<u>ADVANCE CONTRACT AWARD NOTICE (ACAN)</u>

1. Advance Contract Award Notice (ACAN)

An ACAN is a public notice indicating to the supplier community that a department or agency intends to award a contract for goods, services or construction to a pre-identified supplier, thereby allowing other suppliers to signal their interest in bidding, by submitting a statement of capabilities. If no supplier submits a statement of capabilities that meets the requirements set out in the ACAN, on or before the closing date stated in the ACAN, the contracting officer may then proceed with the award to the pre-identified supplier.

2. Definition of Requirements

The Department of Natural Resources Canada (NRCan) has the following requirement:

TITLE

Open Geospatial Consortium Testbed-16: Machine Learning

BACKGROUND

The Canadian Geospatial Data Infrastructure (CGDI) represents Canada’s national Spatial Data Infrastructure (SDI). Similar to traditional physical infrastructure that helps Canadians with their everyday lives (e.g. roads, utilities, telecommunications), CGDI is an infrastructure for geospatial (i.e. location) information. In short, CGDI helps Canadians **find, access, use, and share** geospatial information.

GeoConnections is a national program, led by Natural Resources Canada (NRCan), which is mandated to advance the CGDI. Similar to physical infrastructure that is regularly improved through new technologies (e.g. upgrading analogue electrical meters with digital smart meters), CGDI’s digital infrastructure can consistently be upgraded to take advantage of new developments. This is commonly achieved through new and/or improved **geospatial standards**. Geospatial standards provide a vehicle for geospatial information to be described in a consistent, commonly understood, and agreed-upon way. Such standards enable **interoperability**: the ability to access, use, and understand information regardless of software or technology type.

Canada and the world is at the beginning of new frontier in digital technology. Artificial Intelligence (AI) applications are beginning to demonstrate how new computing capabilities will revolutionize how our economies and societies will work in the future. Canada's geospatial and natural resources domains will be significantly impacted by these trends. At this initial stage, it is important to begin understanding what such impacts will be, along with how they can be leveraged to benefit the Canadian geospatial community.

This project will explore a subset of AI: Machine Learning (ML). ML techniques enable computers to automatically complete specific tasks through exposure to large datasets[1]. Through knowledge of the desired output and characteristics of the data, computers gradually "learn" how to complete tasks when given new sets of information. Due to the voluminous nature of geospatial information, ML presents interesting opportunities to automate and improve geospatial analysis tasks for many domains. Exploring ML capabilities in the context of geospatial standards will help GeoConnections ensure that the CGDI can support ML and other AI related technologies as they become more mainstream.

OBJECTIVES

This project will explore ML in the context of geospatial standards for a specific theme: **wildland fire**. Wildland fires represent those that occur in forests, shrublands, and grasslands. In Canada, wildland fires burn on average 2.5 million hectares of forest annually. Large fires of more than 200 hectares in size account for 97% of this annual burned area. Costs for the suppression of such fires alone are significant, ranging from $500 million to $1 billion per year[2]. When considering additional impacts on Canadian communities, citizens, the environment, and economic activity, wildland fires present major challenges to Canada.

The work will focus on two components of wildland fire: **planning** and **response.** Planning refers to the identification of strategies and approaches to respond to wildland fires before they occur. Response refers to dynamic decision making that occurs throughout the duration of active wildland fires. The response component also encompasses post-event activities (e.g. planning for the long-term aftermath of wildland fire events).

For both components, the primary objective of this work will be to determine how geospatial standards, specifically those published by the Open Geospatial Consortium (OGC), can support the application of ML technologies to improve Canada's ability to manage wildland fire events. It is expected that the outcomes of the project will support multiple uses within the CGDI, NRCan, nationally, and internationally:

- Gain immediate insight into the capabilities and potential of ML for supporting wildland fire event planning and response.
- Identify potential improvements to or the creation of new geospatial

[1] Adapted from the Canadian Encyclopedia: https://www.thecanadianencyclopedia.ca/en/article/artificial-intelligence
[2] From https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/wildland-fires-insects-disturban/forest-fires/13143

standards to better support wildland fire activities.

- Identify strategies to improve the CGDI's ability to support planning and response decision making for extreme events, specifically wildland fire.
- Understand how NRCan and GeoConnections can further improve Canada's ability to leverage ML technologies in the geospatial context.

As a Strategic member of the OGC, it is an inherent interest of NRCan that outcomes of this work will inform future OGC activities that will be of direct benefit to Canada. As such, it is an objective of NRCan that specific deliverables provided through this work have the potential to facilitate additional official OGC activities.

PROJECT REQUIREMENTS

Challenges and Research Questions

Tasks for this project are designed to address the following three challenges of ML in the context of wildland fire planning and response:

1. Discovery and reusability of training data sets.
2. Integration of ML models and training data into standards-based data infrastructures.
3. Cost-effective visualization and data exploration technologies based on Map Markup Language (MapML)

Additionally, the following overarching research questions shall further help guide the work for each task:

- Does ML require data interoperability or can ML enable data interoperability? How do existing and emerging OGC standards contribute to a data architecture flow towards data interoperability?
- Where do trained datasets go and how can they be re-used?
- How can we ensure the authenticity of trained datasets?
- Is it necessary to have Analysis Ready Data (ARD) for ML? Can ML help ARD development?
- What is the value of data cubes for ML?
- How do we address interoperability of distributed data cubes maintained by different organizations?
- What is the potential of MapML in the context of ML? Where does it need to be enhanced?

- How to discover and run an existing ML model?

The following sections provide additional context as well as detailed task descriptions for each challenge:

Training Data Sets

We are currently experiencing unprecedented Earth Observation (EO) capabilities. To combine these with major advances in AI in general and ML in particular, it is necessary to close the gap between ML on one side and EO data on the other. In this context, two aspects need to be addressed. First, the extremely limited discoverability and availability of training and test datasets, and second, interoperability challenges to allow ML systems to work with available data sources and live data feeds coming from a variety of systems and Application Programming Interfaces (APIs).

In this context, training datasets are pairs of examples of labelled data (independent variable) and the corresponding EO data (dependent variables). Together, these are used to train an ML model that is then used to make predictions of the target variable based on previously unseen EO data. Test data is a set of observations used to evaluate the performance of the model using some performance metric. In addition to the training and test data, a third set of observations, called a validation or hold-out set, is sometimes required. The validation set is used to tune variables called hyperparameters, which control how the model learns.
To address the general lack of training data discoverability, accessibility, and reusability, this work shall develop solutions that describe how training data sets shall be generated, structured, described, made available and curated.

Integration of (Live) Data

The second aspect addresses the integration of data in ML model runs. This includes data available through web APIs or web services, and event streams.

Geospatial information required for wildland fire planning and response is commonly obtained from central data repositories. In Canada, large and well-known geospatial repositories, such as the Earth Observation Data Management System (EODMS), the Federal Geospatial Platform / Open Maps and Canada's National Forest Information System provide vast quantities and types of reputable geospatial data through OGC standards. However, these systems have generally not been designed to support advanced ML applications, especially within an emergency planning/response context. This component of the work aims to determine how well these systems can support ML applications in the context of OGC standards. It will also provide initial insight into the readiness of fundamental components of the CGDI for supporting new technologies such as ML. It will give actionable recommendations as to how

CGDI geospatial information repositories can be improved to better support ML applications. Potential improvements to OGC standards in the context of geospatial data repositories and extreme events will also be identified.

Visualization of ML Results

With planning and response activities for wildland fire events, it is critical that stakeholders (e.g. planners, first responders, residents, policy makers) are able to visualize related geospatial information quickly and accurately. Currently, such visualization requires users to have access to specialized software and skills. These barriers shall be reduced using tools supporting MapML. When implemented, MapML allows for viewing and interaction with geospatial information within web browsers. With widespread availability of web browsers on multiple devices, intuitive user interfaces, and no cost constraints, making geospatial information available through MapML has the potential to revolutionize how we interact with geographic information.

This task shall determine the utility of MapML for providing a geospatial information visualization and interaction interface in the context of wildland fire planning and response. Findings will allow NRCan to determine if MapML would provide a benefit to wildland fire stakeholders, including what improvements may be required. It will also aim to increase the visibility of MapML as a practical tool for geospatial visualization and interaction. Potential improvements to OGC standards to further leverage MapML capabilities will also be identified.

To be more precise, all geospatial information results from the wildland fire planning and response components shall be published so that they incorporate MapML capability. The delivery of MapML has been previously explored within OGC Testbed-13 and Testbed-14. The Testbed-13 MapML Engineering Report (OGC 17-019) recommends Web Map Service (WMS) or Web Map Tile Service (WMTS) as services that can be used to deliver MapML documents with small modifications. Other options arise from using OGC web APIs as developed in OGC Testbed-15. NRCan requires MapML be implemented in a web browser to publish results. Several open source web browser engines exist that can be leveraged for this work (e.g. WebKit, Gecko, and Blink). JavaScript implementations for MapML are **not** to be used for final result delivery. Additionally, this work shall investigate the ability of MapML to operate on mobile devices in mobile environments.

A comparison of MapML to other visualization and interaction tools shall complement this work. Here, the project shall compare and contrast the ability of MapML to act as an operational stakeholder geospatial information visualization and interaction tool with current approaches used within a wildland fire context. NRCan is particularly interested in exploring the ability of MapML to federate between authoritative sources (e.g. municipal/territorial/Indigenous/provincial/state/federal governments, international organizations, etc.).

If applicable, the project shall provide actionable recommendations for MapML improvement to better support extreme event advanced planning and active response.

Major Steps

This project consists of the following major steps to complete the above tasks within the wildland fire planning and response components:

Wildland Fire Planning

1. Investigate the application of different ML frameworks (e.g. Mapbox RoboSat, Azavea's Raster Vision, NRCan's GeoDeepLearning) to multiple types of remotely sensed information (i.e. synthetic aperture radar and optical satellite imagery, Light Detection and Ranging (LiDAR)), provided though OGC standards, to identify fuel availability within targeted forest regions.

2. Explore interoperability challenges of training data. Develop solutions that allow the wildland fire training data, test data and validation data be structured, described, generated, discovered, accessed and curated within data infrastructures.

3. Explore the interoperability and reusability of trained ML models to determine potential for applications using different types of geospatial information. Interoperability, reusability and discoverability are essential elements for cost-efficient ML. The structure and content of the trained ML models have to provide information about its purpose. Questions such as: "What is it trained to do?" or "What data was it trained on?" or "Where is it applicable?" need to be answered sufficiently. Interoperability of training data should be addressed equivalently.

4. Deep Learning (DL) architectures can use LiDAR data to classify field objects (e.g. buildings, low vegetation, etc.). These architectures mainly use the Tagged Image File Format (TIFF) and American Standard Code for Information Interchange (ASCII) image formats. Other DL architectures use 3D data stored in a raster or voxel form. However, 3D voxels or rasterized forms may have many approximations that make classification and segmentation vulnerable to errors. Therefore, the proejct shall apply advanced DL architectures directly to the raw point cloud to classify points and segments of individual items (e.g. trees, etc.). Participants shall use the PointNET architecture for this or propose different approaches. If different DL architectures are proposed, the sponsor will consider them as an alternative to PointNET. Sponsor approval will be required before a

different architecture can be used.

5. Leverage outcomes from the previous steps to predict wildland fire behavior within a given area through ML. Incorporate training of ML using historical fire information and the Canadian Forest Fire Danger Rating system (fire weather index, fire behaviour prediction) leveraging weather, elevation models, and fuels.

6. Using ML to discover and map suitably sized and shaped water bodies for water bombers and helicopters.

7. Investigate the use of ML to develop smoke forecasts based on weather conditions, elevation models, vegetation/fuel and active fires (size) based on distributed data sources and data cubes using OGC standards.

Wildland Fire Response

1. Explore ML methods for identifying active wildland fire locations through analysis of fire information data feeds (e.g. the Canadian Wildland Fire Information System, the United States LANDFIRE system) and aggregation methods. Explore the potential of MapML as an input to the ML process and the usefulness of a structured web of geospatial data in this context.

2. Implement ML to identify potential risks to buildings and other infrastructure given identified fire locations. Potential for estimating damage costs.

3. Investigate how existing standards related to water resources (e.g. Water Markup Language (WaterML), Common Hydrology Features (CHyF)), in conjunction with ML, can be used to locate potential water sources for wildland fire event response.

4. Develop evacuation and first responder routes based on ML predictions of active fire behaviour and real-time conditions (e.g. weather, environmental conditions).

5. Based on smoke forecasts and suitable water bodies, determine if suitable water bodies are accessible to water bombers and helicopters.

6. Explore the communication of evacuation and first responder routes, as well as other wildland fire information, through Publication/Subscription (Pub/Sub) messaging.

7. Examine how ML can be used to identify watersheds/water sources that will be more susceptible to degradation (e.g. flooding, erosion, poor water

quality) after a fire has occurred.

8. Identify how OGC standards and ML may be able to support the goals of the upcoming Canadian WildFireSat mission.

Deliverables

Deliverables for this project consist of project design, reporting, and technical requirements. Table 1 summarizes required deliverables, along with completion dates. Reporting and technical components are described in Table 2. Some of the project deliverables may be adjusted in consultation with NRCan and the contractor.

Table 1: Summary of Project Deliverables and Required Delivery Dates

Deliverable	Required Delivery Date
Testbed-16 Call for Participation developed and released.	January 1, 2020
Testbed-16 response evaluation completed, solution providers selected.	March 31, 2020
Initial Engineering Reports complete.	May 31, 2020
Component implementation design.	August 31, 2020
Components ready for first Technical Interoperability Experiments (TIEs).	September 30, 2020
TIEs completed, preliminary draft Engineering Report ready for review.	October 31, 2020
Ad hoc TIE demonstrations and demonstration assets posted to the OGC portal for each technical component listed in Table 2. OGC working group reviews requested for near-final draft Engineering Reports.	November 15, 2020
Final draft Engineering Reports and all technical components delivered.	November 30, 2020
Final Engineering Reports available to the public.	December 31, 2020
Final demonstration event of project outcomes and outreach material available.	January 31, 2021

Table 2: Descriptions of Reporting and Technical Component Deliverables

<table>
<tr><th colspan="2">Reporting Components</th></tr>
<tr><th>Component Name</th><th>Description</th></tr>
<tr><td>Machine Learning Engineering Report</td><td>Engineering Report capturing all results and experiences from this project. It shall respond to all requirements listed above. The Engineering Report shall contain a plain language executive summary to clearly outline the motivations, goals, and critical outcomes of this task, taking into account the mandates of the OGC and NRCan. The report shall be made available to the public. Note: Only summaries of material within the Machine Learning Training Data Engineering Report (below) is required within this Engineering Report.</td></tr>
<tr><td>Machine Learning Training Data Engineering Report</td><td>Engineering Report describing the training data metadata model, structure, file format, media type, and its integration into Spatial Data Infrastructures (SDI) and SDI-based ML tools, which includes discovery, access, and authenticity evaluation. The report shall be made available to the public.</td></tr>
<tr><th colspan="2">Technical Components</th></tr>
<tr><th>Component Name</th><th>Description</th></tr>
<tr><td>MapML Client 1</td><td>A MapML client, to be provided either as server proxy in combination with a web browser frontend, or as a web App supporting MapML for the wildland fire planning tasks. JavaScript implementations are not to be used.</td></tr>
<tr><td>MapML Client 2</td><td>Similar to MapML Client 1, but for the wildland fire response tasks</td></tr>
<tr><td>Machine Learning Environment 1</td><td>An ML framework such as e.g. Mapbox RoboSat, Azavea’s Raster Vision, NRCan’s GeoDeepLearning with support for OGC web services or OGC web APIs to retrieve externally provided data as described above, and to provide results at OGC web APIs or OGC web service interfaces in a form that allows MapML clients to explore results. Preference will be given to contractors that will make the configured ML framework available to NRCan at the end of the project. Ideally, this will be in the form of scripts that build a docker instance or process, which initializes the ML runs.This framework shall meet requirements for the wildland fire planning tasks.</td></tr>
<tr><td>Machine Learning Environment 2</td><td>Similar to Machine Learning Environment 2, but for the wildland fire response tasks.</td></tr>
<tr><td>Deep Learning Environment</td><td>A DL framework DL architecture based on PointNET or sponsor-approved equivalent, capable of the following:
Direct application to raw LiDAR point clouds.
Classifying points and segments for individual field objects (e.g. trees, etc.)
Preference will be given to contractors that will make the configured DL environment available to NRCan at the end of the project.</td></tr>
</table>

Training Data Set 1	Training data set including training data, test data, and validation data compliant with the model and definitions defined in the ML training data engineering report for the **wildland fire planning tasks**. The data shall be made available at web API endpoints.
Training Data Set 2	Similar to Training Data Set 1, but for the **wildland fire response tasks**.

3. Criteria for Assessment of the Statement of Capabilities

Any interested supplier must demonstrate by way of a statement of capabilities that it meets the following requirements:

1) The provider must be an authorized international standards organization committed to developing and maintaining collaborative geospatial standards that are freely available for anyone to use.

2) The provider must be a member of the Open Geospatial Consortium, therefore able to participate in OGC initiatives, including Testbed-16.

3) The provider must have experience developing and maintaining open, international geospatial standards that have achieved widespread adoption by the global geospatial community.

4) The provider will be able to continue its development, management, distribution and maintenance of the Open Geospatial Consortium (OGC) standards that have been implemented in the Canadian Geospatial Data Infrastructure (CGDI), which include but are not limited to Catalogue Service for the Web (CSW), Web Map Service (WMS), Web Feature Service (WFS), Web Map Tile Service (WMTS), GeoSciML, WaterML, GroundWaterML, Web Processing Service (WPS), Sensor Observation Service (SOS), Discrete Global Grid Systems (DGGS) and others, in a way which is officially authorized by the OGC.

5) The provider must have demonstrated that it has an official “Tier 1” formal relationship with other international standards development organizations, including at a minimum: the International Organization for Standardization (ISO), International Hydrographic Organization (IHO) and the World Wide Web Consortium (W3C). The provider must concretely show that its activities with these organizations have resulted in the development of standards.

6) Tier 1 is defined as the provider having demonstrated that it has an official formal relationship with other international standards development organizations for the development of standards. At a minimum, this must include all of the following:

    a. Having Class A liaison status with the ISO;
    b. being an Observer, through an official Memorandum of Understanding, within the IHO;
    c. being an official member of the W3C.
7) The provider must concretely show that its activities within these organizations have resulted in the development of standards.

8) The provider must have at least 500 members representing government, commercial organizations, NGOs, academic and research organizations which:
    a. Can participate in Testbed-16 in a capacity that is officially recognized by the OGC.
    b. Includes amongst its leading members key NRCan collaborators, including the United States Geological Survey, the European Space Agency, the United Kingdom Ordnance Survey, The United States National Aeronautics and Space Administration, and GeoScience Australia.
    c. Can have direct input into the current and future directions of the provider through binding voting rights.
    d. Have rights within the organization that are equivalent to those provided by the OGC at an equivalent membership level (e.g. NRCan's OGC strategic membership rights to be represented in an equivalent way).

9) The provider must have documented organizational structure, policies and procedures that govern open, international geospatial standards development, review, approval, publication, and maintenance. This must include the following (or equivalency):
    a. A Planning Committee, with experience in exploring market and technology trends to ensure that its activities remain effective and agile in a changing technology environment. This committee must contain a mechanism where member organizations can voice their opinion on the direction of the organization through binding voting rights.
    b. A Technical Committee with experience in managing international, open standards development processes. This committee must contain a mechanism where member organizations can voice their opinion on the direction of the standards development process through binding voting rights.
    c. Documented and published policies and procedures that are collaboratively developed and maintained by the organization's members though binding voting rights.
    d. Intellectual Property provisions and processes in place that balance open standards development with commercialization.

10) The provider must be able to demonstrate that they can provide ongoing,

long-term support to its members through the provision of the following services:

   a. Provide member access to other international standards development organizations such as ISO and W3C.
   b. Organize, manage and maintain a member web portal, wiki, mailing list, meeting minutes and online resource repositories for the proposed project, as well as all other initiatives the organization undertakes.
   c. Provide pre-set dedicated staff hours to support NRCan CGDI development activities.

11) The provider must be able to demonstrate that they have in place an Innovation Program (or equivalent) that will enable future research to be completed that will build on outcomes of Testbed-16. This program must be capable of producing results that can be officially accepted and implemented by the OGC.

12) The provider must be able to demonstrate that they have in place a Standards Program (or equivalent) that will enable outcomes of Testbed-16 to be incorporated into official OGC standards. This program must be capable of producing results that can be officially accepted and implemented by the OGC.

4. Trade Agreements

This procurement is subject to the following trade agreement(s):

Comprehensive Economic and Trade Agreement (CETA), World Trade Organization - Agreement on Government Procurement (WTO-AGP), North America Free Trade Agreement (NAFTA), Canada Free Trade Agreement (CFTA), Canada-Chile Free Trade Agreement (CCFTA), Canada-Columbia Free Trade Agreement (CCoFTA), Canada-Honduras Free Trade Agreement (CHFTA), Canada-Panama Free Trade Agreement (CPaFTA), Canada-Peru Free Trade Agreement (CPFTA), Canada-Korea Free Trade Agreement (CKFTA)

5. Justification for the Pre-Identified Supplier

The supplier mentioned in section 11 below is the only known supplier that meets the mandatory criteria set out in section 3 above.

Should Canada receive a statement of capabilities from a supplier that contains sufficient information to indicate that it meets the requirements set forth in this

ACAN, a competitive process will be triggered with a technical and financial evaluation methodology of the bids proposed by the potential bidders

6. Exception to the Government Contracts Regulations

The following exception to the Government Contracts Regulations is invoked for this procurement under subsection *6(d) – only one person is capable of performing the work.*

The identified provider, the Open Geospatial Consortium, is the only one able to meet all of the criteria identified in paragraph 3 above.

7. Exclusions and/or Limited Tendering Reasons

The following exclusion(s) and/or limited tendering reasons are invoked under the:

Applicable Limited Tendering Provision under NAFTA (Article 1016.2)
1016.2(b) - where, for works of art, or for reasons connected with the protection of patents, copyrights or other exclusive rights, or proprietary information or where there is an absence of competition for technical reasons, the goods or services can be supplied only by a particular supplier and no reasonable alternative or substitute exists;

Applicable Limited Tendering Provision under Canada-Chile (Article Kbis-09)
Kbis-09 (b) - where, for works of art, or for reasons connected with the protection of patents, copyrights or other exclusive rights, or proprietary information or where there is an absence of competition for technical reasons, the goods or services can be supplied only by a particular supplier and no reasonable alternative or substitute exists;

Applicable Limited Tendering Provision under CFTA (Article 513.bi)
506.12(b) – where there is an absence of competition for technical reasons and the goods or services can be supplied only by a particular supplier and no alternative or substitute exists;

Applicable Limited Tendering Provision under Canada-Honduras (Article 17.11)
17.11.2 b) a good or service being procured can be supplied only by a particular supplier and a reasonable alternative or substitute does not exist because:
(i) the good or service is a work of art,
(ii) the good or service is protected by a patent, copyright or other exclusive intellectual property right, or

(iii) there is an absence of competition for technical reasons;

Applicable Limited Tendering Provision under Canada-Panama (Article 16.10)
16.10.1b) a good or service being procured can be supplied only by a particular supplier and a reasonable alternative or substitute does not exist because:
(i) the good or service is a work of art,
(ii) the good or service is protected by a patent, copyright or other exclusive intellectual property right, or
(iii) there is an absence of competition for technical reasons;

Applicable Limited Tendering Provision under Canada-Peru and Canada-Colombia (Article 1409.b.ii
a good or service being procured can be supplied only by a particular supplier and a reasonable alternative or substitute does not exist because:
(i) the good or service is a work of art,
(ii) the good or service is protected by a patent, copyright or other exclusive intellectual property right, or
(iii) there is an absence of competition for technical reasons

8. Ownership of Intellectual Property

Ownership of any Foreground Intellectual Property arising out of the proposed contract will vest in the Contractor.

9. Contract Period

The contract period will be January 1, 2020 to January 31, 2021.

10. Estimated Cost

The estimated maximum value of the contract is $240,000.00 CAD inclusive.

11. Name and Address of the Proposed Contractor

The Open Geospatial Consortium
35 Main Street
Wayland, Maryland, 01778

12. Suppliers' right to submit a statement of capabilities

Suppliers who consider themselves fully qualified and available to provide the services/goods described herein, may submit a Statement of Capabilities in writing, preferably by e-mail, to the contact person identified in this Notice on or before the closing date and time of this Notice. The Statement of Capabilities must clearly demonstrate how the supplier meets the advertised requirements.

13. Closing Date

The closing date for a submission of a Statement of Capabilities is December 18, 2019.

14. Contract Authority

Name: Andrea Berthelet
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