Toward Uniformity of Terms and Definitions in Radiometric Calibration of Space-borne Sensors

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The problem of uniformity of terms and definitions for ground-based calibrations of space-borne sensors formulated in [1] is critical for international space programs. This is especially true of the U.S. and Russia. Establishing a unique correspondence between Russian and American terms and definitions requires proper organizing of national terminologies. Substantial efforts were taken in both the U.S. and Russia formerly, in the U.S.S.R. during the last 25 years to standardize the science terminology including optics, optical instrumentation, photometry, radiometry, light engineering, and radiation heat exchange. A system of definitions for radiometric calibrations of space-borne sensors should be based upon a well-developed terminology base in the following areas:

1. Basic concepts of geometric, wave and corpuscular optics;
2. Basic concepts of remote sensing technologies;
3. Basic metrology concepts in the area of ground-based calibrations of space-borne sensors;
4. Radiometric quantities, symbols, and units;
5. Optical phenomena;
6. Optical properties of objects and media;
7. Radiometric systems and their components:
    a. Radiation sources;
    b. Spectral instrumentation;
    c. Optical detectors;
    d. Optical components;
    e. Radiometric instruments for remote sensing;
    f. Auxiliary radiometric equipment;
8. Characteristics of radiometric systems and their components:
    a. Characteristics of optical systems;
    b. Characteristics of spectral instrumentation;
    c. Parameters and characteristics of optical detectors;
    d. Parameters and characteristics of radiometric instruments for remote sensing.

Attempts to unify terminology in the areas of optics, photometry and radiometry had been made in Russia at the governmental level. In 1978 a State Standard (GOST) *Physical Optics. Terms, Symbols, and Definitions of Basic Quantities* [2], which contains 87 standard definitions in physical optics, radiometry, photometry, and optical properties of surfaces and media, had been issued. In 1984 an additional GOST *Photometry. Terms and Definitions* [3] had been published with improved and more detailed definitions in radiometry and photometry. An important role

in the unification of Russian language terminology in those areas belongs to the third edition of the *International Lighting Vocabulary* [4] published in the U.S.S.R.

The situation is more complicated with Russian language terms in the area of space-borne sensors and methods and instrumentation for optical remote sensing. To some extent it is related to departmental specifics, security issues and to the fact there were very few unclassified publications in the area. Since 1975 (*Soyuz-Apollo*) and until recently there were practically no joint Russian-American space programs. This did not help in developing a unified Russian and American terminology in optical remote sensing.

In the U.S., in 1963 R. C. Jones proposed a nomenclature for radiometric and photometric quantities [5], which is still being used. in practically its original form. D. B. Judd [6] had introduced a well-ordered nomenclature of optical properties of objects into the scientific community in 1967. In later years, serious attempts to ensure uniformity of terms and definitions in physical optics, photometry and radiometry were taken by NIST [7-15].

Also, efforts in the direction to standardize terminology in optical measurements, illumination technology, optical properties of materials and media had been made previously and are still being made by The American National Standard Institute (ANSI), The American Society for Testing and Materials (ASTM), and The Illuminating Engineering Society of North America (IESNA).

It is the responsibility of ANSI to coordinate and manage voluntary efforts to standardize terminology in the private sector; it represents interests of about 1000 companies, organizations, governmental agencies and international members. ANSI does not develop American National Standards but rather distributes the task among groups of experts (see, *e.g*. [16]).

ASTM standards (see, *e.g*. [17]) are developed by volunteers from more than 100 countries and the team includes manufacturers, users or interested academic or governmental institutions. They are developed and used on a voluntary basis.

An important role in creating a unity of terms and definitions in optical remote sensing and space-borne radiometric instrumentation is played by the Internet thesauruses developed by NASA and its affiliates [18-21].

A good basis for international terminology in optical phenomenology, radiometry and optical measurement technology is *The International Lighting Vocabulary* [22] along with some other publications by the International Lighting Commission (CIE) [23-27]. Unfortunately, the latest edition (4^{th}) of *The International Lighting Vocabulary* had been published 13 years ago, in 1987. Some suggestions had been rejected by the practice (*e.g. spectral radiance* rather than the suggested term *spectral concentration of radiance*), while some other concepts believed to be rarely used in practice proved to be quite customary in science terminology (*e.g.*, *bidirectional reflectance distribution function, BRDF*).

Vega International, Inc. in cooperation with the Space Dynamics Laboratory and under the scientific and methodological coordination of NIST has developed a first version of bilingual

official document *Ground-based Radiometric Calibrations of Space-borne IR Sensors. Terms and Definitions. Part 1. Calibration Techniques* [30] inside the framework of the Russian-American Observational Satellites program (RAMOS) [28].

The main goal of the document [30] was to develop a one-to-one correspondence between terms, which are used by the Russian and American specialists. Having in mind that this is a compilation and analysis work, the authors did not try to introduce any new terms and/or concepts or redefine some existing ones (though it would have been quite useful in some cases). Comparative assessments of definitions from the Russian (Soviet) State Standards and ANSI, ISA, NASA glossaries and thesauruses were given in doubtful cases. Useful information on remote sensing technology was found on the website of The Canadian Center for Remote Sensing [29]. The decisive criterion was the practice of usage and understanding of terms and definitions, first of all, by the U.S. and Russian governmental agencies (NIST, NASA, NOAA) and (VNIIOFI, VNIIM, VNIIFTRI, VNIIMS), respectively.

The document *Ground-based Radiometric Calibrations of Space-borne IR Sensors. Terms and Definitions. Part 1. Calibration Techniques* contains more than 400 definitions of terms from the area of optical remote sensing, radiometry, optical characteristics of bodies, optical detectors, methods and devices for radiometric calibrations. Currently, the document is under review by Russian and American experts. Part II of the document will cover terms and definitions pertaining to uncertainties in radiometric calibrations.

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