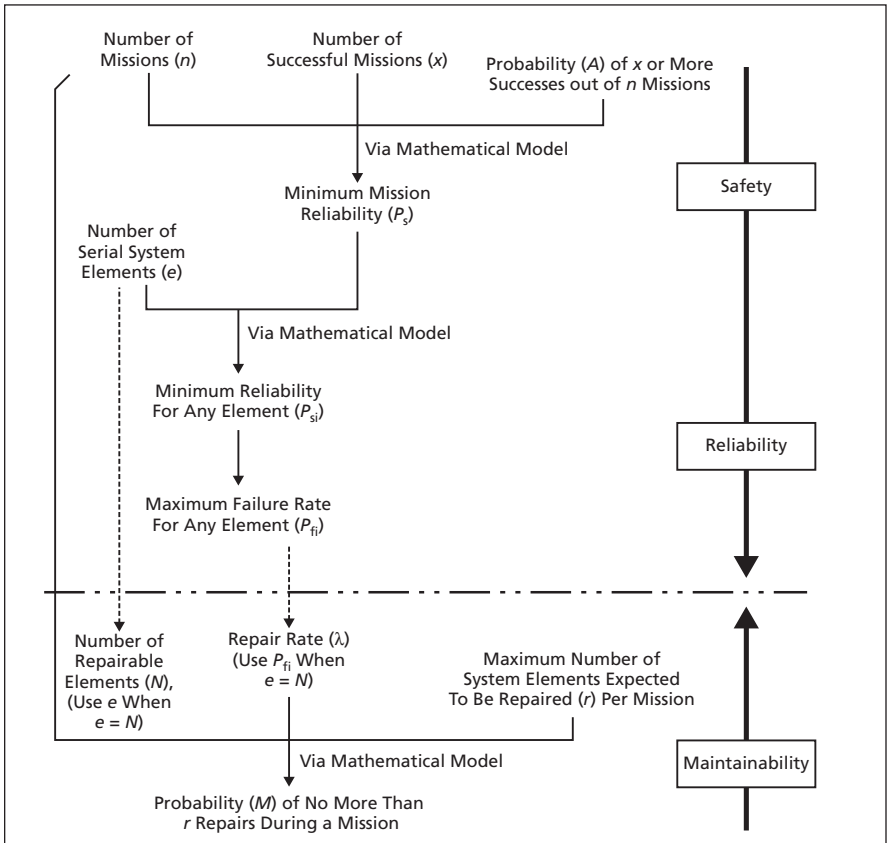
hood of not obtaining x or more successes out of n number of attempts or not obtaining the desired level of safety and reliability over the life of the system's program. When these three inputs are used in the binomial distribution, the minimum mission reliability (P_s) is calculated. At this point of the process, NASA's top-level safety requirement has been established.

The second step uses the minimum mission reliability (P_s) and an estimate of the number of serial line replaceable unit (LRU) elements (e) as inputs into the formula for reliability of a series system to calculate minimum element reliability (P_{si}). Maximum element failure rate (P_{fi}) is equal to $1 - P_{fi}$. Without considering the maintainability burden, which has a very large influence on recurring cost including the system's acquisition (fleet) size, the process at this point has established the safety and reliability requirements for the program.

The last step addresses the maintainability parameter, the parameter that provides a control for recurring costs resulting from maintenance and repair. Similar to assurance or program reliability (A), program maintainability (M) is a probability. The probability M is determined by the Poisson distribution and uses the following inputs: (1) the number of missions (n), (2) the number of elements (N, where $e \leq N$), (3) the LRU failure rate (P_{fi} or λ, where $\lambda \leq P_{fi}$), and (4) the maximum number of LRU repairs (r). Technically, M is the probability of no more than r number of repairs occurring at a particular mission using e number of LRUs with an average failure rate of P_{fi} or λ.

To achieve the desired results in both M and the desired A, adjustments in e, P_{fi}, N, and λ must be made. These values become the enabling requirements to balance and achieve the desired key objectives of the program.



The **Process Described in the Text** can be run from the top down or from the bottom up as represented in this diagram.

This work was done by Timothy Adams and Russel Rhodes of **Kennedy Space Center**. *For further information, contact Timothy Adams at (321) 867-2267.*
KSC-12567

Measuring Two Key Parameters of H3 Color Centers in Diamond

These parameters are needed for the further development of diamond lasers.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of measuring two key parameters of H3 color centers in diamond has been created as part of a continuing effort to develop tunable, continuous-wave, visible lasers that would utilize diamond as the lasing medium. (An H3 color center in a diamond crystal lattice comprises two nitrogen atoms substituted for two carbon atoms bonded to a third carbon atom. H3 color centers can be induced artificially; they also occur naturally. If present in sufficient density, they impart a yellow hue.) The method may also be applicable to the corresponding parameters of other candidate lasing media. One of the parameters is the number density of color centers, which is needed for designing an efficient laser. The other parameter is an optical-absorption cross section, which, as explained below, is needed for determining the number density.

The present method represents an improvement over prior methods in which optical-absorption measurements have been used to determine absorption cross sections or number densities. Heretofore, in order to determine a number density from such measurements, it has been necessary to know the applicable absorption cross section; alternatively, to determine the absorption cross section from such measurements, it has been necessary to know the number density. If, as in this case, both the number density and the absorption cross section are initially unknown, then it is impossible to determine either parameter in the absence of additional information.

In the present method, the needed additional information is extracted from the saturation characteristics of the bulk material: As a laser gain medium (in this case, diamond) absorbs

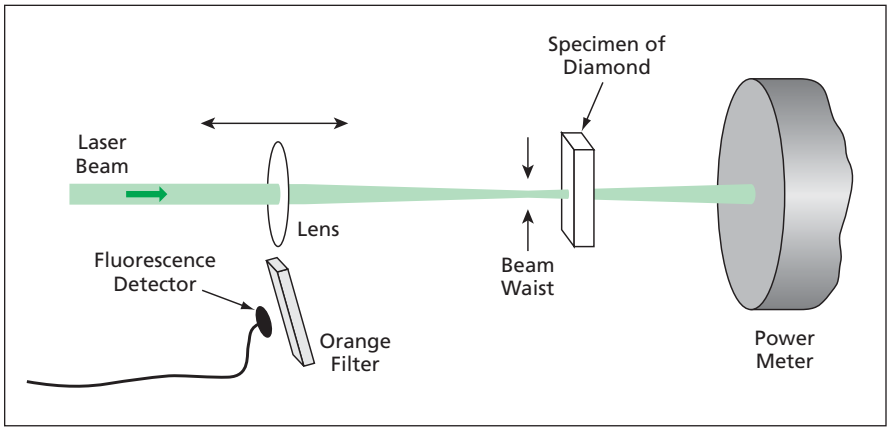


Figure 1. The **Power of a Transmitted Laser Beam** and the level of fluorescence excited by the laser beam are measured at various positions of the beam waist relative to the specimen.

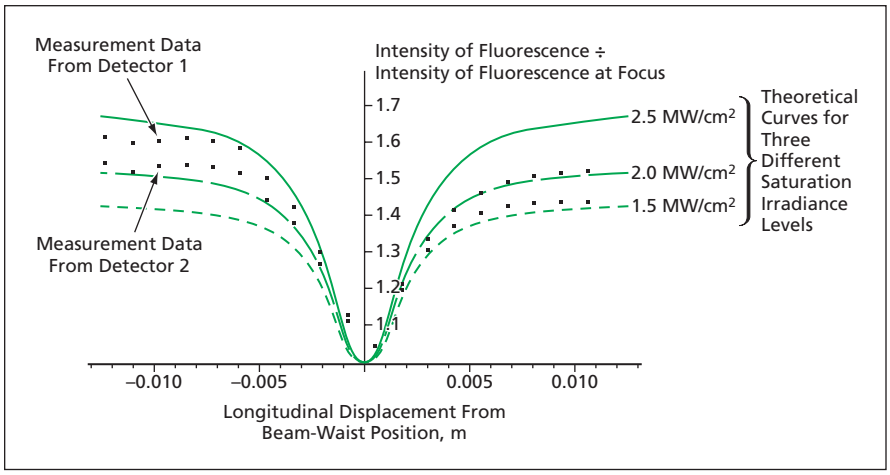


Figure 2. These **Plots of Relative Fluorescence Intensity** versus longitudinal displacement of a diamond specimen from the beam-waist position are typical of the analysis performed in the method described in the text. In this case, the theoretical curve that best fits the readings of two fluorescence detectors represents $I_{sat} \approx 2$ MW/cm^2.

more power from a pump light beam, it begins to absorb a smaller fraction of the incident power. The intensity level at which this saturation effect is observed depends on the atomic-absorption cross section of the material (in this case, the absorption cross section per H3 color center), but not on the number density of color centers. Thus, by measuring the saturation characteristics of the material, the absorption cross section per color center can be determined unambiguously, without knowledge of the number density. Once the absorption cross section is known, the number density of color centers can be determined, in the conventional manner, from measurements of absorption in the bulk material at intensity below the saturation level.

More specifically, the method is based largely on the following principles:

- The absorption cross section (σ) of a single color center can be obtained from a set of measurements of the absorption saturation irradiance (I_{sat}) and the decay time (τ) of the fluorescence excited by the absorption. For this purpose, I_{sat} can be identified as the level of the probe-beam irradiance above which fluorescence decreases and the fraction of incident probe light transmitted through the specimen increases. The absorption cross section can then be calculated by use of the equation

$$\sigma = hc/\lambda_p I_{sat}\tau,$$

where h is Planck's constant, c is the speed of light, and λ_p is the wavelength of the monochromatic light used to probe the specimen.
- Once σ is known, the number density (N) of color centers can be obtained from a measurement of transmission (under a non-saturating condition) of a collimated beam of monochromatic light through a specimen of thickness l, by use of the equation

$$N = [\ln(I_0/I)]/\sigma l$$

where I_0 is the irradiance of the beam incident on the specimen and I is the irradiance of the light emerging from the specimen.

The laboratory apparatus for the saturation measurements (see Figure 1) includes a laser that generates a precisely characterized beam and a mechanism for translating the focus (more precisely, the beam waist) through the specimen. By moving the beam waist through the specimen, one can easily vary the irradiance over a wide range. To obtain the value of σ, the fluorescence and transmission measurement data thus obtained at a succession of beam-waist positions (and, hence, at a succession of known irradiance vales) are plotted and fitted to theoretical curves of transmission and fluorescence as functions of irradiance (see Figure 2).

This work was done by W. Thomas Roberts of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30796