

IARPA PINS Challenge Rules & Regulations

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Background

The IARPA Passive Ionospheric Non-Characterized Sounding (PINS) Challenge is an open innovation competition that asks Solvers to develop an algorithm that characterizes, monitors, and models ionospheric variation effects on high frequency emissions. The PINS Challenge invites Solvers from around the world to develop innovative solutions that can lead to a greater understanding of the ionosphere and the effects it has on our technology.

Overview

Despite starting nearly 100 kilometers above the surface of the Earth, the ionosphere plays an active role in our day-to-day lives affecting High-Frequency (HF) Radio propagation (McNamara, 1991; Kelly, 2011). International air traffic controllers, oceanographers using surface wave radars, the space launch community, and many others are all affected by electron density distribution in the ionosphere. The ionosphere lets you hear distant AM radio stations in your car but it can also affect the quality of long-range air traffic control communications.

Modeling the impacts of the ionosphere on HF Radio can be a significant challenge. Installing and operating ionospheric bottomside sounding systems, called ionosondes, requires a large amount of electricity, human resources, and the construction of an entire infrastructure of high-profile antennas. However, passively receiving a characterized or non-characterized sounder transmission is considerably more convenient. It requires a fraction of the power and resources, and utilizes lower-profile equipment that can be installed temporarily.

Solvers are challenged to characterize the ionosphere with selected digitized radio-frequency (RF) spectrum recordings from sounder receiver data, but not any transmitter data. The PINS Challenge is an open data science challenge that will take place in two stages: Explorer and Master. Part I, the Explorer challenge, will specify the sounder signals to be detected and characterized. Part II, the Master challenge, will add new data sets along the way.

Challenge Timeline and Process

The following timeline outlines the major dates for the PINS Challenge. During the challenge, there may be additional dates, events, and deadlines for materials that will be communicated via direct email, the Microsite, or through forums found on the Topcoder website

<https://www.topcoder.com/challenges/30088355>.

- 4/30/2019: Explorer Challenge Pre-registration
- 5/20/2019: Explorer Challenge Launch
- 6/28/2019: Explorer Challenge Submission Deadline
- 7/19/2019: Explorer Challenge Winners Announced
- 8/5/2019: Master Challenge Launch
- 8/30/2019: Master Challenge Submission Deadline
- 9/23/2019: Master Challenge Winners Announced
- October 2019: Challenge Workshop

Pre-Registration & Registration

All Solvers will need to register for the Topcoder platform, and then register for the PINS Challenge at the following link: <https://www.topcoder.com/challenges/30088355>. During Pre-Registration, Solvers will be able to register via the Topcoder site and begin following the challenge, and a handful of simple examples will be provided. Once the challenge has fully launched on 5/15/2019, Solvers will be able to fully register and accept the terms and conditions of the challenge.

Part 1: The Explorer Challenge – Extracting Vertical Incidence (VI) Ionogram Parameters from I/Q Data

May 20, 2019 – June 28, 2019

The PINS challenge will require Solvers to process In-phase/Quadrature voltages (known as “I/Q” signals; see the References below for more information) measured by a broadband HF antenna that is connected to a set of Software Defined Radios (SDR). The SDRs were time-synchronized with Global Positioning System (GPS) timing. All PINS I/Q recordings were made at several locations in the United States. Within these recordings are many unique signals with a wide variety of modulations and signal strengths, and the recorded signals propagated between sites by ground wave and/or skywave.

The challenge will also offer Solvers a large volume of synthetic data that will present both simple and complex signal environments for algorithm development, testing, and troubleshooting. The data sets will have a good distribution of ‘easy’ and ‘hard’ signal environments. Using these data, the noise and interference environments can be gradually escalated in order to improve the performance of a Solver’s algorithm(s).

During the Explorer Challenge, Solvers will be asked to calculate ionospheric parameters from samples of I/Q data. The parameters of interest are presented below in Figure 1.

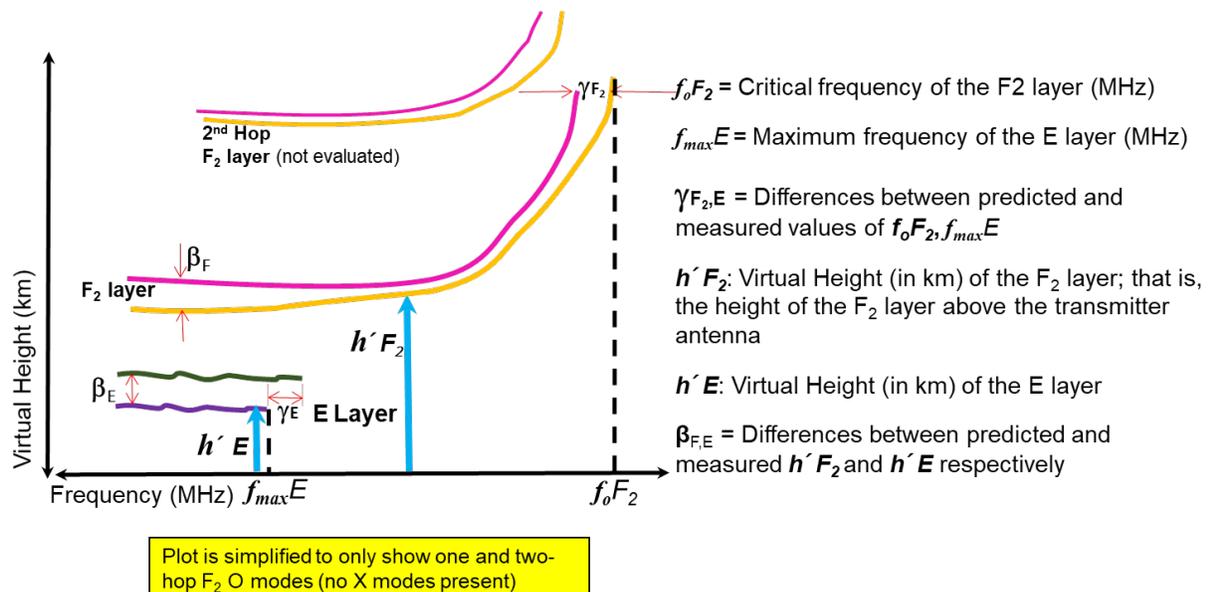


Figure 1: Explorer Challenge (VI Ionogram) Parameters

This process will require Solvers to extract a VI sounder’s waveform from the given I/Q data. Successful Solvers will be able to determine the sounder’s sweep rate and start time. For pulsed soundings, derived parameters may also include number of pulse repeats per frequency and inter-pulse period.

For this challenge, Solvers will be given descriptions of soundings (e.g. continuous linear sweep, coded pulse sounding, chirps) found in raw HF I/Q data. The PINS Challenge Team will then present Solvers with a series of I/Q data sets containing these soundings. The initial data sets will be synthetic with little or no noise or interferers. Subsequent synthetic data sets will be more difficult and include increasing levels of noise and more interferers. The final data sets will be from actual HF data collections that contain real world noise and interference.

The synthetic and first few live data sets will be provided as training data. The evaluation data sets – the problem sets on which PINS challenge participants will be graded - will consist of live data in a realistic noise and interference environment. To reduce the data download and storage requirements on Solvers, much of the training data will include narrow-band step recordings such as that described in Figure 2. Solvers are expected to use the environments with no sounder signals within the much larger, full bandwidth recordings to train against environmental noise and interferers.

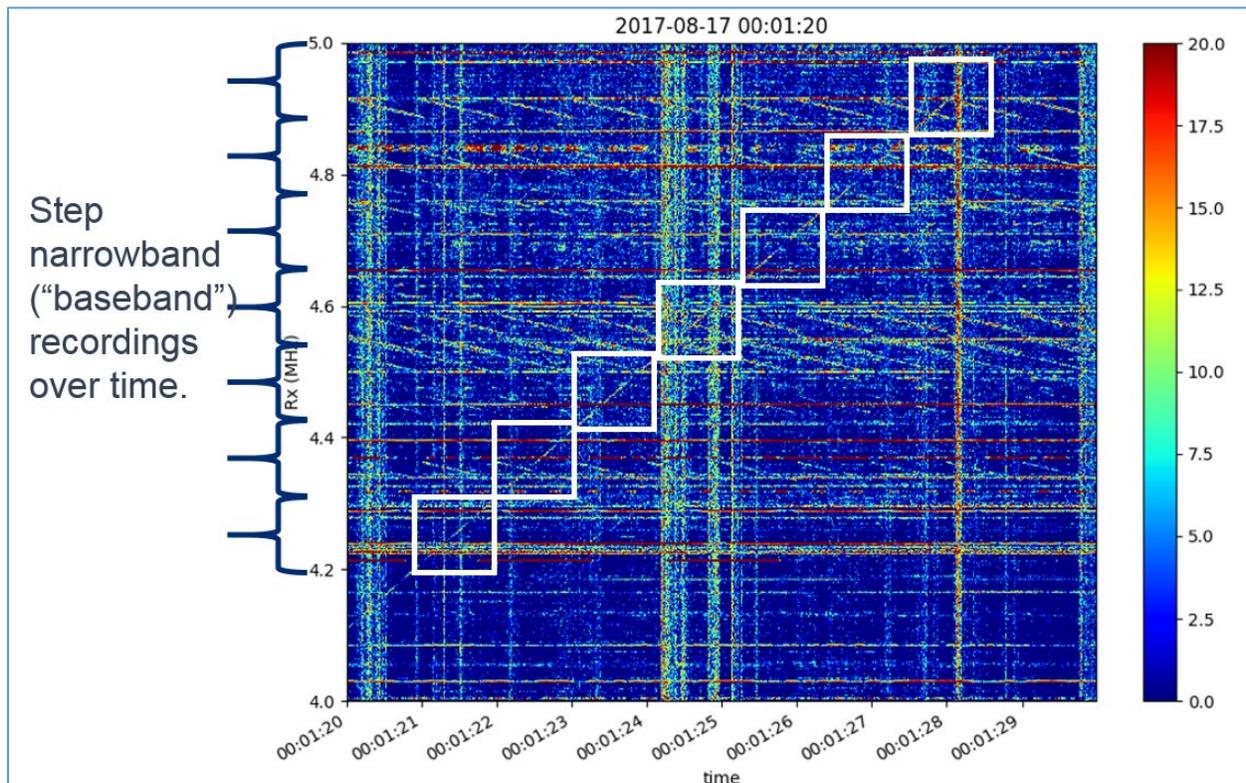


Figure 2: Sounder sweep segmented in a series of stepped narrow band recordings

For each of these datasets, Solvers will develop algorithms to extract sounder waveform details and calculate these basic ionospheric parameters:

- $h'F_2$ & f_oF_2 (McNamara 1991, 54)
- Determine presence of E layer and $f_{max}E$ (McNamara 1991, 53)

To win a prize, Solver submissions must be within 20% of the actual $h'F_2$, f_oF_2 and $f_{max}E$ parameters

Part 2: Master Challenge – Specification of the Bottom-Side Ionosphere

August 5, 2019 – August 30, 2019

The goal of the Master Challenge is to derive specification of the HF sky-wave environment (the bottom-side ionosphere) across a longer circuit. This will be accomplished through passive reception of active sounders from an oblique incidence. This process will require modification of the solver algorithms developed in the Explorer Challenge to determine ionospheric characteristics derived from more difficult Oblique Incidence (OI) datasets.

The parameters of interest are presented in Figure 3.

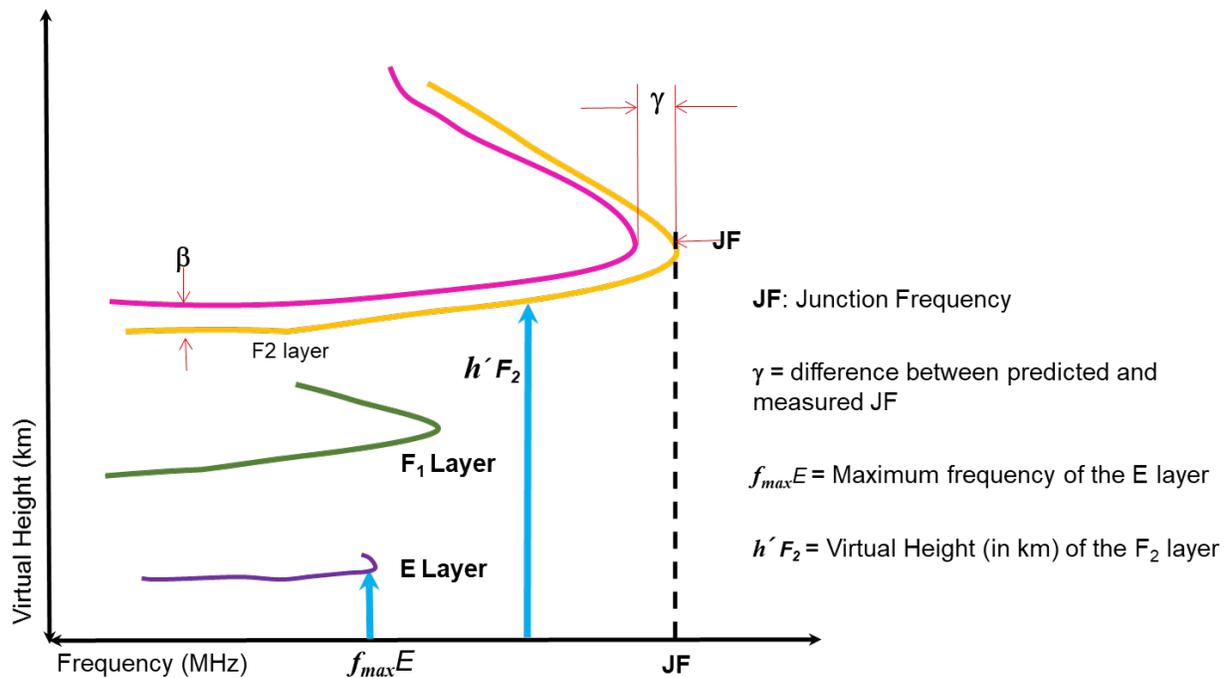


Figure 3: Master Challenge (OI Ionogram) Parameters

In the Master Challenge, Solvers will:

- Produce expected OI ionogram traces
- Identify & segregate the E/F1/F2 layers in these traces as shown in Figure 3
- Determine **Junction Frequency**, f_{maxE} and **F_2 layer virtual height** (Goodman 1991). In doing so, it is anticipated that Solvers will also determine the sounder timing (start time and sweep rate). These parameters will be expected from Solvers as well.

To win a prize, Solver submissions must be within 35% of the Junction Frequency, f_{maxE} and Virtual Height parameters

General Rules

- Only solutions submitted through the PINS Challenge Topcoder page will be evaluated. No submissions will be accepted via email or other means of distribution.
- Solvers may form teams, and companies may enter the competition as a team. For more details, see the 'Team / Companies section' below.
- All challenge submissions and communications must be in English; non-English language documents /communications will not be evaluated.
- Solvers will abide by the Topcoder Code of Conduct <https://www.topcoder.com/community/topcoder-forums-code-of-conduct/>, and may risk being disqualified based on their behavior in the Challenge Forums.
- Solvers must abide by the Topcoder platform rules, except in instances where the PINS challenge rules supersede the platform rules.
- Solvers will not receive feedback on their solution packages.

Prizes

The following Prizes will be awarded for the challenge.

Prize	Amount	Criteria
Explorer Challenge -- \$50,000 Total Purse		
1st Place Overall	\$25,000	Provide a Top 5 Final score, verified on withheld scoring dataset at the end of the challenge. To win a prize, Solver submissions must be within 20% of the actual $h'F_2$, f_0F_2 and $f_{max}E$ parameters
2nd Place Overall	\$10,000	
3rd Place Overall	\$5,000	
4th Place Overall	\$3,000	
5th Place Overall	\$2,000	
6th – 10th Places	\$1,000 each (\$5,000 total)	
Master Challenge -- \$100,000 Total Purse		
1st Place Overall	\$50,000	Provide a Top 3 Final score, verified on withheld scoring dataset at the end of the challenge. To win a prize, Solver submissions must be within 35% of the Junction Frequency, $f_{max}E$, and Virtual Height parameters
2nd Place Overall	\$20,000	
3rd Place Overall	\$7,500	
4th Place Overall	\$3,000	
5th – 10th Place Overall	\$2,000 each (\$12,000 total)	
Workshop Presenter Prize (3)	\$2,500 each (\$7,500 total)	Top Solvers on the leaderboard will present on their solution at a challenge workshop in the Washington, D.C. Area. Solvers will receive prize payment upon completion of in-person presentation.

Table 1: PINS Challenge Prize Awards

Judging & Scoring

Ionospheric Parameter	Objective	Points	Example Solver Results	Example Solver Points
f_oF_2	Match value measured by ionosonde	$1000 - \gamma F_2(\text{kHz}) $	Sounder: 6761 kHz Solver: 7000 kHz $ \gamma F_2(\text{kHz}) = 239$	761 points
$f_{max}E$	Match value measured by ionosonde	$1000 - \gamma E(\text{kHz}) $	Sounder: 4725 kHz Solver: 4500 kHz $ \gamma F_2(\text{kHz}) = 225$	775 points
$h'F_2$	Match value measured by ionosonde	$1000 - \beta F(\text{km}) $	Sounder: 220 km Solver: 250 Km $ \beta F(\text{km}) = 30$	970 points
E layer present	Match call from ionosonde	1000 points for the correct answer	Solver: E present Sounder: E present	1000 points
Total Points for Example Solver:				3,506

Table 2: Explorer Challenge Points Breakdown

The example Solver in Table 2 will receive 3,506 points for this test case which is the sum off all the points awarded for the answer to each parameter, i.e. 761+775+970+1000.

Successful Explorer Challenge Solvers will also submit a short (3 to 5 page) paper describing the algorithms that produced their results from Phase 1. Solvers who do not submit a paper will not be eligible for a prize.

Master Challenge

Ionospheric Parameter	Objective	Points	Example Solver Results	Parameter Points
JF	Match values measured by PINS Challenge Team	$1000 - \gamma \text{ (kHz)} $	In the same OI ionogram, Solver measures JF of 9000 kHz PINS Team measures a JF of 9027 kHz	973 points
f_{maxE}	Match value measured by PINS Challenge Team	$1000 - \gamma E \text{ (kHz)} $	In the same OI ionogram, PINS Team measures an f_{maxE} of 6761 kHz Solver presents 6500 kHz	739 points
Identify & segregate the E/F1/F2 layers and multihops	Match labels assigned by PINS Challenge Team	Maximum of 1000 points; points per trace will be assigned based on the complexity of the ionogram	PINS Team OI ionogram has (1) 1-hop F2 trace, (2) 2-hop F2 trace & (3) E layer trace. 300 points awarded for (1) & (2); 400 points for (3). Solver presents (1) and (3)	700 points
$h'F_2$	Match values measured by PINS Challenge Team	$1000 - \beta \text{ (km)} $	Solver measures $h'F_2$ of 220 km PINS Team measures $h'F_2$ of 280 km	940 points
Total Points for Example Solver:				3,352

Table 3: Master Challenge Points Breakdown

The example Solver in Table 3 will receive 3,352 points for this test case which is the sum off all the points awarded for the answer to each parameter, i.e. 973+739+700+940.

Successful Master Challenge Solvers will also submit short paper (3-5 pages) describing the algorithms that produced their results in the Master challenge. Solvers who do not submit a paper will not be eligible for a prize.

For both the Explorer and Master Challenge, any Solver Result that produces an Ionospheric Parameter score of less than zero, will be recorded as a zero.

The top ten Solvers will then be asked to provide their code for evaluation by the challenge team. Solvers who do not provide their code will not be eligible for a prize. Distribution of Solver code will be

limited to the challenge prize staff and the US Government and marked with the appropriate US Government only rights markings.

Payment Terms

Solvers are responsible for payment and declaration of all taxes incurred from the acceptance of Prize funds. Solvers are responsible for any fees incurred by the Solver for the financial transfer or currency exchange of Prize Funds. Prize funds will be paid in U.S. Dollars. Prize funds will be paid by Topcoder. Solvers will be given 30 days to submit their paperwork upon notification of award. IARPA and Booz Allen Hamilton are not responsible for lost or stolen prize payments, or incorrect routing and payment information provided by the winning Solvers. All payments are subject to verification of recipient eligibility and compliance with U.S. legal requirements.

Intellectual Property

Solvers are required to agree to the Challenge IP Agreement found here:

https://iarpa.gov/challenges/pins/docs/PINS_IP_Agreement.pdf

Eligibility

General Eligibility Requirements

Some individuals or organizations may not be eligible for prizes for reasons listed below. However, these Solvers may, upon IARPA approval, participate in the challenge and be eligible for ranking in the challenge. Approval will need to be obtained in advance of participation by emailing pinschallenge@iarpa.gov.

To be eligible to win a prize under this competition, an individual or entity:

1. Must have completed and submitted a registration form on Topcoder Site;
2. Must have complied with all the requirements under these rules and the Challenge-Specific Terms;
3. Must agree to abide by the decisions of IARPA which shall be final and binding in all respects;
4. Must agree to follow all applicable local, state, federal and country of residence laws and regulations.
5. Must be (1) an individual or team of individuals each of whom are 18 years of age or over, or (2) a for-profit or non-profit entity organized or incorporated under law;
6. May not be a federal entity or federal employee acting within the scope of their employment;
7. Shall not be deemed ineligible because the individual or entity used federal facilities or consulted with federal employees during a competition if the facilities and employees are made available to all individuals and entities participating in the competition on an equitable basis;
8. In the case of federal grantees, may not use federal funds to develop challenge applications unless consistent with the purpose of their grant award;
9. In the case of federal contractors, may not use federal funds from a contract to develop challenge applications or to fund efforts in support of a challenge submission;
10. May not be employees of IARPA, Booz Allen Hamilton, Topcoder, The Johns Hopkins University Applied Physics Laboratory, The Johns Hopkins University, and/or any other individual or entity associated with the development, evaluation, or administration of the

- competition (including PINS judges), as well as members of such persons' immediate families (spouses, children, siblings, parents), and persons living in the same household as such persons, whether or not related, are not eligible to participate in the competition;
11. Employees of the prime and subcontractors for the HFGeo Program are not eligible to compete for cash prizes due to the program's similarity to the PINS prize challenge; and
 12. Must not be currently on the Excluded Parties List ([https:// www.epls.gov/](https://www.epls.gov/)).

Federally Funded Research & Development Centers (FFRDCs) and (DoD) University Affiliated Research Centers (UARCs) not mentioned above may be eligible to submit solutions and receive leaderboard recognition, but are not eligible to win prize dollar awards. In order to compete, an email must be sent to PINSchallenge@iarpa.gov with the team name, organization represented, and team member information.

Companies/Teams

Companies, universities, individuals, and Teams of Solvers can participate in this challenge. Companies / Teams will need to elect a Team Captain, who will be the main point of contact (POC) for communications. Individuals who have registered on the Topcoder PINS Challenge page as an individual competitor, will not be eligible to participate in a team. All Team Members must meet the General Eligibility Requirements, self-register, and acknowledge these rules through the Topcoder PINS Challenge page <https://www.topcoder.com/challenges/30088355>.

- Upon registering for the challenge, the Team Captain will need to provide a breakdown of all Team Members along with the percentage allocation between all Team Members
- Each Team Member will need to sign an agreement that they agree to distribution of prize funds
- A Team Captain may provide information for a company or organization instead of their personal information for tax purposes.
- Only one team member will submit Solutions for the challenge.
- Once a Team has submitted their first Solution, the team members cannot change. This means that adding or removing Solvers from the team will result in disqualification of the team.
- Individuals participating as a member of a team may participate on only one team and may not also participate as an individual solver.

Foreign Nationals and International Solvers

All submissions and any prizes are subject to verification of eligibility and compliance with U.S. legal requirements, such as sanctions prohibitions.

It is the responsibility of the Solver to ensure that they can participate in this challenge and ensure they are allowed to export their technology solution to the United States.

Warranties

By submitting an Entry, you represent and warrant that all information you submit is true and complete to the best of your knowledge, that you have the right and authority to submit the Entry on your own behalf or on behalf of the persons and entities that you specify within the Entry, and that your Entry (both the information and software submitted in the Entry and the underlying technologies or concepts described in the Entry):

(a) Is your own original work, or is submitted by permission with full and proper credit given within your Entry;

(b) does not contain confidential information or trade secrets (yours or anyone else's);

(c) does not knowingly, after due inquiry (including, by way of example only and without limitation, reviewing the records of the United States Patent and Trademark Office and inquiring of any employees and other professionals retained with respect to such matters), violate or infringe upon the patent rights, industrial design rights, copyrights, trademarks, rights in technical data, rights of privacy, publicity or other intellectual property or other rights of any person or entity;

(d) does not contain malicious code, such as viruses, malware, timebombs, cancelbots, worms, Trojan horses or other potentially harmful programs or other material or information;

(e) does not and will not violate any applicable law, statute, ordinance, rule or regulation, including, without limitation, United States export laws and regulations, including, but not limited to, the International Traffic in Arms Regulations and the Department of Commerce Export Regulations;

(f) does not trigger any reporting or royalty or other obligation to any third party;

(g) The submission or method and research to create the method does not interfere with any ongoing or past criminal or civil investigations, does not interfere with a person's employment validation and does not put at harm or distress any individual associated with the development of this method;

Limitation of Liability

By participating in the Competition, you agree to assume any and all risks and to release, indemnify and hold harmless IARPA, Booz Allen Hamilton, The Johns Hopkins University Applied Physics Laboratory, The Johns Hopkins University, TopCoder, ODNI, and Subject Matter Experts, from and against any injuries, losses, damages, claims, actions and any liability of any kind (including attorneys' fees) resulting from or arising out of your participation in, association with or submission to the Competition (including any claims alleging that your Entry infringes, misappropriates or violates any third party's intellectual property rights). In addition, you agree to waive claims against the Federal Government and its related entities, except in the case of willful misconduct, for any injury, death, damage, or loss of property, revenue, or profits, whether direct, indirect, or consequential, arising from your participation in this Competition, whether the injury, death, damage, or loss arises through negligence or otherwise. Entrants are not required to obtain liability insurance or demonstrate financial responsibility in order to participate in the competition.

IARPA is not responsible for any miscommunications such as technical failures related to computer, telephone, cable, and unavailable network or server connections, related technical failures, or other failures related to hardware, software or virus, or incomplete or late Entries. IARPA is not responsible for:

- (1) Any incorrect or inaccurate information, whether caused by a Participant, printing errors, or by any of the equipment or programming associated with or used in the Competition;
- (2) unauthorized human intervention in any part of the Entry process for the Competition;
- (3) technical or human error that may occur in the administration of the Competition or the processing of Entries; or
- (4) any injury or damage to persons or property that may be caused, directly or indirectly, in whole or in part, from a Participant's participation in the Competition or receipt or use or misuse of an Award.

If for any reason an Entry is confirmed to have been deleted erroneously, lost, or otherwise destroyed or corrupted, the Participant's sole remedy is to submit another Entry in the Competition.

Additional Information

These rules cannot be modified except by IARPA. All decisions by IARPA regarding adherence to these rules are final. The invalidity or unenforceability of any provision of these rules shall not affect the validity or enforceability of any other provision. In the event that any provision is determined to be invalid or otherwise unenforceable or illegal, these rules shall otherwise remain in effect and shall be construed in accordance with their terms as if the invalid or illegal provision were not contained herein.

IARPA reserves the right in its sole discretion to amend these rules throughout the duration of the contest should extenuating circumstances arise, to extend or modify the dates of the Competition, and to change the terms set forth herein governing any phases taking place after the effective date of any such change.