STANDARD DECENTRALIZED DECONFLICTION AND CAPABILITY VALIDATION PLAN

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SUMMARY OF CHANGES

Initial approval	*Standard Decentralized Deconfliction and Capability Validation Plan* dated 05 SEP 17 and signed by Joint Functional Component Command for Space/J3.

SECTION 1: INTRODUCTION

1.1. Purpose & Scope.

a. This plan defines a standard approach to the decentralized laser deconfliction process. It is applicable for any laser system receiving decentralized deconfliction support from the Laser Clearinghouse (LCH) or Combat Operations Division (COD) Awareness Duty Operator (ADO). Decentralized deconfliction is the process by which a laser system receives the required input data from the Joint Force Space Component Command (JFSCC) and then computes real-time deconfliction solutions for satellites requiring protection. Validation is an approach to ensure that the functionality of the integrated system of hardware, software, procedures, personnel and communications adequately performs laser deconfliction and ensures safe and responsible laser use. Decentralized deconfliction and capability validation plans will be tailored to the extent necessary for each laser in system-specific appendices to this standard plan.

b. This document describes the responsibilities of the LCH, the ADO and the laser owner to work together to validate and provide safe and responsible laser activities as required by Department of Defense (DoD) Instruction (DoDI) 3100.11.[1] This document identifies the systems, processes, interactions, and schedules to be followed so that a validated end-to-end (E2E) deconfliction solution is available to support each decentralized laser program.

c. This Plan is the basis for validation of decentralized laser deconfliction capabilities and U.S. Strategic Command (USSTRATCOM) authorization for use.

1.2. Background.

a. DoD policy requires that all DoD laser activities be conducted in a safe and responsible manner, consistent with national security requirements, in order to manage the associated risks to space systems, their mission effectiveness, and humans in space. DoDI 3100.11 also mandates that all DoD laser activities be coordinated with USSTRATCOM for a risk management assessment. One of the risk mitigation approaches is deconfliction with U.S., friendly, and other space operations. Chairman Joint Chiefs of Staff Instruction (CJCSI) 3225.01 and Strategic Command Instruction (SI) 534-12[2] implement this policy and prescribe procedures for risk management, including deconfliction.

b. Implementation of this mission has been assigned to USSTRATCOM and delegated to JFSCC in accordance with SI 534-12; LCH is a subordinate unit of JFSCC.

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[1] DoD Instruction 3100.11, “Illumination of Objects in Space by Lasers”, 24 October 2016.

[2] Chairman of the Joint Chiefs of Staff Instruction 3225.01, “Illumination of Objects in Space by Lasers,” August 1, 2008; U.S. Strategic Command Instruction 534-12, “Laser Deconfliction Process,” July 25, 2007. NOTE: these documents are being revised to reflect the content of the recent revision to DoDI 3100.11. The roles and responsibilities of JFSCC may evolve as these Instructions are revised.

1.3. Plan Maintenance.

a. This plan will be periodically updated as necessary to reflect new or evolving policies and procedures.

b. Substantive (non-administrative) changes to the plan will be fully coordinated among all affected stakeholder organizations.

SECTION 2: DECONFLICTION RESPONSIBILITIES

2.1. Joint Force Space Component Command.

a. Develop, in coordination with stakeholders, this *Standard Decentralized Deconfliction and Capability Validation Plan*.

b. Provide final approval for laser firing based on decentralized deconfliction capability validation results.

c. Develop and implement means to deliver input data required for decentralized laser systems to operate.

d. Operate the LCH Space Deconfliction System in support of decentralized laser activities.

e. Coordinate with affected agencies to ensure satellite protection methods are implemented.

f. Develop, in coordination with laser owners, laser-specific appendices to this Plan.

g. Approve and co-sign the laser specific appendices to this plan.

h. Review and analyze deconfliction capability validation results.

i. Participate in deconfliction capability validation testing. Provide decentralized laser deconfliction support to laser program testing; to include the generation of decentralized laser deconfliction-related data files.

j. Receive satellite authorization letters and update the Lasing Approval List (LAL).

k. Conduct analysis of unauthorized laser firings identified by the laser operator to determine if unauthorized lasing likely resulted in inadvertent harm to satellites or humans in space. Report unauthorized firings identified by the laser operator to the USSTRATCOM Global Operations Center (GOC)

l. Maximize support to laser programs while mitigating their risk of inadvertently illuminating unauthorized satellites. Should a laser site fire outside of deconfliction measures, collect and track the site's remedial actions to prevent future occurrences and issue reauthorization once corrective actions have been implemented.

2.2. Air Force Space Command.

a. Validate the numerical integrity of the Space Deconfliction System (DECON).

b. Provide to USSTRATCOM/JFSCC, an Operationally Accepted DECON, able to fulfill laser deconfliction related requirements.

c. Participate, as required, in the numerical validation and Independent Verification and Validation (IV&V) of laser program's decentralized laser deconfliction software.

2.3. Laser Owner/Operator.

a. Participate in the development and coordination of the laser-specific appendices to this plan.

b. Approve and co-sign the laser-specific appendices to this plan.

c. Sponsor, to include fund, the IV&V of deconfliction-critical software in the laser system.

d. Participate in decentralized capability validation by providing technical information, test results, and certification statements to the LCH. This validation culminates with the execution of an end-to-end demonstration.

e. Develop and coordinate test plans, procedures, schedules and reports that fulfill requirements for capability validation. Ensure test reports are provided to the LCH in a timely manner per Table D.1.

f. Provide laser schedules to LCH at least 30 days prior to the planned start date of operations. During the initial trial period of operations, provide LCH requested data, as discussed in Section 5.5.c, to conduct post-mission assessments.

g. Provide target satellite identification numbers and satellite permission letters (as required) to the LCH. Satellite permission letters must be on file with the LCH no later than 10 days prior to the applicable laser activity.

h. Ensure laser system operating parameters are consistent with the requirements in this plan. Notify the LCH of any changes to the laser hardware, software, or operational procedures that may affect any active deconfliction validation and authorization.

i. Incorporate required deconfliction capabilities into the laser system requirements, hardware and software requirements, technical design, test plans, operational concepts, and operational procedures.

j. Report to the LCH all lasing outside of authorized parameters (LOAP) events that propagate energy above the horizon or in space, as discussed in Section 5.3.h, Table 3, Task 3.15.

SECTION 3: GENERAL DESCRIPTION OF SYSTEMS AND ORGANIZATIONS

3.1. Laser System Description.

a. Appendices A and B to this plan will contain a description of the laser program, the objectives of the laser firings, laser parameters, deconfliction requirements, details of typical scenarios, and schedules.

b. The Appendices will also include system-specific descriptions of the scenarios used in laser activities, to include scenario goals, geometries, the laser engagement process, and safety procedures.

3.2. Laser Clearinghouse and Awareness Duty Operator Overview.

a. JFSCC is responsible for the laser Deconfliction mission in accordance with DoD Instruction 3100.11 and U.S. Strategic Command Instruction 534-12. Specific LCH responsibilities are further assigned to the JFSCC/J359 division, in which the LCH resides.

b. Air Force Space Command's 614th Air and Space Operations Center (AOC) provides manning, training, and equipment to the Joint Space Operations Center (JSpOC) which provides the LCH satellite data, deconfliction support, and timely notification of space events, such as satellite launches and maneuvers. Upon evaluation of the laser and support needed, the LCH may task the Awareness Duty Operator (ADO) to provide deconfliction-related data to selected laser programs. The ADO is a 24/7 position on the JSpOC operations floor, and resides within the Combat Operations Division of the JSpOC.

c. The LCH performs the following functions:

(1) Reviews all proposed laser illuminations above the horizon or in space.

(2) Provides deconfliction and safe laser operating parameters.

(3) Coordinates with satellite owners/operators and mission partners.

(4) Reports all laser firings conducted outside authorized parameters (when notified).

d. LCH uses the Space Deconfliction System (DECON) to perform analysis for the deconfliction process. This system generates protect lists and required deconfliction data, computes open firing windows, analyzes satellite susceptibility to lasers, and conducts post-mission analysis of laser activity. The ADO also has a DECON to perform the same functions as the LCH system and it is used to perform deconfliction tasks for specified laser systems.

SECTION 4: LASER DECONFLICTION PLANNING PROCESS

4.1. Planning Summary.

The laser deconfliction planning process for ensuring compliance with DoDI 3100.11 and SI 534-12 involves six steps:

Step 1: Registration of the Laser.
Step 2: Evaluation of the Laser's Potential to Harm Satellites (risk assessment).
Step 3: Analysis of Deconfliction Approaches.
Step 4: Planning Implementation of the Deconfliction Approach.
Step 5: Deconfliction Capability Validation.
Step 6: Authorization of the Laser Activity.

4.2. Registration.

The first step is *Registration of the Laser*. The laser owner provides LCH with the technical parameters concerning their laser's fluence or irradiance.

4.3. Evaluation.

The second step is *Evaluation of the Laser's Potential to Harm Satellites (risk assessment).* In this step, the laser is assessed in a laser categorization process that is based on its potential to inadvertently affect satellites. This determines whether deconfliction is required.

4.4. Analysis.

The third step is *Analysis of Deconfliction Approaches*. LCH and the laser owner jointly perform an analysis on the most suitable deconfliction approach: Centralized where JFSCC provides all deconfliction; Decentralized where the laser owner generates all deconfliction with data provided by LCH; and Hybrid where JFSCC provides a portion of the deconfliction and the laser owner generates the remaining deconfliction. This document applies to the decentralized approach.

4.5. Implementation.

The fourth step is *Planning Implementation of the Deconfliction Approach*. Section 5 of this document describes the deconfliction tasks and actions to be accomplished by LCH, the ADO, and the Laser Owner.

4.6. Validation.

The fifth step is *Deconfliction Capability Validation*. Section 8 of this document defines the means by which the deconfliction process will be tested and analyzed.

4.7. Authorization.

The sixth and final step is *Authorization of the Laser Activity*. JFSCC or designee will issue authorization for the laser activity employing decentralized deconfliction.

SECTION 5: PROCEDURES FOR DECENTRALIZED DECONFLICTION

The following sections describe standardized procedures and capabilities for decentralized deconfliction planning, pre-activity tasks, real-time operations, and post-mission activities.

5.1. Deconfliction Planning.

a. The first step in laser deconfliction mission planning is to identify long-term plans for laser deconfliction support. The laser program will establish the schedule for deconfliction support by sending a one-year projection of laser activities to the LCH per Information Exchange Requirement (IER) #1 in Table 5. This Master Test and Operations Schedule (MTOS) will be updated monthly and used by the LCH to plan support for laser activities. At least three (3) days prior to laser operations, the laser owner will provide a Decentralized Request Message (DRM) to LCH indicating the current: laser POC and contact information, approximate start/stop times, general location the laser(s) will operate, and the laser(s) to be used. For real-time deconfliction processing, the laser system will use a Protect List (PL) provided by LCH. The PL contains the satellites (by SCC number) that must be protected from inadvertent illumination by the laser. See IER #3D1 in Table 5.

b. LCH will use DECON to generate and maintain a Unique Laser Susceptibility (ULS) file that contains satellite susceptibility parameters for use by the laser system during real-time decentralized deconfliction processing. The ULS contains data from the satellite susceptibility database provided by the Satellite Assessment Center. See IER #3D6 in Table 5.

c. For satellite targets, LCH will provide a LAL identifying those satellites that are approved targets. The LAL may be Unclassified. The overall LAL may consist of multiple LAL messages, each covering a separate domain. For instance, one LAL message may list all satellites that are approved for intentional illumination by any DoD laser, a second LAL message may contain approved satellites for the laser program's parent organization and the third message may contain approved satellites that are distinctive for the specified laser program.

d. Table 1 summarizes the tasks performed during laser deconfliction mission planning.

Table 1 – Decentralized Deconfliction Mission Planning Tasks.

Task	OPR	Description	Implementation
1.1	Laser Owner/ Operator	Determine dates and times to be requested; identify lasers to be used and scenario.	Laser owner's internal procedures. Submit laser MTOS inputs monthly per IER #1 in Table 5.
1.2	Laser Owner/ Operator	Identify target or laser firing geometry; define target trajectory and uncertainties.	The targets will be identified by satellite identification numbers, stars, planets, or boxes/points in space or other means. Satellite targets must be on the LAL maintained by LCH or the laser owner must provide letters of permission from the satellite owner.
1.3	Laser Owner/ Operator	Provide DRM	The DRM includes data generated in tasks 1.1-1.2 and will be provided via email or posted on a SharePoint Site per IER #2D in Table 5.

Task	OPR	Description	Implementation
1.4	LCH	Maintain decentralized deconfliction data files, including the PL, ULS, LAL, Time Constants, and Sigma Multiplier (SMP) file.	LCH will generate and maintain data files for decentralized deconfliction using DECON and other resources. Deconfliction data files are provided in Task 2.2 per IERs #3D1, #3D2, #3D3, #3D4, #3D5, #3D6, and #3D7 in Table 5.

5.2. Pre-Activity Deconfliction Tasks.

a. The second step is pre-mission deconfliction activities. Satellite state data for each of the satellites on the PL will be obtained by the Laser Operator in accordance with the interface exchange requirements in Table 5 and the Concept of Operations (CONOPS) for Hybrid and Decentralized Laser Deconfliction Data Handling.[3] This satellite state data may consist of General Perturbation Two-Line Element (TLE) sets provided by LCH or obtained directly from an authorized source using the U.S. Strategic Command Orbital Data Request (ODR), Form 1.

b. Alternately, the Laser Operator may wish to use Special Perturbations (SP) state vectors computed through numerical integration techniques, statistical filtering, and associated covariance matrices which quantify the satellite positional uncertainty. Vector Covariance Messages (VCMs) can be obtained from LCH or JSpOC Combat Operations Division. The Sigma Multiplier (SMP) file is used in conjunction with VCMs to compute the most precise positional uncertainties of satellites.

c. A time constants file will be provided by LCH as required. The time constants can be used to refine the laser location relative to satellites by accounting for very small changes in earth orientation. See IER #3D5 in Table 5.

d. LCH will also transmit the ULS and LAL (if needed) in accordance with Table 5.

e. The formats of these messages are defined in the *Space Deconfliction System Interface Control Document* (ICD).[4]

f. Table 2 summarizes the tasks performed during pre-mission deconfliction activities.

[3] JFCC SPACE CONOPS for Hybrid and Decentralized Laser Deconfliction Data Handling, May 18, 2017. Document is classified.

[4] *Space Deconfliction System Interface Control Document for LP 14-2*, DM-05236 Version 01, Lockheed Martin Information Systems and Global Solutions, December 5, 2014.

Table 2 – Pre-mission Deconfliction Activities.

Task	OPR	Description	Implementation
2.1	LCH	Generate current decentralized deconfliction files.	Decentralized deconfliction files include the PL, ULS, LAL, Time Constants, SMP, and satellite state data (TLEs or VCMs) for each satellite on the PL. Updates to the PL are based on current satellite activity such as new launches and satellite decays. Updates to the ULS, LAL, Time Constants, and SMP occur periodically. Satellite state data is updated frequently.
2.2	LCH	Disseminate satellite state data (TLEs or VCMs), PL, ULS, LAL, and time constant files (if needed) to Laser Operator.	See IERs #3D1, #3D2, #3D3, #3D4, #3D5, #3D6, and #3D7 in Table 5. Laser Owner may retrieve TLEs or VCMs directly for each satellite on the PL if they possess sufficient data privilege and access. Distribution will be done in accordance with the Deconfliction Data Handling CONOP.
2.3a	Laser Owner/ Operator	Check satellite state data and PL to verify consistency and ensure data can be propagated.	Perform check of state data for each satellite and request updates as necessary. Data files will be transferred to the laser system by the Laser Operator using approved media and methods.
2.3b	Laser Owner/ Operator	Assess potential laser deconfliction constraints on the mission.	The Laser Operator may use software tools to determine the potential laser deconfliction constraints on the mission execution. If inadequate laser firing opportunities exist, contact the LCH to identify potential alternatives.

5.3. Real-Time Laser Operations.

a. The laser system will conduct all laser firings using the automated decentralized deconfliction processing in real-time. Deconfliction procedures and capabilities are described in Table 3.

b. At the T-1 hour for each day of a laser activity, the laser operator will contact LCH or the ADO and notify them of the laser status and that laser firings are about to begin. This notification also verifies communications between the laser site and LCH or the ADO (see Table 5, IER #4).

c. At the T-0 hour and during laser firings, the laser system will record all information needed for post-firing reports. During the course of the laser firing, if a satellite on the PL maneuvers or if a satellite is launched, the LCH or ADO will notify the laser operator as soon as possible, and the laser firing will be stopped until further analysis is accomplished. LCH or the ADO will provide the laser operator with revised decentralized deconfliction related data, if necessary.

d. Within 15 minutes of completion of laser firings, the laser operator will send a Quick Look Report to the LCH or ADO. See IER #6 in Table 5 for details. In the event of a LOAP, the laser operator will verbally provide a LOAP Notification to the LCH within 15 minutes of the event, and provide a follow-up written report within 12 hours. See IERs #7 and #8 in Table 5. This notification may occur if the laser's irradiance in space exceeds thresholds, or if the laser inadvertently illuminates a susceptible satellite.

e. The laser system will use a validated methodology to determine safe firing directions and times based on the PL and satellite ephemeris. The laser system may also account for satellite susceptibilities in decentralized deconfliction processing. The system will first determine (in real-time) if there is a decentralized open firing window. If a valid window exists, the laser is enabled for firing. If the system finds a satellite conflict, a further check of satellite susceptibility is performed. If the illumination does not pose a hazard to the satellite then firing will be enabled; otherwise it is disabled until the next valid window occurs.

f. The system must determine the laser location (i.e. geodetic coordinates for an Earth-based laser) by obtaining data from a navigation system such as the Global Positioning System. For fixed systems surveyed geodetic coordinates are preferred. Laser system attitude (roll, pitch and yaw) may be required from an inertial navigation system if the laser is not fixed in attitude. The laser pointing must also be obtained. The current time is obtained from a timing source that provides Coordinated Universal Time.

g. When satellite targets are used, the system will verify that each satellite target is included in the LAL for the laser program prior to enabling laser firing.

h. Table 3 contains the detailed description of the decentralized deconfliction capability that will be used during real-time operations.

Table 3 – Real-Time Decentralized Deconfliction.

Task	OPR	Description	Implementation
3.1a	Laser Owner/ Operator	Load required decentralized deconfliction files. Check for errors.	**See Appendix A.** Load decentralized deconfliction data files obtained in Task 2.2 onto electronic media using approved procedures (i.e. LCH mandated or locally mandated). Transfer the data to the laser system data input capability. Verify that all data are present and loaded properly.
3.1b	Laser Owner/ Operator	Display data to operator.	**See Appendix A.** Display data loaded in Task 3.1a on a Graphical User Interface (GUI), if appropriate.
3.1c	Laser Owner/ Operator	Display situational awareness data to operator.	**See Appendix A.** The GUI, if appropriate, will display data on laser pointing and PL satellite location to aid the Laser Operator in verifying satellite safety. Situational awareness visualization is provided by the GUI for person-in-the-loop checks of the engagement.
3.2	Laser Owner/ Operator	Communications check and Laser Status Report.	Verbal status update provided to LCH. See IER #4 in Table 5.
3.3	LCH and Laser Owner/ Operator	Space Event Notification.	When a Space Event occurs, mission operations may be halted until clearance from LCH or ADO is received. The LCH will notify the Laser Operator when updated decentralized deconfliction data files are available. See IER #5 in Table 5.

Task	OPR	Description	Implementation
3.4a	Laser System	Propagate satellite state information to generate satellite ephemeris data.	**See Appendix A.** The satellite state will be propagated in to compute the location of each satellite on the PL at specified points in time (i.e. ephemeris). The astrodynamic standard software provided by Air Force Space Command (SGP4 or SP) may be used.
3.4b	Laser System	Calculate position of all satellites at time of laser firing.	**See Appendix A.** The satellite ephemeris data generated in Task 3.4a will be assessed to determine the satellite position at the time required for Task 3.4d. This includes accounting for satellite position uncertainty and apparent vs. actual satellite position due to atmospheric refraction.
3.4c	Laser System	Verify that satellite target (if used) is approved for illumination.	**See Appendix A.** The LAL messages contain lists of satellite targets that are approved for illumination for the laser program. The System will compare the satellite target number to the LALs and verify that the satellite target (if used) is approved for illumination. Firing is inhibited if the target is not on the LALs. If the target is on at least one of the LALs, then deconfliction processing proceeds.
3.4d	Laser System	Calculate Keep-Out-Cone (KOC) size.	**See Appendix A and Appendix C.** The KOC is specified as a constant non-zero value or is automatically, dynamically calculated. The KOC accounts for uncertainty components from (a) laser system uncertainties and failure modes, (b) satellite location uncertainty computed by an approved algorithm, and (c) atmospheric refraction uncertainty. The handling of uncertainty components will be detailed in a laser system KOC Analysis document.
3.5a	Laser System	Identify potential conflict between KOC and satellite position during the engagement.	**See Appendix A.** Using data from Tasks 3.4c and 3.4d, the laser system will determine if the engagement geometry will violate a KOC (intersect the cone half-angle) given the shut down time and pointing motion of the lasers. The laser must be inhibited prior to posing a hazard to a satellite. The Laser Operator shall receive a notice when the laser deconfliction function inhibits laser firing.
3.5b	Laser System	Enable laser firing using deconfliction assessment.	**See Appendix A.** The laser system will determine if there is a potential conflict with decentralized laser deconfliction processing from Task 3.5a. If all checks are passed, laser firing is enabled. The laser system will continue to monitor these conditions throughout the laser firing.

Task	OPR	Description	Implementation
3.6	Laser System	Inhibit laser firing if potential illumination of susceptible satellite.	**See Appendix A.** The laser system will determine if an impending decentralized deconfliction KOC violation will occur (Task 3.5a). If so, the laser system will access the satellite susceptibility function to determine if the satellite that may be illuminated is susceptible to the impending firing. If it is not, the engagement will be allowed to proceed. If the satellite is susceptible to the firing, the software will immediately inhibit the engagement until the KOC violation is cleared.
3.7	Laser System	Record laser firing data for post-mission analysis.	**See Appendix A.** Data required for Laser Activity Summary Report (LASR) will be recorded by the laser system and maintained for at least one year. See IER #9 in Table 5.
3.8	Laser Owner/ Operator	Monitor system status and engagement parameters during laser firing. Manually inhibit laser firing if required.	The Laser Operator will use situational awareness displays to continuously monitor the engagement geometry and open firing window status throughout the laser firing to ensure that all remain within authorized parameters and the laser firing can be conducted safely. If any source of data indicates the laser firing is no longer being conducted within authorized deconfliction parameters, laser firing will be manually terminated.
3.9	Laser Owner/ Operator	Send Deconfliction Quick Look Report.	Verbal report sent by Laser Operator to the LCH within 15 minutes of completion of the last laser firing. See IER #6 in Table 5.
3.10	Laser Owner/ Operator	Notify LCH of a Laser firing Outside Authorized Parameters (LOAP).	In the event of a LOAP, the Laser Operator must verbally notify the LCH within 15 minutes. See IER #7 in Table 5.

5.4. Space Event Notification.

a. In the timeframe between the laser operator's receipt of the deconfliction related data and the laser firing, a satellite on the PL may maneuver or a new satellite may be launched. Every effort will be made to prevent these events from interfering with the laser firings; however, the LCH retains the authority to delay or cancel an activity if it is deemed necessary to protect satellites.

b. In the case where a new or maneuvered satellite may be affected by a laser firing, the LCH or ADO may direct a halt to the test, and/or generate and forward to the laser operator updated deconfliction data that incorporate the new/maneuvered satellites.

(1) If satellite state data that accounts for the launch or maneuver are available, the LCH or ADO will notify the Laser Operator to cease laser firings. The updated TLE or VCM will be obtained by the Laser Operator per Tasks #2.2a or #2.2b in Table 2 above. When updated state data are available and the propagated ephemeris is loaded into the laser's deconfliction system, operations may resume.

(2) If updated satellite state data are not available, the LCH will notify the Laser Operator to halt laser firings until further notice. If updated state data are not available for an extended time, the LCH may take other measures to ensure satellite safety such as computing open windows with a significantly expanded KOC for the subject of the Space Event.

5.5. Post-Activity Assessments and Reporting.

a. If a laser operator sends notification of a LOAP, the laser operator must submit additional details to the LCH within 12 hours in the LOAP Report. See IER #8 in Table 5 for details.

b. The laser firing data recorded by the system in Task 3.7 above is used in the Laser Activity Summary Report (LASR). The report must be submitted 24 hours after a LOAP Notification (Task 3.10 above). For all laser firings, the laser operator must archive the data for one year in case LCH requests data for post activity analysis. A LASR is only required if a LOAP occurs or it is requested by LCH. See IER #9 in Table 5.

c. During the initial trial period after operations, the laser program will submit LASRs on a regular basis. The frequency of LASR submittal and duration of the trial period will be delineated in the laser program appendix to this Plan and/or the authorization memo.

Table 4 – Post-mission Assessments and Reporting.

Task	OPR	Description	Implementation
4.1	Laser Owner/ Operator	Download post-mission analysis data.	**See Appendix A.** Transfer pertinent recorded data from Task 3.7 to approved media. Data to be retained for one year.
4.2	Laser Owner/ Operator	Send LOAP Report to the LCH. (if required)	Within 12 hours after the LOAP Notification (Task 3.10). See IER #8 in Table 5.
4.3	Laser Owner/ Operator	Compile post-mission analysis data and generate LASR. Send LASR to the LCH.	Performed by analysis tools and post processing. Within 24 hours after the LOAP Notification (Task 3.10) or within 3 days if requested by LCH. Data will be compiled as specified by IER #9 in Table 5.

SECTION 6: COMMUNICATIONS INFRASTRUCTURE

6.1. Infrastructure Details.

a. Communications connectivity will be established between the laser operator and LCH or the ADO. The communications infrastructure will include voice and data transmissions. To perform decentralized deconfliction the laser operator must support both unclassified and classified communications. Required voice communications capabilities include two unclassified voice lines. Required data communications capabilities include two unclassified e-mail addresses and two classified e-mail addresses. The Remarks section of the support request must list current contact information specific to each laser program.

b. **LCH contact information:**

Position: Duty Officer
Address: JFSCC/J359, LCH
747 Nebraska Avenue, Room B209
Vandenberg AFB, CA 93437
Unclassified phone: (805) 606-1282, DSN 276-1282
Secure phone or Fax: Contact LCH
E-mail: laserclearinghouse@us.af.mil
SIPRNet: usaf.vandenberg.afspc.mbx.jspoc-lch@mail.smil.mil

c. **ADO contact information:**

Position: Duty Officer
Address: JFSCC/JSpOC/COD/ADO
Building 8410
Vandenberg AFB, CA 93437
Unclassified phone: (805) 605-6546, DSN 275-6546
E-mail: JSpOCSSAOps@us.af.mil (subject line include Attn: ADO)
SIPRNet: usaf.vandenberg.afspc.mbx.jspoc-ssa-ops@mail.smil.mil
(Subject line include Attn: ADO)

d. **Laser Owner/Operator contact information:**

Provide in the laser-specific Appendix A and Appendix B to this plan.

SECTION 7: INFORMATION EXCHANGE REQUIREMENTS

The IERs in Table 5 have been established to support the deconfliction procedures discussed above. Administrative information exchanges are not included. The *LCH Reports Handbook*[5] defines the voice and text message formats and content. The *Space Deconfliction System Interface Control Document*[6] specifies the format and content of the data messages. IERs may be tailored in the laser-specific Appendix A.

Table 5 – Information Exchange Requirements for Decentralized Deconfliction.

#	Information	Content	Format	Source / Recipient	Media	Timeframe
1	MTOS	Per Handbook Sect 2.3	Text. Unclassified or classified (Note 1)	Laser Owner/ Operator - to - LCH	E-mail	NLT the 15th day of each month
2D	DRM	Per Handbook Sect 2.4	Text. Unclassified or classified (Note 1)	Laser Owner/ Operator - to - LCH	E-mail or SharePoint	NLT 3 days prior to operations or per agreed-upon schedule
3D1	PL	List of satellite numbers. Per ICD Sect 4.2.1.1. (Note 5)	Text. SECRET // NOFORN (Note 5)	LCH - to - Laser Owner/ Operator	Classified file transfer	Distributed daily or per agreed-upon schedule
3D2	Satellite State Data for GP	TLEs for the PL. Per ICD Sect 4.2.1.4.	Text. SECRET // REL TO USA, FVEY (ORCON) (Note 3) (Note 4)	LCH - to - Laser Owner/ Operator	Classified file transfer	Distributed daily or per agreed-upon schedule
3D3	Satellite State Data for SP	VCMs for unclassified satellites on the PL. Per ICD Sect 4.2.1.9.	Text. Unclassified // CUMI (Note 4)	LCH - to - Laser Owner/ Operator	Classified file transfer	Distributed daily or per agreed-upon schedule
3D4	SMP	Sigma multipliers for VCMs (IER #3D3) Per ICD Sect 4.2.2.	Text. Classified same as PL provided under IER #3D1	LCH - to - Laser Owner/ Operator	Classified file transfer	Distributed daily or per agreed-upon schedule

[5] *Laser Clearinghouse Reports Handbook*, Change 6, 16 June 2017.

[6] *Interface Control Document for the USSTRATCOM JFCC SPACE, Space Deconfliction System*, B002-SPACE-DECON-LP 14-2-ICD-02, 5 December 2014.

#	Information	Content	Format	Source / Recipient	Media	Timeframe
3D5	Time constants	Per ICD Sect 4.2.1.6.	Text. Unclassified	LCH - to - Laser Owner/ Operator	Unclassified or classified file transfer. (Note 6)	Distributed daily or per agreed-upon schedule
3D6	ULS	Per ICD Sect 4.2.2.5.	Text. SECRET // NOFORN (Note 2)	LCH - to - Laser Owner/ Operator	Classified file transfer	Distributed daily or per agreed-upon schedule
3D7	LAL	List of satellites approved for illumination for the laser program. Per ICD 4.2.1.1 (Note 5)	Text. Unclassified or classified	LCH - to - Laser Owner/ Operator	Unclassified or classified file transfer. (Note 6)	Distributed when LALs updated by LCH
4	Laser Status Report	Per Handbook Sect 2.5	Voice. Unclassified (Note 1)	Laser Owner/ Operator - to - LCH or ADO	Phone	One hour prior to beginning of firing
5	Space Event Notification	Per Handbook Sect 2.6	Voice. Unclassified (Note 3)	LCH or ADO - to - Laser Owner/ Operator	Phone	As required
6	Quick Look Report	Per Handbook Sect 2.7	Voice. Unclassified (Note 1)	Laser Owner/ Operator - to - LCH or ADO	Phone	Within 15 minutes of completion of laser firings for the day
7	LOAP Notification	Per Handbook Sect 2.8	Voice. Unclassified or classified (Note 1)	Laser Owner/ Operator - to - LCH or ADO	Phone	Within 15 minutes of determining a laser firing outside authorized parameters occurred
8	LOAP Report	Per Handbook Sect 2.9	Text. Unclassified or classified (Note 1)	Laser Owner/ Operator - to - LCH	Fax or e-mail	Within 12 hours after LOAP Notification (IER #7)
9	LASR	Per ICD Sect 4.2.1.3.	Text. Unclassified or classified (Note 1)	Laser Owner/ Operator - to - LCH	Mail, fax or e-mail	Within 24 hours of LOAP Notification (IER #7); also archive data for 1 year and provide within 3 days upon LCH request

#	Information	Content	Format	Source / Recipient	Media	Timeframe
Note 1. Classified in accordance with Laser Program Security Classification Guide (SCG) per Appendix A. Note 2. Classified in accordance with the SCG for Laser Lethality, Countermeasures, and Counter-Countermeasures, AFRL/DE, November 15, 2004. Note 3. Classified in accordance with SCG for Space Surveillance Operations, USSTRATCOM, 1 July 2007. Note 4. Classified in accordance with JFCC SPACE CONOP for Hybrid and Decentralized Laser Deconfliction Data Handling, May 18, 2017. Note 5. PL may be a list of numbers if exported from DECON or contain additional information if generated via the DECON UPL report. Note 6. Unclassified files may be exchanged along with the classified file transfer.						

SECTION 8: PROCEDURES FOR CAPABILITY VALIDATION

8.1. Validation Purpose and Requirements.

a. The purpose of deconfliction capability validation is to ensure the technical parameters of the laser system are well understood, processes and procedures are in place, personnel are trained on equipment and procedures, and communication mechanisms are established.

b. System validation must be documented by the laser owner in test reports or analyses and provided to LCH as inputs to the validation process. Previously documented tests or analyses may be acceptable.

8.2. Software Test Requirements.

a. Laser systems employing decentralized deconfliction must be sufficiently tested to ensure proper operations. The laser owner must certify that these capabilities have been satisfactorily tested per Appendix G.

b. Re-testing or additional analysis is required whenever a relevant configuration item is modified. Relevant configuration items can include, but are not limited to: laser components; computer hardware and software; telescope mounting, tracking mechanisms or approaches, optical components; and other system configuration items where modifications to those items could affect deconfliction performance.

8.3. Operational Procedures.

a. The laser operator must develop written procedures that outline the responsibilities of personnel participating in the laser activity. In addition, the laser operator will certify that all personnel are sufficiently trained on these procedures per Appendix G.

b. An E2E demonstration will be conducted to ensure procedures and communications links between the laser operator and LCH are sufficient to perform all functions (see Appendix F).

8.4. Validation Procedures.

a. The following table lists decentralized laser deconfliction tasks that must be validated. Section 5 of this plan contains a detailed description of each task. The Deconfliction System/Software Test Report will provide test results where indicated. For procedural tasks 1.1 and 2.3b, no capability validation is required.

Table 6 – Laser Deconfliction Task Validation Matrix.

Task	OPR	Description	Validation Approach
1.1	Laser Owner/ Operator	Determine dates and times to be requested; identify lasers to be used and scenario.	*Validation not required.*

Task	OPR	Description	Validation Approach
1.2	Laser Owner/ Operator	Identify target or laser firing geometry; define target trajectory and uncertainties.	System validated by laser program E2E demonstration.
1.3	Laser Owner/ Operator	Provide DRM	System validated by laser program E2E demonstration.
1.4	LCH	Maintain decentralized deconfliction data files, including the PL, ULS, LAL, Time Constants, and Sigma Multiplier (SMP) file.	System validated by laser program E2E demonstration.
2.1	LCH	Generate current decentralized deconfliction files.	System validated by laser program E2E demonstration.
2.2	LCH	Disseminate satellite state data (TLEs or VCMs), PL, ULS, LAL and time constant files (if needed) to Laser Operator.	System validated by laser program E2E demonstration.
2.3a	Laser Owner/ Operator	Check satellite state data and PL to verify consistency and ensure data can be propagated.	**See Appendix B.** System validated by 1) software testing, 2) IV&V, and 3) Laser program E2E demonstration.
2.3b	Laser Owner/ Operator	Assess potential laser deconfliction constraints on the mission.	*Validation not required.*
3.1a	Laser Owner/ Operator	Load required decentralized deconfliction files. Check for errors.	**See Appendix B.** System validated by 1) software testing, 2) IV&V, and 3) Laser program E2E demonstration.
3.1b	Laser Owner/ Operator	Display data to operator.	**See Appendix B.** System validated by 1) software testing, 2) IV&V, and 3) Laser program E2E demonstration.
3.1c	Laser Owner/ Operator	Display situational awareness data to operator.	**See Appendix B.** System validated by 1) software testing, 2) IV&V, and 3) Laser program E2E demonstration.
3.2	Laser Owner/ Operator	Communications check and Laser Status Report.	System validated by laser program E2E demonstration.
3.3	LCH and Laser Owner/ Operator	Space Event Notification.	System validated by laser program E2E demonstration.
3.4a	Laser System	Propagate satellite state information to generate satellite ephemeris data.	**See Appendix B.** System validated by 1) Software testing 2) Numerical Validation 3) IV&V, and 4) Laser program E2E demonstration.
3.4b	Laser System	Calculate position of all satellites at time of laser firing.	**See Appendix B.** System validated by 1) Software testing 2) Numerical Validation 3) IV&V, and 4) Laser program E2E demonstration.

Task	OPR	Description	Validation Approach
3.4c	Laser System	Verify that satellite target (if used) is approved for illumination.	**See Appendix B.** System validated by 1) Software testing 2) Numerical Validation 3) IV&V, and 4) Laser program E2E demonstration.
3.4d	Laser System	Calculate Keep-Out-Cone (KOC) size.	**See Appendix B.** System validated by 1) Software testing 2) Numerical Validation 3) IV&V, and 4) Laser program E2E demonstration.
3.5a	Laser System	Identify potential conflict between KOC and satellite position during the engagement.	**See Appendix B.** System validated by 1) Software testing 2) Numerical Validation 3) IV&V, and 4) Laser program E2E demonstration.
3.5b	Laser System	Enable laser firing using deconfliction assessment.	**See Appendix B.** System validated by 1) Software testing 2) Numerical Validation 3) IV&V, and 4) Laser program E2E demonstration.
3.6	Laser System	Inhibit laser firing if potential illumination of susceptible satellite.	**See Appendix B.** System validated by 1) Software testing 2) Numerical Validation 3) IV&V, and 4) Laser program E2E demonstration.
3.7	Laser System	Record laser firing data for post-mission analysis.	**See Appendix B.** System validated by 1) software testing, 2) IV&V, and 3) Laser program E2E demonstration.
3.8	Laser Operator	Monitor system status and engagement parameters during laser firing. Manually inhibit laser firing if required.	**See Appendix B.** System validated by 1) software testing, 2) IV&V, and 3) Laser program E2E demonstration.
3.9	Laser Owner/ Operator	Send Deconfliction Quick Look Report.	System validated by laser program E2E demonstration.
3.10	Laser Owner/ Operator	Notify LCH of a Laser firing Outside Authorized Parameters (LOAP).	System validated by laser program E2E demonstration.
4.1	Laser Owner/ Operator	Download post-mission analysis data.	System validated by laser program E2E demonstration.
4.2	Laser Owner/ Operator	Send LOAP Report to the LCH. (if required)	System validated by laser program E2E demonstration.
4.3	Laser Program	Compile post-mission analysis data and generate LASR. Send LASR to the LCH.	**See Appendix B.** System validated by 1) software testing, 2) IV&V, and 3) Laser program E2E demonstration.

SECTION 9: DECONFLICTION CAPABILITY VALIDATION CRITERIA

9.1. Criteria.

a. The criteria listed in Table 7 must be satisfied to validate deconfliction capabilities for the laser activity. These criteria may be validated through incremental testing. In the event of system modifications to deconfliction capabilities, the system will be re-tested to ensure these criteria remain valid.

b. Validation tests and analyses must be completed and reports submitted to the LCH per the schedule identified in Table 7. LCH will compile the validation results provided by the laser owner and submit a coordinated recommendation to the JFSCC (or designee) for final authorization of the laser activity. JFSCC will make the authorization decision within 30 days of the successful accomplishment of all validation criteria.

c. Final Authorization for the LCH to provide the Laser Owner/Operator with decentralized deconfliction support in accordance with the deconfliction plan occurs after signature of *Appendix A to the Standard Decentralized Deconfliction Plan,* signature of *Appendix B to Standard Decentralized Deconfliction Capability Validation Plan,* and satisfactory completion of all validation requirements. Final authorization is granted by JFSCC and provided to the laser owner.

d.

9.2. Revalidation.

If required, re-validation may be accomplished through updated analyses, regression tests, updated numerical validation, or targeted capability demonstrations. Re-authorization by JFSCC may be required depending on the scope of the changes as assessed by LCH.

Table 7 – Decentralized Deconfliction Capability Validation Criteria.

#	Validation Criteria	Validation Documentation	OPR	Data Due No Later Than
1	LCH Space Deconfliction System capabilities identified as required in the laser-specific *Appendix A to the Standard Decentralized Deconfliction and Capability Validation Plan* have been satisfactorily tested.	Numerical Validation Report or Operational-Acceptance Memo for most recent version of DECON.	AFSPC	90 days prior to authorization

#	Validation Criteria	Validation Documentation	OPR	Data Due No Later Than
2	Laser decentralized deconfliction capabilities identified in the laser-specific *Appendix A* and *Appendix B to the Standard Decentralized Deconfliction and Capability Validation Plan* have been satisfactorily tested.	Deconfliction System/Software Test Reports. See Appendix B.	Laser Owner/ Operator	Initial draft 120 days prior to authorization need date; final document 90 days prior
3	The numerical integrity of the critical elements of the decentralized deconfliction software has been verified.	Deconfliction Numerical Validation Analysis reports. See Appendix C for details.	Laser Owner/ Operator and LCH	Initial drafts beginning 90 days prior to authorization need date; final documents 60 days prior
4	Verification of laser system parameters (including laser positional uncertainty, laser beam divergence, boresight errors and laser system failure modes) affecting the keep-out cone size for open window computation.	Laser System Keep Out Cone (KOC) Analysis Document. See Appendix C.	Laser Owner/ Operator	Initial draft 90 days prior to authorization need date; final document 60 days prior
5	Deconfliction procedures have been developed, documented, and verified; and trained personnel are available.	Statement of Certification of Deconfliction Capabilities due prior to the E2E demonstration. See Appendix G for sample.	Laser Owner/ Operator	1 week prior to E2E
6	DoD 3100.11 Compliance Statement whether the laser activity requires SECDEF approval.	Statement of Compliance with DoDI 3100.11. Due prior to the E2E demonstration if a DoD program. See Appendix H for sample.	Laser Owner/ Operator	1 week prior to E2E
7	Interfaces, interoperability and procedures between the LCH and the laser operator including information exchange requirements have been verified.	Report of a laser-specific and DECON Interoperability Demonstration accomplished at least 30 days prior to the E2E demonstration. Report of E2E Decentralized Deconfliction Demonstration. See Appendix F for details.	LCH and Laser Owner/ Operator	Interoperability 60 days prior; E2E 30 days prior to authorization
8	IV&V of decentralized deconfliction-critical software.	IV&V Report. See Appendix D for details.	IV&V Agent sponsored by Laser Owner/ Operator	Initial drafts beginning 60 days prior to authorization need date, final document 30 days prior
9	Completed Operational Trial Period of the decentralized deconfliction capability.	Report documentating operational useability of decentralized satellite deconfliction.	Laser Owner/ Operator	90 days after operations begin

ACRONYMS AND GLOSSARY

Term	Definition
ADO	Awareness Duty Operator
AFRL	Air Force Research Laboratory
AFSPC	Air Force Space Command
CJCSI	Chairman Joint Chiefs of Staff Instruction
COD	Combat Operations Division
CONOPS	Concept of Operations
DECON	Space Deconfliction System (software program)
Deconfliction	A procedure that governs the firing of a laser that may intentionally or inadvertently illuminate satellites. The procedure may be conducted using a centralized, decentralized, or other approved method. *Previously known as predictive avoidance*
DoD	Department of Defense
DoDI	Department of Defense Instruction
DoD Laser Activity	Laser activities receiving resources, manpower, or funding from a DoD department or agency for Research, Development, Test and Evaluation purposes, or for operational employment purposes after integration into DoD weapon systems.
DRM	Decentralized Request Message
E2E	End to End
GOC	Global Operations Center
GUI	Graphical User Interface
ICD	Interface Control Document
IV&V	Independent Verification and Validation
IER	Information Exchange Requirement
Illumination	A laser light incident on the surface of an intentional or unintentional target.
JFCC SPACE	Joint Functional Component Command for Space
JFSCC	Joint Force Space Component Command, previously named JFCC SPACE
JSpOC	Joint Space Operations Center
LAL	Lasing Approval List
LASR	Laser Activity Summary Report
LCH	Laser Clearinghouse
LOAP	Laser firing Outside Authorized Parameters
MTOS	Master Test and Operations Schedule
ODR	Orbital Data Request
Open Windows	Times within which it is safe for the laser to fire its lasers since no conflict exists with satellites on the Protect List
OPR	Office of Primary Responsibility
PL	Protect List
SI	Strategic Command Instruction
SIPRNet	Secret Internet Protocol Router Network
SMP	Sigma Multiplier, a data file
SP	Special Perturbations
TLE	Two-Line Element
ULS	Unique Laser Susceptibility
USSTRATCOM	U.S. Strategic Command
VCM	Vector Covariance Message

REFERENCES

[1] DoD Instruction 3100.11, *Management of Laser Illumination of Objects in Space*, October 24, 2016.
[2] Chairman of the Joint Chiefs of Staff Instruction 3225.01, *Illumination of Objects in Space by Lasers*, August 1, 2008.
[3] U.S. Strategic Command Strategic Instruction 534-12, *Laser Deconfliction Process*, July 24, 2007.
[4] DoD Directive 3100.10 Change 1, *Space Policy*, November 4, 2016.
[5] *Space Deconfliction System Interface Control Document for LP 14-2*, Lockheed Martin Information Systems and Global Solutions, December 5, 2014.
[6] *Laser Clearinghouse Reports Handbook*, prepared by JFCC SPACE, Change 6, June 16, 2017.
[7] *Security Classification Guide for Laser Lethality, Countermeasures, and Counter-Countermeasures*, AFRL/DE, November 15, 2004.
[8] *Security Classification Guide for Space Surveillance Operations*, U.S. Strategic Command, July 1, 2007.
[9] *JFCC SPACE CONOPS for Hybrid and Decentralized Laser Deconfliction Data Handling*, May 18, 2017.

APPENDIX A – LASER SPECIFIC DECONFLICTION INFORMATION

A.1. Appendix A is a laser-specific document that mirrors the content of this *Standard Decentralized Deconfliction and Capability Validation Plan* but with laser-specific information focused on Sections 1-7. The Appendix provides a description of the laser program and system, typical scenarios for laser activities, details of the laser safety system, unclassified laser parameters, deconfliction procedures, any unique requirements not addressed in this Standard Plan, a schedule of laser activities, and points of contact. Appendix A will be signed by the JFSCC/J35 and the laser owner responsible official (i.e. O-5, GS-14, Test Director, Chief Scientist, etc.).

APPENDIX B – LASER SPECIFIC CAPABILITY VALIDATION INFORMATION

B.1. Appendix B is a laser-specific document that mirrors the content of this *Standard Decentralized Deconfliction and Capability Validation Plan* but with laser-specific information focused on Sections 8-9. It includes a description of the laser program and system, with detailed laser-specific validation processes, criteria and schedules. Appendix B will be signed by the JFSCC/J35 and the laser owner responsible official (e.g. O-5, GS-14, Test Director, Chief Scientist, Program Manager, etc.).

APPENDIX C – LASER SPECIFIC KEEP-OUT CONE INFORMATION

C.1. Appendix C documents laser-specific analysis of possible pointing uncertainties and failure modes for laser firings. The assessment addresses the worst-case uncertainties in laser pointing that must be accounted for in the deconfliction Keep-Out Cone (KOC). Appendix C will be signed by the laser owner responsible official (e.g. O-5, GS-14, Test Director, Chief Scientist, Program Manager, etc.).

C.2. KOC Analysis will address, as a minimum, the following:

a. Short summary of the system description and deconfliction process as documented in Appendix A.

b. Laser pointing uncertainties under normal operations. These typically include laser beam divergence, position errors, timing errors, platform jitter, internal alignment accuracy, accuracy of laser pointing relative to inertial space, search pattern, and beam refraction.

c. Laser shut-down time. The laser shuttering process and maximum slew rates should be described, with analysis showing the maximum pointing error that may accrue.

d. Laser system failure modes. These typically include hardware, beam control, software and structural failures, with analysis showing the maximum pointing error that may accrue.

e. Summary of the uncertainties and total recommended KOC.

C.3. A *Keep-Out Cone Analysis* document template and *KOC Estimation* spreadsheet tool are available from the LCH.

APPENDIX D – NUMERICAL VALIDATION

D.1.Background.

a. Seven laser system algorithms have significant roles in the decentralized deconfliction process and require numerical validation. These include: propagation of the satellite state data to produce an ephemeris, computation of satellite uncertainty and converting it to an angular uncertainty from a specific location, computing the atmospheric refraction correction and associated uncertainties, calculating dynamic and static keep-out cone (KOC) values, geometric closure calculation including accounting for laser motion if required, real-time susceptibility, and the integration of all the software modules into a functioning system.

b. Numerical validation is the substantiation through analysis and review that algorithms, software code, and supporting databases are accurate, complete, and should meet requirements when the system is tested. Table C.1. below defines the numerical validation criterion for each algorithm.

c. Prior to entering numerical validation the laser owner must publish an Algorithm Description Document (ADD), system/subsystem Test Reports, and provide for configuration control of the software modules under consideration. The ADD should describe the seven key laser system algorithms. Test Reports should document the developmental testing performed that indicates the software modules are mature and ready for numerical validation. Configuration control is necessary to ensure the modules that have been numerically validated are the ones deployed for laser operations.

d. Numerical validation will be performed by the LCH or a "designated NumVal Agent." If used, the Agent will be approved by the Laser Clearinghouse but funded by the laser program. LCH or the designated representative will perform the analysis and write the numerical validation report.

D.2. Selection of Space Objects.

a. Selecting a representative set of space objects to be used in the numerical validation process is important to the integrity of V&V. Space objects are described by Two-Line Element (TLE) or Vector Covariance states. Space objects may be generally classified in five orbital categories; geostationary earth orbit (GEO), medium earth orbit (MEO), low earth orbit (LEO), highly elliptical orbit (HEO), and "other" (OTH) for objects not fitting within the other four categories. These are defined as follows:[7]

- GEO: 0.99 <= Mean Motion (rev/day) <= 1.01, and eccentricity < 0.01
- MEO: 600 <= Period (minutes) <= 800, and eccentricity < 0.25
- LEO: Mean Motion (rev/day) > 11.25, and eccentricity < 0.25
- HEO: eccentricity > 0.25
- OTH: does not fit any of the above

[7] See https://www.space-track.org/, under "Bulk Catalog Data Downloads"

b. AFSPC Astrodynamic Standard algorithms further delineate orbital states such that six possible conditions may need to be considered when assessing satellite uncertainty with TLEs. Additional states may need consideration to ensure a fully representative subset of space objects. These additional states may include satellites whose Brouwer and Kozai Mean Motions differ significantly, objects nearing or at reentry, objects at the extremes of eccentricity, retrograde satellites, and objects with unusual inclinations.

c. TLEs (and/or VCMs if necessary) will be selected from the Full Catalog with 30 objects that represent each of the five categories, for a total of 150 objects. The "OTH" category will be used to fill out coverage of the six satellite uncertainty conditions and additional special states that may need consideration. Within each category the full range of states will be emphasized, e.g. GEO satellites will be selected all around the globe vs. just over the U.S. and Europe.

D.3. Selection of Test Cases.

a. Six test locations will be used to ensure the deconfliction software is assessed globally, to include nominally a site in the U.S., Europe, the Middle East, South America, the South Pacific, and Africa. This list will be tailored or expanded to account for unique laser characteristics, e.g. handling of the real-time horizon, laser look ahead, a shipborne installation should be tested as it crosses the Equator, an airborne system may need testing at very high latitudes, etc. The number of test locations may be tailored down for a fixed system only used in one location.

b. Test cases will be crafted to cover the full range of laser system CONOPS, to include different lasers and laser combinations, source configurations, types of targets, and operating environments. These include, for example:

- Platform: Fixed site, mobile but stationary, mobile moving, shipborne, airborne
- Target: Fixed pointing, satellite, ship, boat, UAV, artillery
- Source: Single laser, multiple lasers, multiple simultaneous lasers
- Environment: Desert, mountaintop, littoral, island mountaintop

c. Ideally the test cases would cover a full permutation of all the variable combinations, however this is not possible except in the simplest situations. Therefore, a realistic number of test cases will be crafted that cover the full range of operational configurations and combine the most stressing cases, e.g. a fast moving platform against a fast moving target. These test cases will then be distributed amongst the selected test locations for execution of the numerical validation.

D.4. Numerical Validations.

a. LCH Space Deconfliction System Software (DECON). This software is validated by AFSPC for each software release. DECON is the standard by which deconfliction systems are evaluated and as such its numerical validation documentation provides the starting point in the "chain of evidence."

b. Propagator. The Satellite Propagation model is a component of the real-time predictive avoidance software. The two most common models are Satellite General Perturbation (SGP4) and Special Perturbation (SP) vector processing. The SGP4 satellite propagation software

predicts the satellite location in the future based on General Perturbation Two-line Element (TLE) sets. The SP satellite propagation model predicts satellite location using Vector Covariance Messages (VCMs). The satellite locations are used by the decentralized deconfliction system to determine when laser firing must be inhibited and where targeted satellites are located. The SGP4 and SP software are astrodynamic standard modules provided by Air Force Space Command.

To conduct the numerical validation, the satellite propagation results of the laser system will be compared with the outputs of the astrodynamic standard. LCH or a designated representative will provide a numerical validation procedure and the sample satellite TLE or VCM data. The laser program will provide their propagation results. Success critera: 1m.

c. Satellite Uncertainty. When TLEs are used, the satellite location uncertainty can be computed from a validated algorithm provided by Air Force Space Command. When VCMs are used, the satellite location uncertainty is available from the SP propagator as radial, in-track, and cross-track components. To conduct the numerical validation, the satellite location uncertainty element of the KOC size computation by the laser software will be compared with the computation from the Air Force Space command algorithm. LCH or a designated representative will provide a numerical validation procedure and the sample satellite TLE or VCM data. The laser program will provide their satellite uncertainty results. Success criteria: 0.005°.

d. Real-time Refraction. If the refraction component to the KOC is computed dynamically by the laser system, numerical validation of the refraction algorithm will be discussed in Appedix B to this plan. LCH or a designated representative will provide a numerical validation procedure and the scenarios. The laser program will provide their refraction correction computation results.

e. Keep-out Cone. The KOC model computes the size of the KOC for each satellite processed by the laser system. The laser system contribution to the KOC size includes a fixed value established prior to the mission based on the KOC Analysis document. In addition, the KOC size may include dynamic components such as satellite uncertainty, velocity-dependent slew rate contributions, and adjustments for atmospheric refraction. LCH or a designated representative will provide a numerical validation procedure and the scenarios. The laser program will provide the total and constituent parts of the KOC computation results. Success criteria: 0.005°

f. Closure Calculator. The laser system’s Decentralized Closure Calculator is a software module that is comparable to the Air Force Space Command astrodynamics standard Field of View module and the DECON system. It determines real-time when a satellite on the Decentralized Protect List is within the laser Field of View as defined by the laser pointing direction plus the KOC size.

To conduct the numerical validation, satellite conflicts (i.e. closed time windows) from the laser system Closure Calculator will be compared with the outputs of the astrodynamics standard Field of View module and/or DECON system. LCH or a designated representative will provide a numerical validation procedure and the scenarios. Scenarios will include testing of handling the real-time horizon and laser look-ahead if used. The laser program will compile sample satellite

ephemeris data, laser platform location data, and laser pointing data. The laser program will provide the predicted times when laser firing is inhibited. Success criteria: 0.02sec.

g. Real Time Susceptibility. Real-Time Susceptibility software provides the capability to determine satellite susceptibility during real-time deconfliction processing. The capability includes the methodology, algorithms, software, and database.

To conduct the numerical validation, the results of the Real-Time Susceptibility computations for satellite conflicts (i.e. laser firing inhibited) will be compared with the outputs of the Real-Time Susceptibility software. LCH or a designated representative will provide a numerical validation procedure and the scenarios. The laser program will compile sample satellite ephemeris data, laser platform location data, and laser pointing data. The laser program will provide time-tagged Real-Time Susceptibility computations of irradiance, fluence, and laser firing inhibits.

h. Integrated System. When all the laser deconfliction software modules have been developed, numerically validated, and integrated, a Laser System Integrated Deconfliction Numerical Validation will be performed.

To conduct this numerical validation, satellite conflicts (i.e. laser firing inhibited) from the laser deconfliction integrated system will be compared with the outputs from DECON or tools that provide comparable results. LCH or a designated representative will provide a numerical validation procedure, a sample Decentralized Protect List, the sample satellite ephemeris data, a sample ULS, and the scenarios. The laser program will generate sample laser platform location data and laser pointing data. The laser program will provide time-tagged laser firing inhibits that result, both with and without use of Real-Time Susceptibility.

D.5. Risk Management.

a. In the event a numerical validation does not satisfy the success criteria, the LCH will work with the laser program to correct the decentralized deconfliction software and bring it in compliance.

b. If the software cannot be brought into compliance within reasonable cost and schedule constraints, the LCH will apply the Operational Risk Management (ORM) model. This may include various risk mitigation approaches or acceptance of certain risk factors. The course of action requires approval by the JFSCC.

Table D.1 – Numerical Validation Criteria.

#	Criteria	Method	OPR	Completion Date
1	Validate the numerical integrity of LCH Space Deconfliction System software.	Comparison of test cases accomplished in Space Deconfliciton System software to previously validated astrodynamics standards software as documented in Operational Acceptance Review Panel results.	AFSPC	90 days prior to authorization need date for latest version of Space Deconfliction System

#	Criteria	Method	OPR	Completion Date
2	Validate the numerical integrity and precision of the decentralized deconfliction satellite ephemeris propagator.	Determine by analysis the precision of satellite propagation by comparing the laser's decentralized deconfliction satellite propagation results versus the Air Force Space Command astrodynamic standards. Validation to include top level review and assessment of a methodology document provided by the laser program.	Laser program and LCH or a NumVal Agent	Initial drafts beginning 120 days prior to authorization need date; final documents 90 days prior
3	Validate the numerical integrity and precision of the decentralized deconfliction satellite uncertainty KOC.	Determine by analysis the accuracy of the KOC size for each satellite by comparing the laser's decentralized deconfliction KOC size results versus the Air Force Space Command astrodynamic standard algorithms or other models giving independent estimates. Validation to include top level review and assessment of a methodology document provided by the laser program.	Laser program and LCH or a NumVal Agent	Initial drafts beginning 120 days prior to authorization need date; final documents 90 days prior
4	Validate the numerical integrity, precision and implementation of the real-time refraction calculation and contribution to the KOC.	Determine by analysis the accuracy of the refraction correction computation and uncertainty computation by comparing the laser's decentralized deconfliction refraction results versus the LCH-approved refraction model. Validation to include top level review and assessment of a methodology document provided by the laser program.	Laser program and LCH or a NumVal Agent	Initial drafts beginning 120 days prior to authorization need date; final documents 90 days prior
5	Validate the overall KOC size computations used by the laser system for real-time laser deconfliction computations.	Determine by analysis the accuracy of the overall KOC size by comparing the laser's decentralized deconfliction KOC size results versus the constituent components from Air Force Space Command astrodynamic standard algorithms, the KOC document, the LCH-approved refraction model, or other models giving independent estimates. Validation to include top level review and assessment of a methodology document provided by the laser program.	Laser program and LCH or a NumVal Agent	Initial drafts beginning 90 days prior to authorization need date; final documents 60 days prior
6	Validate the numerical integrity and precision of the decentralized deconfliction Closure Calculator software.	Verification of the Closure Calculator by comparison of laser firing inhibits computed by the laser's decentralized deconflicton as compared to predicted closures from the Air Force Space Command astrodynamic standard Field of View algorithms or the LCH DECON system. Validation to include top level review and assessment of a methodology document provided by the laser program.	Laser program and LCH or a NumVal Agent	Initial drafts beginning 90 days prior to authorization need date; final documents 60 days prior

#	Criteria	Method	OPR	Completion Date
7	Validate the methodology and numerical integrity of the Real-Time Susceptibility function.	Determine by analysis the accuracy of Real-Time Susceptibility software processing as implemented in the laser's decentralized deconfliction. Validation by comparing the results versus results of other models giving indepent estimates, such as the DECON system. Validation to include top level review and assessment of a methodology document provided by the laser program.	Laser program and LCH or a NumVal Agent	Initial drafts beginning 90 days prior to authorization need date; final documents 60 days prior
8	Validate laser firing inhibits computed by the laser decentralized deconfliction.	Verification of the deconfliction function by comparison of laser firing inhibits computed by the laser decentralized deconfliction as compared to predicted closures from the LCH DECON system.	Laser program and LCH or a NumVal Agent	Initial drafts beginning 90 days prior to authorization need date; final documents 60 days prior

APPENDIX E – INDEPENDENT VERIFICATION AND VALIDATION

E.1. As part of the capability validation process, the laser program will sponsor an IV&V of the decentralized deconflicton software. The scope of the IV&V effort will focus on the specific software modules that comprise the decentralized deconfliction software critical chain of events. Within the critical software chain of events only software calls to specific laser deconfliction-oriented functionality will be addressed. Calls to utility functions and logging functions are not considered part of the critical software chain of events.

E.2. The IV&V will include:

a. Verification of software requirements, development, testing, configuration control, and quality assurance standards and processes used in the decentralized deconfliction development to ensure that best practices are established and followed.

b. Verification of decentralized deconfliction software requirements performed by tracing *Standard Decentralized Deconfliction and Capability Validation Plan* requirements to the laser's System Requirements Document to the laser's System Design Document [or comparable documents] and into the code.

c. A code review to verify that functions or features are present in the software and to assess the adherence to coding standards.

d. Validation of software unit test and integration test results by reviewing developmental Formal Test documentation.

E.3. LCH and the the laser owner will jointly develop and approve a detailed IV&V Plan that identifies the critical software chain of events. The laser owner will engage an IV&V Agent to carry out the IV&V as specified in the IV&V Plan. The IV&V Agent may be either a Government office or a contractor, but must have extensive and relevant experience in the verification and validation of complex, real-time software such as the decentralized deconfliction capability. The IV&V Agent will generate a formal IV&V Report that includes findings and recommendations for use. The Report will be submitted to the laser owner and to LCH.

APPENDIX F – END-TO-END DEMONSTRATION

F.1. As part of the capability validation process, the laser program and LCH will conduct an E2E demonstration to evaluate the decentralized deconfliction capabilities required in this plan including the Information Exchange Requirements identified in the *Standard Decentralized Deconfliction Plan*. The E2E demonstration may cover all decentralized deconfliction tasks identified in Table B.2. in Appendix B above. Alternately, if a generic decentralized capability is developed, a sub-set of the tasks in Table B.2. may be included in the demonstration. When the decentralized deconfliction capability is integrated into a laser system, a follow-up demonstration will be conducted to validate the remaining tasks, including integration into the laser system, the laser system procedures, and personnel training.

F.2. A script for the demonstration will be generated by LCH or a designated representative at least 60 days prior to the demonstration. The E2E demonstration will be used to verify that the integrated system of hardware, software, and interfaces adequately perform laser deconfliction and ensure safe and responsible laser use.

APPENDIX G – CERTIFICATION OF DECONFLICTION CAPABILITIES

From: [insert Laser Owner/Operator name/organization]

To: Laser Clearinghouse
JFSCC/J359
747 Nebraska Avenue
Vandenberg AFB, CA 93437

Subject: Statement of Certification of Deconfliction Capabilities for the [insert laser name]

References:

a. Standard Decentralized Deconfliction and Capability Validation Plan for Laser Clearinghouse (LCH) Support to Lasers (insert date of most current document).

b. [insert laser name] Appendix A to the Standard Decentralized Deconfliction and Capability Validation Plan (insert date of most current document).

c. [insert laser name] Appendix B to the Standard Decentralized Deconfliction and Capability Validation Plan (insert date of most current document).

d. Laser Clearinghouse Reports Handbook (insert date of most current document).

e. Deconfliction System Interface Control Document (insert date of most current document).

f. Statement of Certification of Laser Deconfliction Capabilities [insert laser name] (insert date of most current document).

g. If applicable: [insert laser name] Deconfliction System/Software Test Report (insert date of most current document).

1. We certify that all deconfliction capabilities required of the [insert laser name] in the referenced plans are in place and have been satisfactorily verified through testing and analysis.

2. We also certify all personnel who will participate in deconfliction operations are fully trained and available, and will comply with the processes documented in the references.

3. In addition, we certify all the [insert laser name] operational procedures required to implement the referenced plans have been developed, evaluated, reviewed, and approved.

//Signed//

[Laser Owner/Operator Responsible Official
(O-5/GS-14 or equivalent level.)]

APPENDIX H – DoDI COMPLIANCE STATEMENT

From: [insert Laser Owner / Operator name / organization]

To: Laser Clearinghouse
JFSCC/J359
747 Nebraska Avenue
Vandenberg AFB, CA 93437

Subject: Statement of Certification for Compliance with DoD Instruction 3100.11

References:

a. DoD Instruction 3100.11, Management of Laser Illumination of Objects in Space, 24 October 2016.

b. Standard Centralized Deconfliction and Capability Validation Plan (insert date of most current document).

c. [insert laser name] Appendix A to the Standard Decentralized Deconfliction and Capability Validation Plan (insert date of most current document).

d. [insert laser name] Appendix B to the Standard Decentralized Deconfliction and Capability Validation Plan (insert date of most current document).

In accordance with the reference (a) Instruction, we certify that Secretary of Defense approval of [INSERT SYSTEM/PROGRAM NAME HERE] firings as described in reference (b) are not required. None of the criteria in reference (a) Section 3.4.b(1) apply, including having an impact on foreign relations, raising issues of compliance with treaties, requiring coordination with other Government departments or resulting in adverse media coverage.

//Signed//

[Laser Owner/Operator Responsible Official
(O-5/GS-14 or equivalent level)]