01. IDENTIFYING DATA:

ID: 08-007.03
CL: U
SU: LASER WEAPON SYSTEMS AND TECHNOLOGY
OC: NAVSEA 05T
CA: NAVSEA 05
OD: 10 DEC 74
CD: 09 APR 13
RD: 09 APR 18

02. THREAT/BACKGROUND:

A. The development of U.S. Navy Laser Weapon (LW) systems and technologies is covered by this guide. LWs use lasers of any type or power level as the primary lethality mechanism to deny, degrade, damage or destroy targets or target components. This security classification guidance applies to all DoN components and DoN contractor efforts involving LW technology. This guide provides general instructions regarding the classification of LWs. Guidelines herein represent minimum security classification levels; higher classification levels may be required in accordance with associated host platform/weapons systems' SCGs. Users of this guide shall review all related SCGs for any information pertinent to LW systems consisting of any or all of the following major systems: gain generator, optical control, optical pulse shaping, an optical transport, beam pointing and directing, and auxiliary support.

B. This Security Classification Guide (SCG) is intended to deny information regarding LW capabilities and intentions that would permit foreign intelligence services/military organizations and non-traditional adversaries to modify their military systems and plans in a manner to lessen the effectiveness of U.S. LWs and devalue investment in the acquisition of these systems. Information to be most protected is: effectiveness, countermeasure susceptibility, limitations, and concepts for potential operational deployment and tactics. Of equal importance is the guarding of information that could reduce the time, cost, and risk of developing viable LW systems.

C. Information originally classified by this guide is classified under categories 1.4(a), 1.4(e), and 1.4(g) of Executive Order 13526. These categories are applicable to

Sections 6 through 9 of this document. This guide applies to any system, program, plan or project, regardless of Navy funding element/source, related to LW technology developed in whole or in part with information or knowledge obtained from or developed for the Department of the Navy (DoN). The criteria found in this guide may be expanded for individual programs by other related SCGs referenced to this guide when needed to provide guidelines for protecting technology/information associated with a specific LW program, technology, or efforts pertaining to a particular LW technology development. Classified information shall not be declassified automatically as a result of unauthorized disclosure of identical or similar information.

D. Key definitions that will be used throughout this document:

(1) Breakthrough: A breakthrough occurs when a technological development is imminent or is achieved that constitutes a marked or sudden deviation from a trend or shows unexpected progress in relation to time and is not predictable qualitatively; or when an increase in performance or capability appears to open a field of application to new military system uses.

(2) Significant technical advance: A technological advance demonstrating direct, potential use in an operational or advanced system that results in a measurable military advantage.

(3) Critical technologies (e.g., systems, subsystems, components): Technologies that (1) are generally funded by the Navy, and (2) become breakthroughs, significant technical advances, or states of the art. Technologies developed outside Navy funding can be determined to be critical technologies if their application in a LW system can result in a significant technical advance or breakthrough.

E. Generally, the following information should be reviewed for possible classification:

(1) Quantitative and other detailed information relative to specifications, performance parameters, overall performance capabilities, and details of the developmental status that may reveal critical information.

(2) Quantitative information concerning breakthroughs and significant technical advances.

(3) Quantitative technical information that could provide significant assistance in the development of similar technology, thus reducing the requirement for commensurate expenditure of resources.

(4) Quantitative test results from operational and developmental LW tests, a weapon-like test bed, simulations, technology, or a component, prototype, or subsystems tests.

(5) Data and theoretical analyses regarding damage to and vulnerability or susceptibility of U.S. and foreign weapon systems.

(6) Quantitative and qualitative information concerning the development of countermeasures or counter-countermeasures that reveals the LW system vulnerability or susceptibility, or the judgment of the effectiveness of LW system applications.

(7) Discussions of LW systems and tactics based on war-game results supported by data from static demonstration or representative testing.

F. There may be difficulty in determining when fundamental research advances to a point where it should be classified. Fundamental research information that advances to a point where it should be classified or basic research information that approaches a state indicating possible military application at any point shall be forwarded to the cognizant Original Classification Authority (OCA) for a classification determination.

03. MISSION: To develop the required laser and support technologies for Naval forces (surface, air, and subsurface) so that weapons can be built based on speed-of-light technologies that will provide point and area defense against air, surface and subsurface threats.

04. FINANCIAL:

A. Prior to budget submission: U
B. Subsequent to budget submission to Congress: U

05. MILESTONES: U

06. PERFORMANCE DATA AND TECHNICAL CHARACTERISTICS:

A. General: Information obtained through testing, modeling, simulation, or other research and development activity that provides fundamental knowledge and insight to the development of LW systems:

(1) Fact that Navy is pursuing a LW research or programs to investigate potential use of all types of lasers in a variety of military applications, including weapons and sensors: U

(2) Information on the fundamental physics of laser excitation, kinetics, propagation, and basic materials interactions: U

(3) Qualitative description of potential characteristics of a LW system as could easily be derived by physicists or engineers from well-known physical principles: U

(4) Description of goals or interest areas for a Navy LW program or research, including interests for technology development/demonstration, applications, or military mission utility:

(a) General description: U

(b) Description of capabilities or limitations of current or planned LWs for specific missions that could limit current or future LW effectiveness: S-25X4

(5) Environmental and safety information concerning LW efforts, provided information classified by other topics is not disclosed: U

(6) Descriptions of LW technical characteristics of a breakthrough or a significant technical advance: S-25X4

(7) Functional or engineering specifications of LW systems or sub-systems that reveal details, critical technologies, or approaches which would reduce the investment or time required for another country to develop the same technology or system approach: S-25X4

B. Support Systems: Systems that provide services required for the basic operation of the LW:

(1) Thermal management systems including heat rejection methods and capacities: U

(2) Prime power, wall plug efficiencies, conversion efficiencies: U

(3) Power stability requirements including current and voltage values: U

(4) Mechanical structures providing structural support and vibration isolation or damping: U

C. Gain Generator: System that incorporates the necessary components to create the population inversion, provides feedback for gain, and transports the resulting laser energy to the beam shaping system:

(1) Pumping mechanism to provide the electronic population inversion necessary for lasing: U

(2) Gain medium composition, thermal, and optical properties: U

(3) Manufacturing methods for gain medium, mirrors, or optical elements which only have application in a LW: S-25X4

(4) Resonator/Optical feedback mechanism/design: U

(5) Optical coatings, substrate treatments, and/or optical controls allowing for operation at irradiances above 200 kW/cm^2 when the technology has progressed beyond basic research (TRL ≥ 3): S-25X4

E. Beam Shaping: System that transports the optical power from the gain generator to the beam control system. This system also alters the transverse and longitudinal characteristics of the optical field (including phase) appropriate for the desired LW effects. For LWs that use multiple gain generators, beam combination is considered to occur in the beam shaping system:

(1) Multiple beam combination general concepts, whether coherent, incoherent or spectral: U

(2) Specific methodology or implementation in a LW at the advanced development model maturity level or greater (TRL > 4): S-25X4

(3) Beam conditioning techniques including clipping, alignment, polarization and/or steering: U

(4) Adaptive optics:

(a) Measurement methodology: U

(b) Residual wavefront error:

(1) In systems at the advanced development model maturity or greater (TRL > 4): S-25X4

(2) All others: U

(5) Optical coatings, substrate treatments, and/or optical controls allowing for operation at irradiances above 200 kW/cm^2 when the technology has progressed beyond basic research (TRL ≥ 3): S-25X4

F. Beam Control: Transport the beam to a director that provides pointing stability and control and focuses the beam in the far-field. This system also incorporates the interface to the host fire control system that provides cueing (initial azimuth and elevation) and may host other lasers (e.g. illuminators) or tracking systems (e.g. wide angle view and fine tracker cameras).

(1) Fire control system interfaces and interface methodologies unique to laser weapons: S-25X4

(2) Beam director window materials:

(a) Materials and coatings specific to LW applications in a maritime environment when the technology has progressed to an Applied Research level of maturity or greater: S-25X4

(b) Methods of manufacture or processing when they significantly deviate from those used for commercial applications and are unique to LW applications: S-25X4

(3) Transport optical coatings, substrate treatments, and/or optical controls allowing for operation at irradiances above 200 kW/cm^2 when the technology has progressed beyond basic research (TRL $\geq$ 3): S-25X4

G. Acquisition System: System that receives image data, chooses or receives an aim point, and provides the inputs to the beam director to maintain the high energy laser beam of the LW on the appropriate aim point.

(1) Aim point selection and maintenance algorithms

(a) At the Exploratory Development Model level of maturity and prior (TRL $\leq$ 4), using simple shapes: U

(b) At the Advanced Development Model level of maturity or greater (TRL > 4): S-25X4

(c) When shapes representative of foreign or U.S. assets (targets of interest) are used: S-25X4 or as classified by target SCG, whichever is higher

H. Modeling and Simulation: The use of computers or surrogates to develop data in place of actual testing or test articles.

(1) Fundamentals of laser physics reasonably determinable by physicists or engineers from well known physical principles: U

(2) Laser interactions with materials reasonably determinable by physicists or engineers from well known physical principles that does not reveal information that would be classified elsewhere in this or a related SCG: U

(3) LW subsystem performance in isolation from the rest of the LW system, when performance data would not be classified elsewhere in this SCG: U

(4) Notional LW performance using parameters not related to a particular LW platform: U

(5) LW performance when using parameters related to a particular LW platform, when parameters are not classified elsewhere in this SCG: U

(6) Engagement modeling revealing effectiveness of proposed or actual LW systems based upon an approved concept of operations where threat data or critical employment techniques are revealed: S-25X4

(7) Engagement modeling revealing effectiveness where proposed or actual LW systems can be decoupled from actual threat data or critical employment techniques: U

(8) Engagement modeling based upon notional LW systems not revealing threat data or critical employment techniques: U

I. Testing: Collection of data that provides a measurement of performance at the system or sub-system level. This includes material interaction testing.

(1) System or sub-system level testing of non-critical technology or components: U

(2) System or sub-system level testing of critical technology or components, when specific data is not classified elsewhere in this SCG: U

(3) Raw data, when data reveals or is associated with:

(a) Tactical or future tactical performance capabilities of a LW: S-25X4

(b) Vulnerabilities of U.S. systems or defenses: S-25X4

(4) Reduced data associated with:

(a) Total system jitter of a developmental or operational LW: S-25X4

(b) Power in the bucket delivered to a target when associated with some combination of the following details: specific LW or specific LW configuration, specific atmospheric conditions, adaptive optics techniques and/or aim point maintenance algorithms.

(1) Data that specifies only one detail: U

(2) Data that specifies 2 – 3 details: U

(3) Data that specifies all 4 details: S-25X4

(5) Materials interaction testing not associated with a specific LW:

(a) Parametric, predicted, raw, and reduced data associated with laser effects on materials: U

(b) Parametric, predicted, raw and reduced data associated with laser effects on commercially available systems when those systems are not associated with U.S. systems: U

(c) Data associated with laser susceptibility and vulnerability of foreign systems:

(d) Raw data products: U

(e) Reduced data products: S-25X4 or as classified by target SCG, whichever is higher

(d) All data associated with susceptibility and vulnerability of U.S. systems to lasers: S-25X4 or as classified by target SCG, whichever is higher

(e) Data associated with laser lethality capabilities of U.S. LW systems:

(1) Raw data products when disassociated from test conditions: U

(2) Raw data products when accompanied by test conditions: S-25X4

(3) Reduced data products: S-25X4 or as classified by target SCG, whichever is higher

(6) Laser interaction with materials when obtained from theoretical analysis or basic physical phenomenon: U

07. OPERATIONAL AND TACTICAL:

A. General: Information relevant to the operational employment and use of LWs, laser countermeasures (CM) and counter-countermeasures (CCM). Fundamentally, this section applies to fielded and soon-to-be-fielded systems, materials or information that could affect such LW systems.

B. Specific descriptions of applications or targets of interest if vulnerability, susceptibility, or lethality mechanism is revealed: S-25X4

C. Values for key performance parameters as delineated in an approved capabilities document for a LW system: S-25X4

D. Tactics and LW employment concepts of operations that reveal details of approved tactics, techniques and procedures (TTPs) for:

(1) Surface, air, and subsurface employment: S-25X4

(2) Surveillance: U

E. Countermeasures and Counter-countermeasures (CM/CCM):

(1) Existence of laser hardened materials or CM/CCM: U

(2) Scope of laser hardened materials or CM/CCM program or research in terms of:

(a) Generic range of materials covered, not associated with a U.S. or foreign system: S-25X4

(b) Range of generic systems or components considered: S-25X4

(c) Hardening or survivability goals in terms of energy and/or power level on target when coupled with a dwell time, including pulse shaping techniques: S-25X4

(d) Specific laser hardening materials or CM/CCM related to a specific system: S-25X4

(3) Laser hardened materials or CM/CCM concepts in terms of:

(a) Specific materials or details of concept construction: S-25X4

(b) Manufacturing or materials processing techniques: S-25X4

(c) Specific designs or technical descriptions of integration of hardened materials and concepts into hardened system components: S-25X4

(4) Reduced performance data associated with laser hardened materials or CM/CCM performance under laser irradiation (burn through flux and time, fracture conditions, pulse lengths) when:

(a) Obtained on small test samples for materials screening purposes: S-25X4

(b) Obtained on a LW or HEL with classified power or beam characteristics: S-25X4

(c) Obtained on systems component configurations for purposes of validating the performance of laser hardened materials or concepts when applied to a system beyond the basic research level: S-25X4

(d) Obtained on or applied to specific system components when those components are revealed: S-25X4

(e) Basic physical, mechanical or chemical property reduced data obtained on samples before or after exposures when accompanied by laser irradiation details: S-25X4

(5) Analysis or experimental data on application of laser hardened materials or other CM/CCM when specific military system vulnerabilities are revealed: S-25X4

08. HARDWARE: Information concerning the technical approach, goals, requirements, specifications, design details, and predicted or actual performance which discloses the information given in the sub-topics below relating to: (1) Systems after IOC and their critical components, regardless of power or (2) exploratory development models, engineering development models, and advanced prototypes, including critical state of the art LW subsystem or component technology which closely represents that required for use in a LW system, even if not associated with a specific LW system.

A. Engineering construction, fabrication details or manufacturing processes unique and essential to LW or application efforts defined as critical technologies: S-25X4

B. Physical or visual access to a LW system, its subsystems, or components where such access would not reveal essential details that could result in providing an adversary a timeline advantage. Components include, but are not limited to, elements of the laser electrical power system, gain generation, optical

control, and thermal management when information revealed is not classified elsewhere in this SCG: U

09. COMPUTER RESOURCES:

A. Modeling, Simulation, and Analysis: Computer models and their products, where classified parameters are incorporated into the model: classification determined by the highest classification parameter included in the model product.

B. Breakthroughs of significant technical advances in adaptive optics techniques or other wavefront error control algorithms where eventual application is associated with a LW: S-25X4

C. Software implementation of fire-control algorithms, to include target acquisition, target tracking, aim-point establishment, and aim-point maintenance algorithms, associated with systems:

(1) At the Exploratory Development Model or earlier (TRL ≤ 4): U

(2) At the Advanced Development Model or later (TRL > 4): S-25X4

10. OTHER:

A. Unclassified technical documents that are marked with a controlling distribution statement in accordance with this Security Classification Guide shall also be marked and handled as "For Official Use Only". Classified and unclassified technical documentation generated under this program shall have the following handling caveats affixed on the cover and title page:

(1) WARNING: This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C. Sec. 2751 et seq.) or the Export Administration Act of 1979, as amended, (Title 50, U.S.C., Appendix 2401, et seq.). Violations of these export laws are subject to severe criminal penalties. Disseminate per the provisions of OPNAVINST 5510.161.

(2) Destruction Notice: Classified Information, destroy in accordance with the SECNAV M-5510.36, (DoN Information Security Program) or DoD 5220.22-M, (National Industrial Security Program Operating Manual). Unclassified Limited documents, (e.g., FOUO, distribution statement control) destroy by any methods that will

prevent disclosure of contents or reconstruction of the document.

(3) DISTRIBUTION STATEMENT D: Distribution authorized to the Department of Defense and U.S. DoD contractors only; Administrative/Operational use, April 2013. Other U.S. requests shall be referred to NAVSEA (05) via COMNAVSEASYSCOM (SEA 09P3).

B. Public Release: No publicity releases, Internet or World Wide Web Sites, or public displays of any kind are authorized on this program without the prior expressed written consent of COMNAVSEASYSCOM (SEA 00D) or higher DoD authority. The fact that certain details of information are shown to be unclassified information does not automatically mean it is eligible for public release. All requests for public release shall be processed through appropriate channels for publication approval.

C. This Security Classification Guide is For Official Use Only; therefore, it shall not be released to the public.

D. Foreign Disclosure: Foreign disclosure considerations will be handled on a case-by-case basis in accordance with DoD 5220.22-M (National Industrial Security Program Operating Manual) or SECNAVINST 5510.34A (Disclosure of Classified Military Information and Controlled Unclassified Information to Foreign Governments, International Organizations, and Foreign Representatives). The program sponsor must be advised of any foreign disclosure considerations involving the program.

E. Classified information derivatively generated based upon this SCG shall be marked as follows:

Classified by: Derivative Classifier’s Name, Title, and Code
Derived from: OPNAVINST 5513.8C, SCG ID# 08-007.03
Declassify on: 25X4, specify a date up to 50 years from the date origin of the document.

NOTE 1: New information derivatively classified by this SCG must contain a date or event not to exceed 25 years from the date of the document, data, equipment, or material.

NOTE 2: Information in this SCG over 25 years old is exempted from automatic declassification for a period not to exceed 50 years from the date of origin. When assigning the 25X4 exemption code the derivative classifier must include a date or event. Immediately following the 25X4 marking indicate a declassification date or event up to 50 from the date of the document, data, equipment, or material.

F. Shipping instructions: Shipment of Classified and Sensitive materials shall be conducted in accordance with the applicable transportation security requirements of the following regulations:

(1) DOD 5220.22-M (National Industrial Security Program Operating Manual) describes procedures for preparation and methods of transmission and transportation of classified material inside and outside contractors' facilities.

(2) SECNAV M-5510.36 (Department of the Navy Information Security Program) Chapter 9 describes procedures for preparation and methods of transmission and transportation of classified material.

(3) SECNAVINST 5510.34A (Disclosure of Classified Military Information and Controlled Unclassified Information to Foreign Governments, International Organizations, and Foreign Representatives).

(4) FAR (Federal Acquisition Regulation) Parts 47 and 52 (NOTAL).

G. All questions regarding "need-to-know" which cannot be resolved shall be forwarded to NAVSEA (05), via COMNAVSEASYSCOM (SEA 09P3) for resolution

I. Inquiries concerning security classification assignments outlined herein shall be forwarded to NAVSEA (05) via COMNAVSEASYSCOM (SEA 09P3).

J. Issues concerning ballistic missile defense shall be forwarded to NAVSEA (00G) for guidance.

K. Classification guidance for ultrashort pulse lasers may be found in the Security Classification Guide for Ultrashort Pulse Laser (USPL) Weapon Technology, available from the OCA: Air Force Research Laboratory, 3550 Aberdeen Avenue SE, Kirtland AFB, NM 87117-5776.

L. Information concerning the use, or potential use, of lasers from thermo-nuclear applications, regardless of power or energy output, developed in or associated with the DoD HEL program shall be classified per applicable security classification guidance issued by the Department of Energy (CG-ICF-1 Inertial Confinement Fusion SCG (NOTAL)).

M. Compilation of Information: Compilations of information that are individually unclassified or classified at a lower level may be classified or classified at a higher level if the compiled information reveals an additional association or relationship that qualifies for classification pursuant to; Section 1.4 of EO 13526, is not otherwise revealed by the

individual information, and shall be classified per the applicable section of this guide.

N. Any intelligence data related to this system/program will be classified per the applicable source document(s).

O. Laser weapon systems that are approaching or have reached TRL 6 or greater should consider development of a program/system specific SCG to provide more detailed guidance for protection of critical information than is possible under this SCG.

P. Glossary. For the purpose of this SCG, the following definitions apply:

(1) Adaptive Optics: Active distortion correction of an optical wavefront using deformable mirrors.

(2) Advanced Component Development and Advanced Prototypes: Efforts necessary to evaluate integrated technologies and representative modes or prototype systems in a high-fidelity and realistic operating environment, and system-specific efforts that help expedite technology transition from the laboratory to operational use. The emphasis is on proving component and subsystem maturity prior to integration in major and complex systems and may involve risk-reduction activities. Typically funded with budget activity (BA) 4 funds.

(3) Advanced Development: The development of an item used for experimentation or tests to (a) demonstrate the technical feasibility of a design, (b) determine its ability to meet existing performance requirements, (c) secure engineering data for use in further development and, where appropriate, (d) establish the technical requirements for contract definition. Dependent upon the complexity of the equipment and the technological factors involved, it may be necessary to produce several successive models, to achieve additional objectives. The final advanced development model approaches the required form factor and employs standard parts (or nonstandard parts approved by the agency concerned). Serious consideration is given to military requirements such as reliability, maintainability, human factors, and environmental conditions. Typically funded with budget activity (BA) 3 funds.

(4) Applied Research: Translates promising basic research into solutions for broadly defined military needs and includes studies, investigations, and non-system specific technology efforts. It may also include design, development, and improvement of prototypes and new processes to meet general mission area requirements. Typically funded with budget activity (BA) 2 funds.

(5) Basic Research: Scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs. Typically funded with budget activity (BA) 1 funds.

(6) Beam jitter: The random wander of a particular (e.g. intensity centroid or peak) of the laser beam at the target. Typically measured in milliradians (mrad) or microradians (µrad).

(7) Beam quality: A comparative measure of a laser beam to a diffraction limited beam. Beam quality can be measured or reported as "M^2", "times-diffraction-limited", as a Strehl ratio, or as a "power-in-the-bucket" comparison.

(8) Breakthrough: A breakthrough occurs when a technological development is imminent or is achieved that constitutes a marked or sudden deviation from a trend or shows unexpected progress in relation to time and is not predictable qualitatively; or when an increase in performance or capability appears to open a field of application to new military system uses.

(9) Critical Information: Information, technologies, or systems that, if compromised, would degrade combat effectiveness, shorten the expected combat-effective life of the system, or significantly alter program direction. This includes classified military information or unclassified controlled information about such programs, technologies, or systems.

(10) Critical Technologies (e.g., systems, subsystems, components): Technologies that (i) are generally funded by the Navy, and (ii) become breakthroughs, significant technical advances, or states-of-the-art. Technologies developed outside Navy funding can be determined to be critical technologies if their application in a LW system can result in a significant technical advance or breakthrough.

(11) Engineering Development Model: An item used in tests to determine tactical suitability for military use in real or simulated environments for which the item was designed. It closely approximates an initial production design, has the required form, employs standard parts (or nonstandard parts approved by the agency concerned), and meets the standard military requirements such as reliability, maintainability, human factors, environmental conditions, etc.

(12) Engineering Specification: Record which provides detailed documentation of the construction, wiring, arrangement, and related engineering details of a system.

(13) Exploratory Development Model: An item (preliminary parts or circuits) used for experimentation or tests to investigate or evaluate the feasibility and practicality of a concept, device, circuits, or system in breadboard or rough experimental form, without regard to the eventual overall fit or final form (see Applied Research).

(14) Functional Specification: Documentation that describes the expected behavior of an engineering system, usually describing system needs and the properties of inputs and outputs.

(15) Hardened Materials: Materials that have been purposely or specifically designed or processed to resist or reduce laser damage susceptibility.

(16) Parametric Data: Data collected using a discrete range of physical parameters in which the primary design point is not explicitly stated.

(17) Power in the Bucket: The integrated irradiance (power/cm^2) over an intended aimpoint area.

(18) Predicted Data: Data collected in which a rigorous, often qualitative, statement predicted what would happen under specific conditions.

(19) Raw Data: Uncalibrated data that is not referenced in engineering units.

(20) Reduced Data: Calibrated data referenced in engineering units.

(21) Significant Technical Advance: An advance of sufficient magnitude to have potential use in an operational or advanced system that results in a definite military advantage.

(22) State-of-the-art: The current level of development of a particular concept, technology, device, or system.

(23) Susceptibility: The degree to which a system or component is open to effective attack due to inherent weakness. Susceptibility is the characteristic of a component, subsystem, or system that permits undesired responses, when exposed to a hostile environment. Susceptibility is considered a subset of vulnerability.

(24) Technical Information: Information which relates to research, development, engineering, test, evaluation, production, operation, use, and maintenance of munitions or weapons and other military supplies and equipment.

(25) Technology Readiness Level:

TRL	Description
1: Basic principles observed and reported	Lowest level of technology readiness. Scientific research beings to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
2: Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
3: Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4: Component and/or breadboard validation in a laboratory environment	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.
5: Component and/or breadboard validation in a relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.
6: System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in simulated operation environment.
7: System prototype	Prototype near, or at, planned operational

demonstration in an operational environment	system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.
8: Actual system completed and qualified through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9: Actual system proven through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

(26) Vulnerability: The characteristic of a system that causes it to suffer a definite degradation (loss or reduction of capability to perform its designated mission) as a result of having been subjected to certain (defined) level of effects in an unnatural (man-made), hostile environment. Vulnerability is the characteristic of a system that permits degradation sufficient to compromise the system mission when exposed to its anticipated hostile environment. Vulnerability exists when an environmental level for a system equals or exceeds the corresponding susceptibility level.

(27) Ultrashort Pulse Laser: A system using specific lasers (most specifically ultrashort, nominally less than 1 to 10 picoseconds). USPL systems may be used at low powers or sufficiently high power (multi Terawatt) to produce a conducting path for electrical discharge / electromagnetic energy primarily as a direct means to damage or destroy enemy equipment, facilities, and personnel (From DoD Ultrashort Pulse Laser Weapon Technology SCG).