



**DEPARTMENT OF THE AIR FORCE
AIR FORCE RESEARCH LABORATORY
KIRTLAND AIR FORCE BASE NEW MEXICO**

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MEMORANDUM FOR RECORD

FROM: AFRL/RV
3550 Aberdeen Avenue SE
Kirtland AFB, NM 87117-5776

SUBJECT: Assessment of Export Administration Regulations (EAR) to the International Radiation Environment Near Earth (IRENE) software

1. **PURPOSE.** This MFR captures the project officer's assessment of Export Administration Regulations (EAR) as they pertain to AFRL/RV's International Radiation Environment Near Earth (IRENE) software source code, object code, and documentation. As such it documents the good-faith effort of AFRL/RV to comply with applicable export control measures. This document is not a professional legal opinion.

2. **WHAT IS IRENE?** The International Radiation Environment Near Earth (IRENE) software package is a suite of models of the fluxes of radiation belt and plasma particles in near-Earth space. It specifies the geophysical environment in which spacecraft operate and supports a wide variety of applications such as model validation, space weather sensor architecture analysis, human spaceflight, and spacecraft requirements analysis. Outputs include various statistical quantities relating to the flux of electrons and ions trapped in the Earth's geomagnetic field, and will in the future include similar quantities characterizing charged particles associated with solar dynamics.

IRENE also provides facilities for transforming those environmental outputs in the presence of various materials, such as aluminum or silicon, thereby estimating the space environment inside or behind those materials. This permits the computation of approximate radiation dose and notional upset rates to electronics or humans.

3. **WHAT DOES IRENE NOT DO?** IRENE is a product of fundamental research into the climatology of the space environment, gathered over decades of scientific investigation. It is a representation of the geophysical environment, akin to an almanac of temperatures for major cities around the world.

The IRENE capabilities to transport this environment through aluminum or other materials are idealized algorithms deliberately limited to generic geometries such as "slabs" or "half-spheres". The software does not natively support specific shielding geometries or the assessment of specific electronic components. It does not offer guidance for constructing hardware suitable for operation in any particular radiation environment or for protecting humans exposed to that environment. As an environmental specification, it does not contain or expose tradecraft relating to the development, production, operation or maintenance of spacecraft or missile systems.

4. IS IRENE EXPORT CONTROLLED? IRENE is pertinent to materials and technologies intended for use in the near-Earth space environment. The Export Administration Regulations (EAR) at 15 C.F.R. §730 *et seq.*, and specifically the Commerce Control List (CCL) at §738 enumerate technologies and categories of information that are restricted from export. Category 9 (Aerospace and Propulsion), Group D (Software) includes a potentially applicable CCL category (9D515), specifically:

“Software” “specially designed” for the “development,” “production,” operation, installation, maintenance, repair, overhaul, or refurbishing of “spacecraft” and related commodities.

Also relevant are the provisions of the Exclusion List at §734, which identify conditions under which information is not subject to EAR. Part 734.8 specifically excludes information and software that arises during or resulting from fundamental research. Fundamental research is further defined as:

“Research in science, engineering or mathematics, the results of which are ordinarily published and shared broadly within the research community, and for which researchers have not accepted restrictions for proprietary or national security reasons.”

Given the fact that IRENE is a geophysical model of the Earth’s natural trapped radiation belts, which have been the subject of research, observation and modeling since the dawn of the Space Age and are routinely the subject of academic publishing, it is unambiguously fundamental research by the definition at §734.8.

This is consistent with other representations of space environmental phenomena impacting space vehicles and spaceflight, such as solar protons. The standard in this area is the NASA Emission of Solar Protons (ESP) model, publicly available in a technical report at <https://ntrs.nasa.gov/citations/20000021506>

Furthermore, the transport and effects calculations included in IRENE remain fundamental research as long as they are limited to generic or idealized geometries such as spheres and slabs. Such algorithms are found throughout the relevant open literature. The ability to simulate specific geometries (such as an actual electronic enclosure) or specific electronic parts (such as a radiation-hardened processor) would potentially disqualify these algorithms from the fundamental research exclusion. This is not a built-in IRENE capability. Users desiring to undertake such computations in support of spacecraft development would be required to develop and implement those algorithms themselves.

To anchor the latter assessment regarding effects algorithms, we refer to related previous export control decisions by the National Aeronautics and Space Administration (NASA). The following software packages represent similar or more complex effects calculations that NASA makes available to the public after internal review for EAR compliance:

- **ShieldDose:** Software to compute total ionizing dose for spherical and slab geometries. It was originally released by the National Institutes of Standards and Technology (NIST) and was hosted on their website until it moved to NASA for public distribution: https://ccmc.gsfc.nasa.gov/pub/modelweb/radiation_belt/shielddose/

- **EQFLUX:** Software to compute solar cell degradation for realistic solar arrays. Provided publicly by NASA at: <https://opensource.gsfc.nasa.gov/projects/eqflux/index.php>
- **OLTARIS:** The On-Line Tool for the Assessment of Radiation in Space computes radiation dose and energy deposition in tissue or silicon and is provided by NASA at: <https://oltaris.nasa.gov/> Access is restricted from “NASA Designated Countries” (see https://www.nasa.gov/sites/default/files/atoms/files/designated_country_list_8-16-2019_tagged_0.pdf), but not limited to US persons. Unlike IRENE, OLTARIS supports user-defined geometries, described on the NASA website as follows (current 9 Mar 2022):
 - User Defined Geometry*
 - *Upload thickness distribution(s)*
 - *Interpolation-based analysis limited to three user-defined materials/layers*
 - *3D analysis available for up to 5000 user-defined materials/layers*
 - *Slabs and spheres can be defined with any number of materials/layers in any order*
- **HZETRN:** A radiation transport code that transports particle fluxes through any custom geometry (“user-defined combinatorial or ray-trace geometry”) and tabulates transmitted spectrum or resulting energy deposits. It is provided by NASA as “general public release” at <https://software.nasa.gov/software/LAR-18803-1>. HZETRN is a far more advanced and detailed capability than that offered by IRENE.

The broad availability of these software packages from NASA indicates a consistent assessment by that agency that effects calculation tools – even those much more complex and flexible than those offered by IRENE – do not transfer essential knowledge that would trigger an export under Category 9D515 of EAR.

5. CONCLUSION. Based on the above description of IRENE capabilities and limitations, the specific requirements and exclusions of the EAR, and prior export control assessments performed by NIST and NASA regarding software (including source code) with similar and often more advanced capabilities, it may be confidently concluded that the IRENE software package does not meet the standard for export control under Category 9D515 or any other category of the CCL. IRENE is specifically covered by the EAR Exclusion List as a product of fundamental research as defined in §734.8. IRENE binaries and source code may therefore be released without restriction following standard agency security and public affairs clearance processes.

DR. MICHAEL J. STARKS
IRENE Project Lead

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