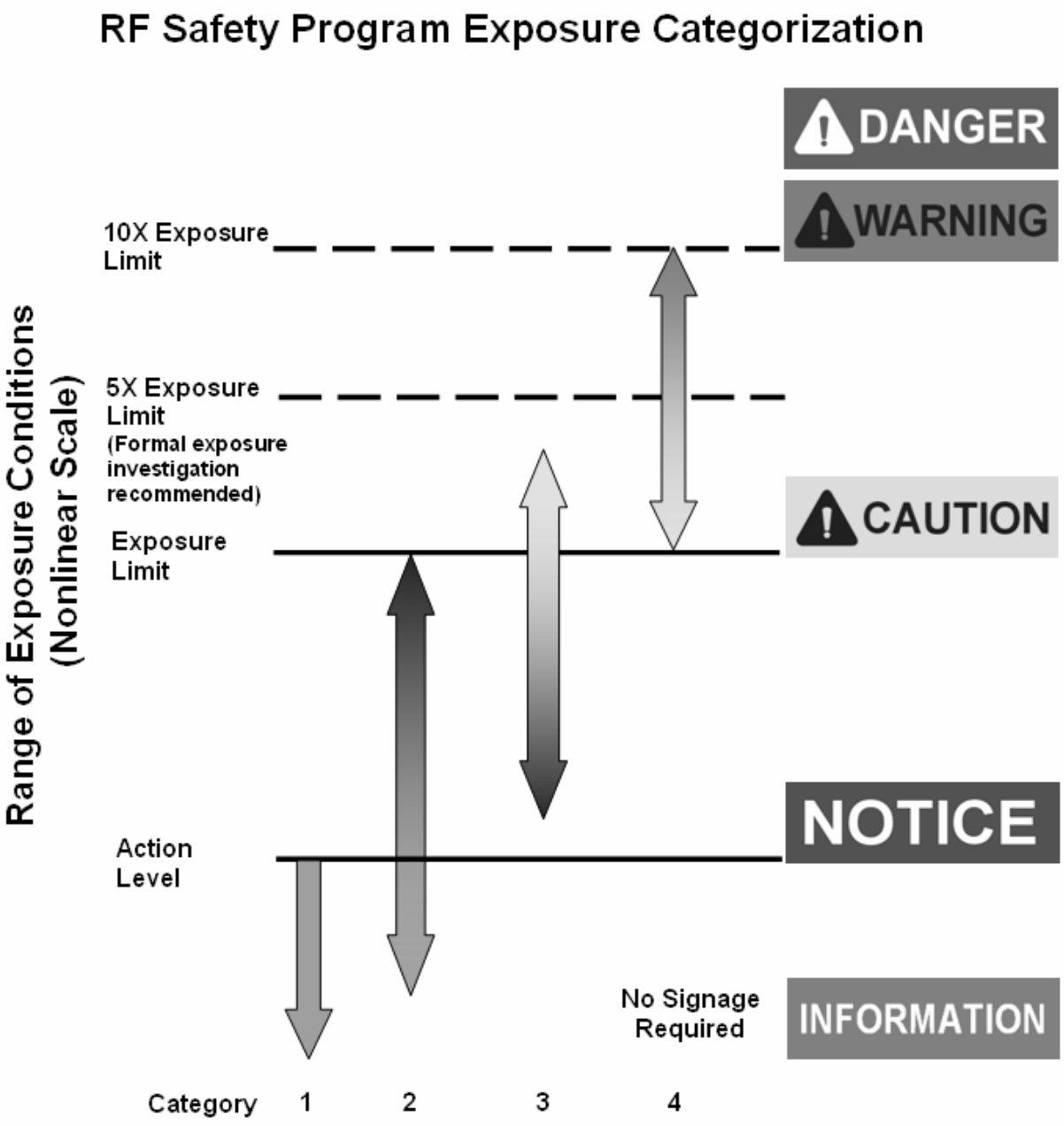


Figure 1—Graphical representation of the categorization corresponding to categories 1–4 listed below

### 4.8.1 Category 1

**INFORMATION** – Operational characteristics of source(s) would not cause the action level to be exceeded. No RF hazard and signage is required but may be displayed for information purposes only.

### 4.8.2 Category 2

**NOTICE** – Operational characteristics of source(s) could cause the action level to be exceeded, but would not cause the MPE limit to be exceeded in accessible areas.

### 4.8.3 Category 3

**CAUTION** – Potential to exceed the MPE limit in accessible areas, if mitigating controls are not applied; MPE established by IEEE C95.1.

### 4.8.4 Category 4

**WARNING –** Five times (5x) the MPE will be exceeded in accessible areas.
**DANGER** – Ten times (10x) the MPE will be exceeded in accessible areas.

Exposure will exceed exposure limit in accessible areas. Restrict RF source or device output to achieve a category 3, 2, or 1 condition, or prevent personnel access.

## Appendix A – Definitions

**A.1 Action Level.** The values of the electric and magnetic field strength, the incident power density, contact and induced current, and contact voltage above which steps should be initiated to avoid exposures that exceed the upper tier of the applicable standards, guidelines and regulations, and in areas that are in close proximity (e.g., < 2 m) to RF conductors that may cause shock and burn hazards on contact

**A.2 Administrative Controls.** Procedures and information provided to personnel for the purpose of reducing exposure to potential RF hazards and that generally depend on the awareness and participation of personnel for their effectiveness. Examples include warning signs and visual/audible alarms, indicative barriers (e.g., rails and chains), standard operating procedures (safe work practices), personal protective equipment (PPE), time limits on the duration of exposure (time averaging), and RF safety training.

**A.3 Approved User.** Any employee or contractor who has been selected by management and approved by the NIRSC to use specific sources and devices that emit RF/EMF radiation for specific purposes and at specific locations.

**A.4 Averaging Time.** The appropriate time period over which exposure is averaged for purposes of determining compliance with a maximum permissible exposure or reference level.

**A.5 Controlled Environments.** An area where the occupancy and activity of those within is subject to control and accountability as established by GSFC's RPP for the purpose of protection from RF exposure hazards. Persons working within the controlled environment would be considered RF radiation workers, which require them to become approved users. To become an approved user they will have to seek approval as is listed under section 2.1.

**A.6 Custodian.** An approved user who has been designated by the appropriate management and approved by the NIRSC to assume the responsibility of accountability for specific sources of RF/EMF radiation. The custodian is not an equipment manager.

**A.7 Engineering Controls.** Controls and performance guidelines to reduce RF exposures as implemented by use of specific types of equipment, such as interlocks, protective housings, man-proof barriers, or the configuration of equipment at a site. Engineering controls do not depend on the awareness of personnel for their effectiveness in reducing exposure.

**A.8 General Public Exposure.** For purposes of this GPR, RF exposure of persons who have not received any form of RF safety awareness information or training. Typically, general public exposure occurs in uncontrolled environments and includes individuals of all ages and varying health status, including children, pregnant women, individuals with impaired thermoregulatory systems, individuals equipped with electronic medical devices, and persons using medications that may result in poor thermoregulatory system performance.

**A.9 Man-proof Barriers.** Locked doors and ladder cages, etc., that are forms of engineering controls and provide a positive restriction on access.

**A.10 Maximum Permissible Exposure (MPE).** Derived limits in RF exposure standards for time-averaged and peak exposures to ambient electric (E) and magnetic (H) fields to which a person may be exposed without harmful effect due to the effects identified in the standard, and with an acceptable safety factor for protection from such effects as described in the standard.

**A.11 Occupational Exposure.** RF exposure of persons induced as a consequence of their employment that have been made fully aware of the potential for exposure and can exercise control over their exposure such as through the use of administrative or engineering controls or safe work practices (e.g., use of personal protective equipment (PPE) or time-averaging of exposures).

**A.12 Overexposure Incident.** An incident in which RF exposure of a person exceeds the exposure limit after spatial averaging and time averaging have been taken into account.

**A.13 Personal Protective Equipment (PPE).** Equipment designed to protect personnel from serious workplace injuries or illnesses resulting from exposure to RF energy, contact with chemical, radiological, and physical agents, and electrical, mechanical and other workplace hazards. For purposes of RF safety, PPE includes electrically insulating gloves and RF-attenuating clothing in the form of coveralls, gloves, socks, and shielding hood assemblies.

**A.14 Radio Frequency Control Area (RFCA).** For purposes of this recommended practice, an area in which RF fields or contact/induced currents or contact voltages may exceed the exposure limit or reference levels of an RF exposure regulation, standard, or guideline.

**A.15 Radio Frequency Safety Officer (RFSO).** One who has authority to monitor and enforce the control of RF hazards and effect the knowledgeable evaluation and control of RF hazards.

**A.16 Radio Frequency Safety Plan (RFSP).** An organized system of policies, procedures and practices designed to protect against hazards associated with RF fields, contact voltage, and contact and induced currents. RFSPs shall be documented in writing and submitted with any GSFC 23-6RF for approval by the NIRSC.

**A.17 Uncontrolled Environment.** Any area other than a controlled environment. The uncontrolled environment includes locations where persons are non-occupationally exposed. These exposures may occur in residential or work locations where there are no expectations that RF exposure levels may exceed the exposure limits.

## Appendix B – Acronyms

| | |
|---|---|
| ACGIH | American Conference of Governmental Industrial Hygienists |
| ALARA | As Low As Reasonably Achievable |
| ANSI | American National Standards Institute |
| EMF | Electromagnetic Field |
| EMI | Electromagnetic Interference |
| GSFC | Goddard Space Flight Center |
| IEEE | Institute of Electrical and Electronics Engineers |
| LSO | Laser Safety Officer |
| MPE | Maximum Permissible Exposure |
| NIRSC | Non-Ionizing Radiation Safety Committee |
| OS&H | Occupational Safety and Health |
| PPE | Personal Protective Equipment |
| RF | Radio Frequency |
| RFCA | Radio Frequency Control Area |
| RFSO | Radio Frequency Safety Officer |
| RPO | Radiation Protection Office |
| RPP | Radiation Protection Program |
| RSO | Radiation Safety Officer |
| SAR | Specific Absorption Rate |
| SEHO | Senior Environmental Health Officer |
| WFF | Wallops Flight Facility |

## CHANGE HISTORY LOG

| Revision | Effective Date | Description of Changes |
|---|---|---|
| Baseline | 02/15/05 | Initial Release |
| A | 04/02/2010 | Administratively Revised to update the Responsible Office Code, Organization Title and organization name within the document.<br>Administratively extended for 1 year from original expiration date. |
| B | 06/17/2011 | Updated to make changes in regulations, aligned title and content to be consistent with other RPO GPRs.<br>Table of Contents was added with each section numbered.<br>Section 1: Established the Non-Ionizing Radiation Safety Committee (NIRSC) and clarified their roles and responsibilities.<br>Section 2: Updated information on the process to get approval for users and uses of RF on GSFC<br>Added Section 4.8: *RF Categories and Warning Sign Requirements* and organized GPR per the most recent GSFC GPR template. |
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