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## **I. BACKGROUND**

In Order No. 830, the Commission approved Reliability Standard TPL-007-1 - Transmission System Planned Performance for Geomagnetic Disturbance Events.<sup>5</sup> In this order, the Commission also directed NERC to submit a work plan describing how NERC would conduct research on the GMD-related topics specified by the Commission and any additional topics selected in NERC's discretion and subsequently, one or more informational filings addressing the results of this research.<sup>6</sup>

NERC submitted a preliminary GMD Research Work Plan on May 30, 2017.<sup>7</sup> On October 19, 2017, the Commission accepted NERC's preliminary work plan and directed NERC to file a final, or otherwise updated, plan within six months.<sup>8</sup> As noted above, the Commission accepted NERC's revised GMD Research Work Plan in Order No. 851.

## **II. GMD RESEARCH WORK PLAN PROGRESS UPDATE**

The GMD Research Work Plan is progressing on schedule with the engagement of the Electric Power Research Institute ("EPRI"), electricity sector participants, U.S. national laboratories, equipment manufacturers, and other North American research collaborators. Through this research, NERC and its collaborators expect to improve the capabilities and accuracy of GMD Vulnerability Assessments<sup>9</sup> performed by NERC entities and help ensure the

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<sup>5</sup> Order No. 830 at P 22.

<sup>6</sup> Order No. 830 at P 77.

<sup>7</sup> *Geomagnetic Disturbance Research Work Plan of the North American Electric Reliability Corporation*, Docket No. RM15-11-002 (May 30, 2017).

<sup>8</sup> *Order on GMD Research Work Plan*, 161 FERC ¶ 61,048, at PP 1 and 12 (2017).

<sup>9</sup> GMD Vulnerability Assessment is defined in the *Glossary of Terms Used in NERC Reliability Standards* as "Documented evaluation of potential susceptibility to voltage collapse, Cascading, or localized damage of equipment due to geomagnetic disturbances."

effectiveness of GMD Reliability Standards in reducing risks to the BPS from severe GMD events.

EPRI has initiated a \$3.6 million, multi-year project for GMD research. Earlier in 2019, EPRI released technical reports summarizing the results of significant research efforts to date. These reports have been made publicly available free of charge by EPRI and are summarized below.<sup>10</sup> NERC provides opportunities for technical and scientific review of EPRI's research results through the NERC GMD Task Force.<sup>11</sup>

Work on the EPRI project continues through 2019, with remaining research scheduled to conclude before the end of the first quarter in 2020. EPRI will continue to provide technical reports to the GMD Task Force for broad technical and scientific review.<sup>12</sup> NERC encourages anyone who is interested in NERC's GMD research activities to participate in GMD Task Force meetings. These meetings are open to the public, and remote participation is available.

Below is a summary of work completed under the GMD Research Work Plan to date, organized by specific GMD Research Work Plan task.

**A. Task 1: Further Analyze Spatial Averaging Used in the Benchmark GMD Event**

EPRI collaborated with researchers at the Los Alamos National Lab ("LANL") to develop a comprehensive data set that will analyze severe GMD event characteristics. The data set and analysis are part of research in Task 1: *Further Analyze Spatial Averaging Used in the*

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<sup>10</sup> The cost to execute the research components of the plan is shared among NERC and electricity sector participants through a research program executed by EPRI.

<sup>11</sup> The NERC GMD Task Force is open to the public and includes participants from U.S. and Canadian government space weather researchers, representatives from the manufacturer and vendor community, and subject matter experts from both within and outside the electric power industry.

Additional information on the GMD Task Force is available on NERC's website at [https://www.nerc.com/comm/PC/Pages/Geomagnetic-Disturbance-Task-Force-\(GMDTF\)-2013.aspx](https://www.nerc.com/comm/PC/Pages/Geomagnetic-Disturbance-Task-Force-(GMDTF)-2013.aspx).

<sup>12</sup> As an independent research organization, EPRI will make the final decision on format and findings in its research results.

*Benchmark GMD Event.* Researchers obtained and processed magnetic field data from a global consortium of magnetic observatories to create a single data set to analyze large GMD events across all available magnetometer stations. Based on analysis of the data set, the report highlights how strong GMD hazards can be organized by the auroral oval location and notes the expansion of the auroral zone, towards the pole and equator, during strong geomagnetic activity. Further, it is noted that different times of day may have different geomagnetic hazard characteristics. Finally, the report affirms the value of high resolution magnetic time series (sampling periods shorter than 1 minute) to accurately estimate geoelectric fields.

Researchers will use this comprehensive data set for additional Task 1 activities as well as research into the effects of geomagnetic latitude on geoelectric fields during severe GMD events (Task 2: *Further Analyze Latitude Scaling*) as called for in the GMD Research Work Plan. The efforts in Tasks 1 and 2 will continue until the end of 2019 and, when complete, are expected to offer improved understanding of severe GMD event characteristics and the potential effects that they can have on the BPS.<sup>13</sup>

## **B. Task 2: Further Analyze Latitude Scaling**

EPRI collaborated with researchers at the National Aeronautics and Space Administration (“NASA”) to review recent research into the effects of geomagnetic latitude on geoelectric fields.<sup>14</sup> This review and analysis are part of research in Task 2: *Further Analyze Latitude Scaling*. Researchers performed an in-depth review of recent peer-reviewed published work, including work by the United States Geological Survey and LANL, on the variation in

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<sup>13</sup> In an initial published report, EPRI described the data set and provided some initial observations. See EPRI Technical Update report, *Improving Understanding of Characteristics of Geoelectric Field Enhancements Caused by Severe GMD Events*, June 2019, <https://www.epri.com/#/pages/product/3002016832/>.

<sup>14</sup> See EPRI Technical Update report, *Review of Peer-Reviewed Research Regarding the Effects of Geomagnetic Latitude on Geoelectric Fields*, June 2019, <https://www.epri.com/#/pages/product/3002016885/>.

geoelectric field with respect to geomagnetic latitude that can be attributed to the source electric current systems in the atmosphere (i.e., geomagnetic latitude scaling). The report highlighted new ways to analyze the geomagnetic data (e.g., via conditioning with global geomagnetic indices and other relevant parameters, utilizing historical records of extreme storms, and modern geospace models).

These highlighted methods are part of the efforts in Task 1 and 2 that will continue until the end of 2019 and when complete will offer additional insights into the geomagnetic latitude scaling under severe space weather conditions.

### **C. Task 3: Improve Earth Conductivity Models for Geomagnetically Induced Current (“GIC”) Studies**

EPRI analyzed estimates of peak geoelectric fields for the Benchmark GMD Event<sup>15</sup> as derived from one-dimensional (“1D”) and three-dimensional (“3D”) earth conductivity models and published the results in a technical report.<sup>16</sup> This research, which is part of GMD Research Work Plan Task 3: *Improve Earth Conductivity Models*, helps to evaluate the performance of existing 1D conductivity models against models derived from new magnetotelluric measurement data, where available.<sup>17</sup>

NERC and its stakeholders will consider these results, along with the results of ongoing research being performed under Task 3, in order to refine the earth conductivity models and

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<sup>15</sup> The Benchmark GMD Event is used by NERC Entities in performing GMD Vulnerability Assessments. See the Benchmark GMD Event description here: [https://www.nerc.com/pa/Stand/TPL0071RD/Benchmark\\_clean\\_May12\\_complete.pdf](https://www.nerc.com/pa/Stand/TPL0071RD/Benchmark_clean_May12_complete.pdf).

<sup>16</sup> Results of this research are published in EPRI Technical Update report, *Use of Magnetotelluric Measurement Data to Validate/Improve Existing Earth Conductivity Models*, January 2019, <https://www.epri.com/#/pages/product/3002014856/>.

In furtherance of earth conductivity model research, EPRI used geoelectric field calculation algorithms that were developed and benchmarked as specified in GMD Research Work Plan Task 7: *Geoelectric Field Evaluation and Calculation of Beta Factors*. See EPRI Technical Update report, *Tool Evaluation and Electric Field Estimate Benchmarking Results*, January 2019, <https://www.epri.com/#/pages/product/3002014853/>.

<sup>17</sup> Magnetotelluric data is not available for much of the southern continental U.S. See Figure 7-8 in the EPRI Report.

technical guidance that inform NERC entities in performing GMD Vulnerability Assessments. Following completion of the remaining GMD Research Work Plan Task 3 activities, NERC will evaluate whether the research findings may inform potential enhancements to the TPL-007 Reliability Standard. NERC expects the remaining GMD Research Work Plan Task 3 activities to conclude at the end of 2019.

#### **D. Task 6: Section 1600 Data Request**

In addition to overseeing the GMD Research Work Plan, NERC continues to develop the necessary processes and systems to implement GMD Research Work Plan Task 6: *Section 1600 Data Request*. In August 2018, the NERC Board of Trustees authorized NERC to issue a data request under Section 1600 of the NERC Rules of Procedure to collect GMD monitoring data from U.S. registered entities. The data request was developed by NERC staff and the GMD Task Force. NERC is finalizing the data reporting instructions that will guide reporting entities on how to submit the required GIC monitor data or magnetometer data that has been recorded during severe GMD events. Work to develop the necessary processes and technology solutions to collect and host the GMD monitoring data is ongoing. NERC anticipates beginning data collection in 2020.

#### **E. Task 8: Improve Harmonics Analysis Capability**

EPRI released a beta version of an open-source software tool for performing wide-area harmonic impact assessment.<sup>18</sup> This tool is the objective for GMD Research Work Plan Task 8: *Improve Harmonics Analysis Capability*. Completion of the development of this tool is expected at the end of 2019. The tool will provide Transmission Planners, Planning Coordinators and other users with wide-area harmonics assessment capability that is not currently available in

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<sup>18</sup> See EPRI Software Product *GIC HARM V.0.0*, January 2019, <https://www.epri.com/#/pages/product/3002014854/>.



commercial software packages. EPRI has made the beta version of the software tool publicly available, and stakeholders are encouraged to provide feedback to inform development and publication of the final version. This capability will improve the accuracy of GMD Vulnerability Assessments required by the TPL-007 standard. Once completed, this tool will complete GMD Research Work Plan Task 8.

#### **F. Task 9: Harmonic Impact Studies**

Working with utilities and transformer manufacturers, EPRI performed analysis to assess potential impacts of vibrations due to GMD-related harmonics on power transformers.<sup>19</sup> This research informs GMD Research Work Plan Task 9: *Harmonic Impact Studies*. Researchers based the report on factory and field test data of power transformers and analysis of a population of transformers that have been exposed to a large number of strong solar storms. They concluded that long-term exposure to vibrations caused by GIC does not adversely affect transformer mechanical integrity. Furthermore, the research indicates that a severe GMD event is not likely to lead to transformer mechanical damage from vibrations because factory tests show that tank vibrations reach their maximum at lower levels of GIC and do not increase further when GIC levels continue to rise. To further validate the findings, EPRI intends to continue to perform long-term monitoring of tank vibrations of large power transformers in the field.

Publication of this report concludes GMD Research Work Plan Task 9 activities related to transformer vibration impacts due to GMD-related harmonics. Research into generator harmonic assessment is underway and expected to conclude by the end of 2019.

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<sup>19</sup> See EPRI Technical Update report, *Impact of Geomagnetically Induced Currents on Transformer Tank Vibrations*, January 2019, <https://www.epri.com/#/pages/product/3002014855/>.

### III. CONCLUSION

Since commencing the GMD Research Work Plan in December 2017, NERC, EPRI, and the electricity sector and research collaborators have made significant progress in achieving established GMD research goals. The project remains on schedule for completion at the end of 2019. NERC will submit one or more informational filings in future months to keep the Commission informed of the results of ongoing research.

Respectfully submitted,

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**CERTIFICATE OF SERVICE**

I hereby certify that I have served a copy of the foregoing document upon all parties listed on the official service list compiled by the Secretary in the above-referenced proceeding.

Dated at Washington, D.C. this 26th day of July, 2019.

*/s/ Lauren A. Perotti*

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