Bridging the Chasm: Aligning Simulation and C2 Geospatial Data Production

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ABSTRACT

Simulations and Command and Control (C2) systems share a common need for high quality, correlated, and consistent geospatial data. The Simulation and C2 communities have robust processes for integrating data from multiple sources and multiple processes that exist within each community. Development of correlated databases is very expensive. However, opportunities to share and reuse this integrated data across C2 and simulation communities are largely unmet, resulting in duplicative data production and missed cost avoidance opportunities. The obstacles and resultant lost opportunities are most commonly a lack of knowledge and understanding of the production processes used and the integrated data that is produced by these processes, owing to a general lack of documentation, visibility, and access. There are both technical and policy challenges in coordinating co-production between organizations as well as establishing effective repositories supporting reuse. Differences in data standards are also contributing factors.

This paper describes the results of a U.S. Army Simulation to Mission Command Interoperability Overarching Integrated Product Team (SIMCI OIPT) Geospatial Initiative Stakeholder's Workshop focusing on aligning terrain database generation processes between these communities. Key recommendations from the workshop include the need for 1) a common framework for aligning terrain database production processes, 2) data generation process documentation to support reuse and 3) mechanisms for improving visibility and accessibility of terrain data. These recommendations share the common goal of improving data reuse and realizing the resulting cost savings from a shared production capability. While the initiative that produced these results was convened under the U.S. Army, the same opportunities exist across the DoD Services and across partner nations.

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INTRODUCTION

In a time of decreasing resources, the Department of Defense (DoD) must continually seek opportunities to effectively produce, share, and reuse data. Currently duplicative data production occurs, causing cost avoidance opportunities to be missed. This could be substantially addressed by sharing data, reusing resources, and co-producing data. The production of geospatial data, and specifically terrain data, has always been an expensive proposition, and is conducted in a myriad of organizations using varying processes. Both simulations as well as Command and Control (C2) systems share a common need for high quality, correlated, and consistent geospatial data. The modeling and simulations (M&S) and C2 communities have robust processes for integrating data from multiple sources and multiple processes exist within each community. However, opportunities to share and reuse this integrated data across M&S and C2 communities are largely unexploited. The two communities are starting to merge capability requirements and share technology. But, the lack of understanding of the different production processes and the available products (integrated data, data layers, and terrain databases) often happens when organizations do not share data and their production systems do not interoperate.

In addition to the economic efficiencies possible from reuse, the need for interoperable systems, both within and across the M&S and C2 communities, is also a driver for aligning data production processes. Both C2 and simulation capabilities have evolved from primarily monolithic systems to "systems of systems" where capabilities can be combined and deployed into useful configurations. As C2 systems become more advanced, they use simulation capabilities for functions such as route planning and course of action analysis. These common functions should be interoperable at the level of shared data and common data interfaces.

For many years, technical interoperability between simulation and C2 systems was adversely impacted by differences in: 1) terrain data content and density requirements and 2) the formats used to interchange and archive the resulting terrain databases. Progress in improving interoperability was very slow due to significant differences in the density and types of geospatial data required by the simulation and C2 and M&S systems. In general, simulation systems required much more data at much higher resolution (especially for features and attributes) than those data used by C2 systems. Moreover, there were only very minimal requirements for simulations to interact in C2 activities. Now, much of the resistance to interoperability between C2 and simulation activities is being lowered and/or eliminated as C2 activities have recognized the potential to use more simulation technology in the functions cited above as well as for mission rehearsal and training in a higher resolution geospatial data environment.

Simulation to Mission Command Interoperability Overarching Integrated Product Team (SIMCI OIPT) Geospatial Initiative

The U.S. Army's Simulation to Mission Command Interoperability Overarching Integrated Product Team (SIMCI OIPT) is comprised of over thirty Army Organizations that work to improve the interoperability of simulations and

C2 Systems. The SIMCI OIPT is co-chaired by the Program Executive Office (PEO) Command, Control, and Communications-Tactical (C3T) and the PEO for Simulation, Training, and Instrumentation (STRI). Respectively these organizations are the Army materiel developer of tactical C2 systems and the Army materiel developer of simulations and training devices. The charter of the SIMCI OIPT (Hieb, et al, 2002) directs the OIPT to work to develop interoperability between the M&S domain and the C2 domain. The SIMCI OIPT did not focus in the Geospatial area in its first years. Subsequently, the SIMCI OIPT started to sponsor projects in this area in 2007. These projects were only able to make limited progress due to larger interoperability issues (both technical and non-technical). Over the years, the SIMCI effort has highlighted the significance of having "correlated" or "aligned" terrain between simulation and C2. In August 2010, the U.S. Army SIMCI OIPT established a Geospatial Initiative to address the issues of aligning simulation terrain database generation to the digital maps and terrain databases used by Mission Command (C2) systems. This spurred by meetings and agreements between representatives of PEO STRI, the Army Geospatial Center (AGC), and Assistant Secretary of the Army for Acquisition, Technology, and Logistics (ASA(ALT)).

To address the challenges of interoperability and sharing of data between C2 and simulation, SIMCI sponsored two workshops to bring the relevant stakeholders together for an intensive week of brainstorming. The first Workshop in 2011 resulted in a consensus on issues affecting geospatial data co-production across C2 and simulation. A paper published at last year's I/ITSEC (Hieb & Maxwell, 2012a and 2012b) documented the systemic and long-term issues related to geospatial data use in C2 and M&S. Among the issues identified in this first workshop were a lack of data reuse, a lack of uniform processes for data production, and a lack of convergence of standards. A second Workshop followed in 2012 and focused on solutions to the issues identified in 2011. This paper presents the findings of the 2012 SIMCI OIPT Geospatial Initiative Stakeholder's Workshop in the area of data co-production and sharing, and identifies activities that can lead to more effective co-production of data.

2012 SIMCI OIPT Geospatial Initiative Stakeholders Workshop 2012

On 16-19 October 2012, the SIMCI OIPT hosted a meeting of forty-three key subject matter experts and stakeholders from both the C2 and M&S communities. These stakeholders represented eighteen major DoD, Army, and USMC organizations who have responsibilities for generating, processing, storing, distributing, managing, and using geospatial data to support C2 and/or simulation activities. The workshop used four work groups to focus on specific areas related to 1) geospatial data co-production processes, 2) data repositories, 3) management, and 4) cost benefit assessment. The four work groups were asked to develop detailed, actionable recommendations to address shortfalls of current geospatial data, information and services from an Army Common Operating Environment Standard and Shareable Geospatial Foundation perspective, given a baseline of current issues and problems. The paper focuses on the first two of these areas, which are highly related.

COMMON FRAMEWORK FOR GEOSPATIAL CO-PRODUCTION

One of the significant outcomes of the workshop was the definition of a high-level process framework for geospatial data co-production. This framework was found to be applicable to data co-production in both C2 and simulation communities. The framework, shown in Figure 1, provides a lexicon for describing the common steps that occur in geospatial data co-production. Regardless of community, the process begins with raw data, for example, imagery or Light Detection and Ranging (LIDAR) data. Those data are then converted into foundation products such as feature, elevation, and vector data products. Because these foundation products are consolidated and conflated from different data sources, they are not necessarily consistent with respect to time or location. Thus the next step is to integrate those data. As that process occurs, data inconsistencies may be addressed by aligning the content of the datasets. For example, water features may be precisely aligned with the elevation data. Additionally, unnecessary data for the targeted application may be removed and duplicate data eliminated. If a data producer finds inconsistencies in the data set according to their own process, updates should be fed back to the foundation data provider so that the products can be updated. Especially in the case of data to be used for simulation applications, data may be added to fill in gaps or add necessary detail (intensified) often for software reasoning in simulation applications. The result is a set of correlated, consistent data products. Those data are then converted into formats consistent with the C2 and simulation applications in which they will be used.
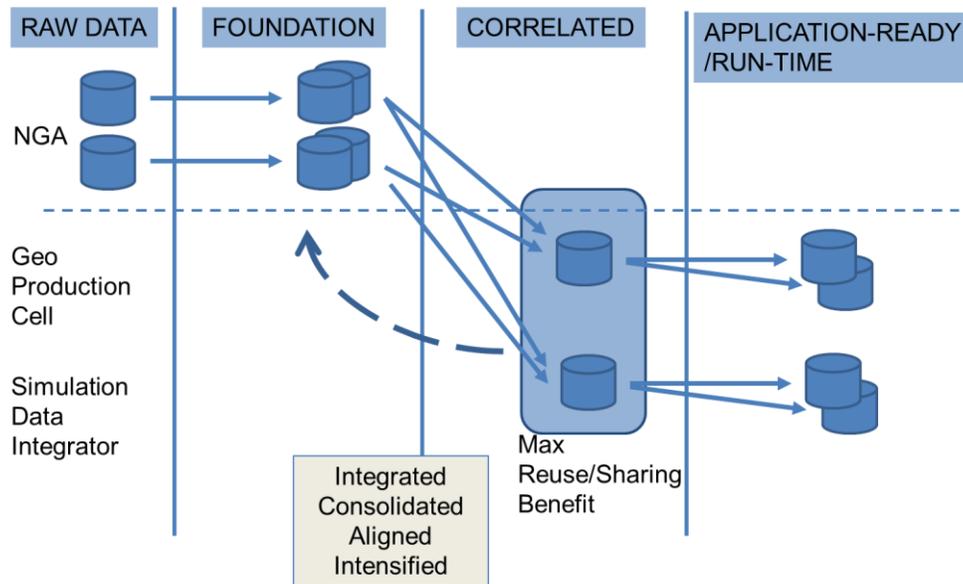
Figure 1. Co-Production Framework

In terms of reuse, the workshop participants agreed that it is the correlated data that have the most potential benefit from both economic and interoperability perspectives. Foundation data can be reused, but they eventually have to be correlated. It is this process of preparing correlated data products (including the integration, aligning, and intensification) that often takes up the most time in the process. So, avoiding duplication of this effort is desirable. Even when the end-use requirements differ, there is still significant reuse potential of correlated products. Where the same applications are used, or where they share common formats and standards, reuse potential also exists for the application-ready data.

POTENTIAL GEOSPATIAL CO-PRODUCTION IMPROVEMENTS

The workshop group focused on co-production processes reached consensus that improvements could be made in three key areas:

1. The establishment of best practices and means for assessing production against those practices
2. Mechanisms for increasing awareness of data production requirements and plans
3. Convergence of geospatial data standards

Establishing Best Practices

One of the barriers to geospatial data sharing and reuse is the issue of trust. Without an understanding of the processes and standards used to produce a terrain database, a potential consumer is less likely to use that database. The workshop participants agreed that evolution to a common best practice for terrain database co-production is desirable. However, differences in database production processes will exist when there are differences in database requirements. Thus, the stakeholders at the workshop reached consensus that multiple steps needed to be taken: 1) the establishment of a common template for describing co-production processes, 2) the development of best practices based on that template, and 3) the establishment of an assessment program. These three activities are interrelated as shown in Figure 2.
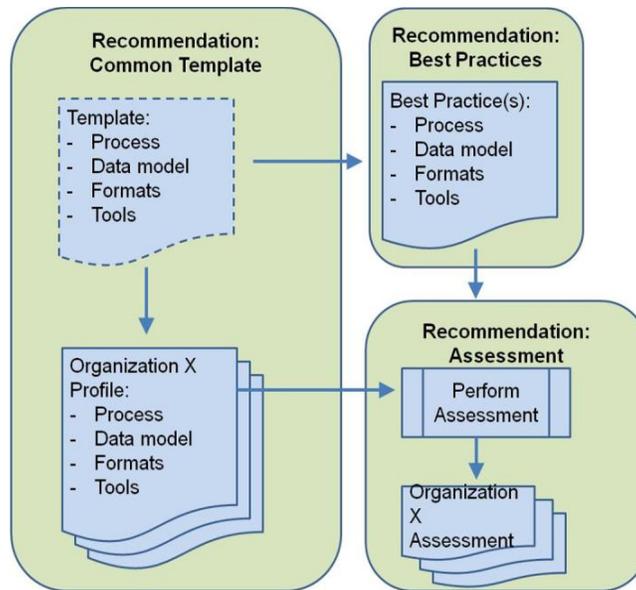
Figure 2. Relationship of Co-Production Process Recommendations

Co-Production Process Template

The Co-Production Process Template delineates the categories of information needed to define a geospatial co-production process. That template could be used to document the current processes employed by individual organization for database generation. Items covered by the template would include the steps in the process that the organization uses to produce products, sources used, formats in which the data products are made available, and tools used to both produce the data products and verify their quality. Consumers of those databases could examine that documentation to make informed decisions about appropriate reuse and determine the steps necessary to augment the database for their use.

Best Practices for Co-Production

That template can then be applied to the creation of best practices for terrain database generation. Significant work by some of the Geospatial Initiative participants has resulted in a terrain database generation best practices guide (Maxwell, et. al., 2012), which serves as a starting point, as well as guide the construction of the Co-Production Process Template.

Co-Production Assessment Program

Those best practices serve as a basis for examining individual organizations' database generation processes in an assessment program. The Army has many organizations that generate terrain databases for a variety of users. The Workshop stakeholders agreed that the Army needs a process for assessing the credibility and validating the accuracy of terrain databases generated by these co-producers. This recommendation calls for establishing a process for independent assessment or self-assessment of an organization's database generation process for database production.

Increasing Awareness of Data Production Requirements and Plans

Another process recommendation was to define a means by which requirements and plans for co-production can be shared among terrain database producers and mandate its use. There is a lack of situational awareness of terrain database generation requirements and scheduling, the terrain databases that are available, the intended use of existing terrain databases, and the processes being used to generate the terrain databases. As a result, opportunities

to combine efforts for co-production or to broaden a specific terrain database generation requirement to support multiple applications are missed. The National Geospatial-Intelligence Agency is developing a program, called the Geospatial Requirements One-stop Visualization Environment (GROOVE) (Fiske, 2012) that provides a central repository and clearinghouse for geospatial source (foundation) data requirements and could be adapted to capture the production processes used and information on the availability of both existing and proposed terrain databases.

Standards Convergence

The final recommendation relating to co-production was to develop a migration path to converge on common standards (data formats, data models, feature coding, and services) and the tools for producing correlated data. Note that the migration path does not imply that all producers use the same standards in every case ("one size fits all"), but that, over time, the number of different standards is minimized or implementation profiles of the same base standards are used. Where such convergence is not feasible, the relationship between standards should be fully defined. The stakeholders noted a lack of compatibility in standards used for geospatial data to support the C2 and simulation communities. While the two communities do respond to differing requirements, explaining some of the existing divergence, there appears to be opportunities for convergence.

The SIMCI Geospatial Initiative specifically, and the terrain co-production community in a larger sense, should take steps to identify where divergence has occurred and takes steps to converge where practical. Much of the source data used by C2 is the same as that used for simulation. In order for this to occur, the Army should identify a proponent who could review data, production processes for C2 and simulation communities to explore possibility of integrating or synchronizing source data and terrain database generation for the two communities. This convergence of standards will remove some of the barriers to effective reuse of correlated and application-ready source data and generated terrain database reuse .

POTENTIAL GEOSPATIAL REPOSITORY IMPROVEMENTS

In an ideal world of perfect information, users and producers of terrain databases would have full access to complete information about existing or proposed geospatial source data and terrain databases that are available or in the process of being generated.

Unfortunately, the world of geospatial data in the Army (and the DoD as well) is not one of perfect information. As a result, those with terrain database requirements frequently generate new terrain databases that duplicate those that already exist or fail to reuse previously integrated / cleaned source data or data layers. For example, the 2011 SIMCI OIPT Geospatial Initiative Stakeholder's Workshop identified that six different terrain databases generated for Kandahar, Afghanistan.

The 2012 Geospatial Initiative Stakeholder's Workshop identified key issues and constraints related to the archiving, discovery, and reuse of existing terrain databases as well as efforts to facilitate the discovery and reuse of geospatial source data. Recommendations were made to ensure that co-producers of terrain databases use existing repositories and guidelines established in a best practices guide for simulation terrain database generation.

Sharing of Correlated and Application-Ready Geospatial Data

The Workshop participants recommended that co-producers, as a best practice, should use existing repositories to store geospatial data and terrain databases, focusing on the sharing of correlated and application-ready data layers as shown in Figure 1. Key repositories that were identified to facilitate sharing:

- AGC Common Map Background (CMB) – CMB is Army's online repository of both AGC and National Geospatial Intelligence Agency (NGA) data products. The products requested range from map and image datasets of small areas of interest to large country or command datasets. CMB also provides simulation-ready data.
- Synthetic Environment Core (SE Core) Active Catalog. The SE Core Master Database (MDB) is the central repository for the creation of correlated databases used for Army training, mission planning, or mission rehearsal in the Live, Virtual, or Constructive (LVC) domains. Using the Army Model Exchange, the SE Core

effort will also make common virtual vehicle models accessible through the Rapid Data Generation (RDG) capability.

- NAVAIR Portable Source Initiative (N-PSI) repository. N-PSI provides reusable high-fidelity visual and sensor databases to Navy aircraft simulators and other fleet training systems. The N-PSI acquires data in a suitable form, with suitable intellectual property rights.
- Special Operations Forces Planning, Rehearsal and Execution Preparation (SOFPREP). SOFPREP uses highly sophisticated GEOINT database production centers to provide U.S. Special Operations Command (USSOCOM) support in scene visualization generation, distribution, archiving and maintenance. SOFPREP provides training and mission rehearsal support for multiple mission rehearsal system databases, as well as USSOCOM common database formats.
- USAF Simulator Data Base Facility (SDBF). The SDBF serves as the repository and dataset redistribution center for Air Force and other service simulator training system programs. SDBF supports the Distributed Mission Operations (DMO) data requirements, and shares their data with other DoD training programs.

The Data Repositories Work Group at the workshop agreed that any best practices should include archiving, discovering, distributing, and updating data repositories by co-producers. They also endorsed the need for a repository of requirements for geospatial source data, production processes and information on existing and planned terrain database generation available through a collaborative portal. The NGA GROOVE project, with extensions, should be considered as a tool to ensure that the information collected would be available.

Services-based Geospatial Data Clearinghouse

The Data Repositories Work Group agreed that there was a need for a geospatial clearinghouse function, with a primary purpose to ensure that the required source data, data layers, and terrain databases are not already available in a repository before approving the new terrain database generation. The clearinghouse would support evaluation of requirements for new terrain databases and proposed processes for terrain database generation. A similar clearinghouse function is used by the Army Materiel Systems Analysis Agency (AMSAA) to manage a wide variety of Characteristics and Performance (C&P) data that is used for testing and evaluating new Army hardware programs and systems. The C&P Configuration Control Board (CCB) holds bi-monthly telecom meetings that include producers and users of C&P data to discuss problem with data and to encourage the discovery and reuse of existing data. This geospatial clearinghouse would serve as a Geospatial Reuse Working Group and would include representatives from the major Army Geospatial producer and consumer organizations. This Working Group could serve as a link between terrain database users and producers.

The Data Repositories Work Group also reached consensus that a service-based enterprise approach should be used to catalog, publish, discover and download environmental/geospatial data across the Army. The multiple existing catalogs identified in the previous section each reside in a separate system. There is not currently a way to search across these catalogs. A service-based enterprise approach would allow this integration and searching across catalogs in a "one-stop-shop" fashion. The Data Repositories Work Group recommended that the RDG Common Data Production Environment (CDPE) (Scrudder, et. al., 2013) sponsored by the DoD M&S Steering Committee be evaluated as a potential mechanism to meet this need. The RDG CDPE will integrate data discovery and data access across all of the data repositories previously listed, and is based on a services-based approach. The stakeholders recommended that an implementation of Catalog Service for the Web (CSW) that is Common Access Card (CAC) controlled for both Non-classified Internet Protocol (IP) Router Network (NIPRnet)/Secret Internet Protocol Router Network (SIPRNet) users should be used. The RDG CDPE architecture currently plans to use these technologies and is planned for fielding in both NIPRnet and SIPRnet environments.

Figure 3 shows the planned Full Operating Capability (FOC) for the CDPE as it will be fielded on the NIPRnet. In addition to environmental (ENV) data providers, this figure also shows order of battle (OOB) data providers that will also be accessible via CDPE. A separate architecture will be support SIPRnet users, and includes the SOFPREP system identified above.
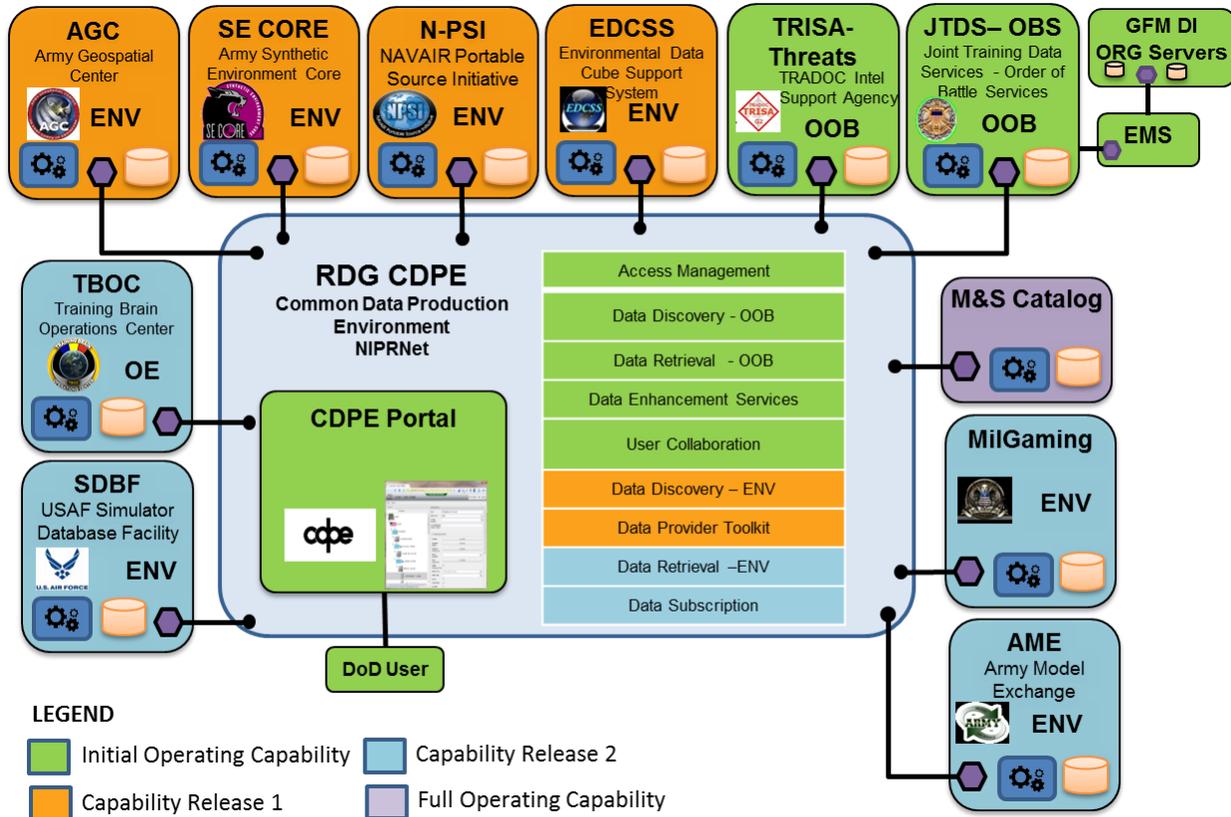
Figure 3. Rapid Data Generation Common Data Production Environment - NIPRnet

SUMMARY AND CONCLUSIONS

The 2012 SIMCI OIPT Geospatial Initiative Geospatial Stakeholder's Workshop brought forty-three subject matter experts from many activities across the Army and eighteen DoD organizations to discuss problems and form recommendations for connecting producers and users from C2 and simulation communities. Attendees discussed ways that geospatial data, information, and services could be synchronized and better aligned across C2 and simulation to reduce unnecessary duplication of effort, inefficient use of resources, and conflicting priorities, and to facilitate the support of C2 activities with synchronized and aligned geospatial data in simulation. They also discussed a broad range of specific actions and decisions that the Army could take to improve the synchronization, alignment, and interoperability of geospatial information and services between C2 and simulation communities and thereby help support our Soldiers now and in the future. Focusing on the common aspects of geospatial data generation for the C2 and simulation communities, will make a significant contribution to improving the efficiency of production processes as well as the ability to share and reuse data. Moreover, progress in the areas where the communities have common interests will likely make addressing the more vexing aspects of the geospatial data challenge easier for all stakeholders.

Specific actions that will impact the broader terrain co-production community across C2 and simulation stakeholders are:

- Define a process and infrastructure by which requirements and plans for co-production can be shared and mandate its use.
- Develop a template that documents common procedures that will be used by individual organizations to document their co-production processes.
- Develop a set of co-production best practices applicable to both simulation and C2, corresponding to steps in the process template.
- Establish an assessment program for co-production relative to the best practices.

- Develop a migration path to converge on standards (data formats, data models, data dictionary, services) and tools for co-producing terrain data.
- Use an enterprise service-based approach and existing repositories/catalogs to:
    - catalog, publish, discover and download correlated and application-ready data; and
    - expose requirements and planned future geospatial production.

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