GOES-R Proving Ground Demonstration Proposal:
Hazardous Weather Testbed – 2014 Spring Experiment

1. **Project Title:** 2014 GOES-R Proving Ground – Hazardous Weather Testbed (HWT) Experimental Warning Program (EWP) Product Demonstrations

2. **Organization**: HWT/EWP, Norman, OK

3. **Products to be Demonstrated as a GOES-R Proving Ground activity at the HWT:**
   - **a.** NSSL-WRF GOES-R ABI Synthetic Imagery (Baseline)
   - **b.** NearCast Model (Risk Reduction)
   - **c.** GOES-R Convective Initiation (Future Capability)
   - **d.** Probability of Severe (Decision Aid)
   - **e.** Overshooting Top Detection (Future Capability)
   - **f.** Total Lightning Detection/PGLM (Baseline)
   - **g.** Total Lightning Tracking Tool (Decision Aid)
   - **h.** Lightning Jump Algorithm (Risk Reduction)

4. **Demonstration Project Summary:**
   - **a. Overview:** The HWT will receive early exposure to GOES-R Proving Ground (PG) products during the 2014 Spring Experiment through activities led by the SPC/HWT GOES-R PG Liaison, William Line. The GOES-R PG portion of the Spring Experiment will take place 05 May – 06 Jun 2014, primarily within the EWP. The EWP provides a conceptual framework and a physical space to foster collaboration between research and operations to test and evaluate emerging technologies and science. Products will be demonstrated within a simulated warning operations environment using a real-time AWIPS-II framework within the HWT. This year, in addition to National Weather Service (NWS) operational forecasters, broadcast meteorologists will participate in the experiment as the PG looks to get the broadcast community more involved in its activities. Various project scientists will also be in attendance throughout the experiment to provide further project expertise and to communicate directly with the user community. Additionally, the NearCast Model may be demonstrated informally in the Experimental Forecast Program (EFP) during particularly interesting and applicable situations as a short-term forecast tool. The exposure to appropriate pre-operational GOES-R products during the height of the spring severe weather season will provide NWS forecasters, broadcast meteorologists, and scientists an opportunity to help determine operational applicability as well as critique and suggest improvements for products relatively early in their development cycle.

   - **b. Plan, Purpose, and Scope:** The HWT provides the GOES-R PG with an opportunity to demonstrate baseline and future capabilities products associated with the next generation GOES-R geostationary satellite system that have the potential to improve short-range hazardous weather nowcasting and forecasting. The availability of GOES-R products will demonstrate, pre-launch, a portion of the full observing

capability of the GOES-R system, subject to the constraints of existing data sources to emulate the satellite sensors. The structure of the GOES-R PG portion of the Spring Experiment in the EWP will be as follows:

There will be a total of 16 participants spanning the four weeks, with four participants in attendance each week. Forecasters will work in pairs participating in simulated warning operations in County Warning Areas (CWA's) determined via collaboration with the Experimental Forecast Program (EFP). Each week will begin with a 1-9 pm shift on Monday, while the Tuesday through Thursday eight hour shifts will begin between 9 am and 3 pm, depending on when convective activity is likely to start. The goal will be to begin Tuesday through Thursday one to two hours before the onset of severe thunderstorm development as many of the GOES-R products are designed to have their greatest utility in helping to increase lead time to initial convective development and to the issuance of hazardous weather warnings. At the end of the day on Thursday, in collaboration with the Warning Decision Training Branch (WDTB), participants will develop presentations sharing their experiences in the Spring Experiment, highlighting particular cases and products. These will be presented virtually Friday morning as part of the "Tales from the Testbed" webinar, in which product scientists and NWS entities outside of Norman are encouraged to participate.

Training for each product will be in the form of a narrated PowerPoint Articulate presentation to be sent to participants and completed before their arrival in Norman. Additionally, quick-guides, which highlight key points about each product, will be available as a reference for participants during daily experimental operations.

Feedback will be gathered throughout the experiment in the form of: surveys to be completed at the end of each day, real-time blogging, real-time discussions, and daily debriefs at the start of each day. Forecasters will be asked questions gauging the utility of each product in operations, and what changes/improvements could be made to make them more operationally relevant. Additionally, AWIPS-II product displays will be evaluated and potential improvements to them will be discussed.

This year, we seek to learn how to more effectively and efficiently incorporate new satellite-based products into the forecasters already saturated array of analysis and forecast tools. Part of this effort will involve testing and refining a "Satellite Convective Products Procedure" which concentrates several satellite-based (NearCast, CI, OTD, PGLM) and other observational (satellite imagery, radar imagery, surface observations, etc.) tools into one four-panel display in AWIPS-II. Not only will this guide forecasters to use various satellite-based products as compliments to one another, but it will also steer them towards viewing these new products in conjunction with more traditional observational datasets. This technique is expected to be especially beneficial during warning operations, as a forecaster will have a dedicated satellite convective product display as opposed to having to toggle between many additional loops.

c. **Goals:** The main objective of the GOES-R product demonstrations within the HWT is to demonstrate and evaluate baseline and future capabilities products that have the potential to improve nowcasts and forecasts of hazardous weather. Highlights of forecaster feedback will be organized in a final report which will be submitted to the GOES-R PG, and eventually provided to product developers so that recommended changes and improvements to products can be addressed. The one-on-one interactions between the SPC/HWT GOES-R PG Liaison, project scientists, NWS forecasters, and broadcast meteorologists will allow for valuable discussions during real-time hazardous weather events, maximizing operations-to-research (O2R) feedback, a key GOES-R PG goal. Finally, exposing NWS forecasters and broadcast meteorologists to GOES-R products and capabilities pre-launch increases day-1 readiness, another goal of the PG.

5. **Participants Involved:**
   a. **Providers:**
      i. Synthetic Satellite Imagery (Lindsey – CIRA)
      ii. NearCast Model (Petersen – CIMSS)
      iii. GOES-R Convective Initiation (Mecikalski – UAH)
      iv. Probability of Severe (Pavalonis – CIMSS)
      v. Overshooting Top Detection (Bedka – CIMSS)
      vi. Total Lightning Detection (PGLM) (Stano/Kuhlman – SPoRT/NSSL)
      vii. Tracking Tool (Stano – SPoRT)
      viii. Lightning Jump Algorithm (Carey/Kuhlman – UAH/NSSL)
   b. **Consumers:**
      i. Hazardous Weather Testbed
6. **Project Schedule/Duration (some dates are preliminary and subject to change):**
   a. Products tested in AWIPS-II system: 14 Apr 2014
   b. Training sent to participants: 21 Apr 2014
   c. Product demonstrations begin: 05 May 2014
   d. Product demonstrations end: 06 Jun 2014
   e. Final evaluation report: 03 Jul 2014

7. **Project Decision Points and Deliverables:**
   a. Proving Ground Operations Plan – First Draft: 31 Mar 2014
   b. Proving Ground Final Report: 03 Jul 2014

8. **Responsibilities and Coordination:**
   a. William Line, OU-CIMMS and NOAA/NWS/SPC – SPC/HWT Satellite Liaison
   b. Gabriel Garfield, OU-CIMMS and NOAA/NWS/WFO OUN – EWP Coordinator
   c. Kathryn Miretzky, AS&D for GOES-R Program Office – PG Coordinator

9. **Budget and Resource Estimate:** Funded through the GOES-R Science Office as part of the Omnibus Proving Ground funding to CIRA, CIMSS, UAH, and NASA/SPoRT.

Product Name: NSSL-WRF Synthetic Satellite Forecasts

Primary Investigator: Dan Lindsey (STAR/RAMMB)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Synthetic satellite forecasts allow forecasters to become familiar with the different bands and band differences associated with the GOES-R Advanced Baseline Imager (ABI) imager.
- Comparisons of synthetic satellite imagery with actual satellite imagery provide a method for NWP model performance evaluation.
- Realistic satellite bands using the model output allow forecasters to more easily identify features that may be difficult to determine using standard and derived model output fields.
- ABI synthetic imagery will be looked at before convection begins and during less active periods throughout the experiment. Its main purpose will be to familiarize forecasters with various ABI bands as well as train forecasters to use it as a model evaluation tool.

Product Overview:

- Synthetic cloud and moisture imagery from the ABI replicates how atmospheric features will appear in the GOES-R ABI bands.

Product Methodology:

- After the NSSL runs the 0000 UTC 4-km WRF-ARW, several variables including temperature, water vapor, and other physical and microphysical parameters are obtained.
- When all variables have been received, a radiative transfer model (RTM) is run to generate the synthetic imagery bands.
- Hourly output of NSSL-WRF data between 0900 UTC of Day 1 and 1200 UTC of Day 2 (F009-F036) is processed daily
- Resolution of the output is 4-km to match the input resolution of the NSSL-WRF model; the GOES-R ABI IR bands will have 2-km resolution.

NSSL-WRF Synthetic Satellite Forecast Products:

- ABI Bands 7-16, including wavelengths from 3.9 to 13.3 μm
- 10.35-3.9 μm Difference (to identify liquid water clouds)
- 10.35-12.3 μm Longwave Difference (to identify low-level moisture convergence)

Concept for Operational Demonstration:

- The NSSL-WRF product will be converted into AWIPS-II format and sent to the HWT.

Concept for Operations:

- Cloud and moisture data expected to be centrally produced at OSPO/ESPC and delivered by SBN or PDA. Synthetic imagery expected to be generated and displayed via plug-in on AWIPS-II.

Product Name: NearCast Model

Primary Investigator: Ralph Petersen (UW-CIMSS)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Provides forecasters with a highly observation-based decision support and situational awareness analysis and forecast tool, particularly for the development and intensification (or weakening) of convection.
- Forecast products will be evaluated on their utility in determining where the environment will be more (and less) conducive to convective development and maintenance at the current time and in the near (0-9 hour) future. Additionally, loops of recent NearCast analyses will be demonstrated as a way to visualize how the thermodynamic environment has evolved to its current state, an important step in the forecast process.

Product Overview:

- Helps to fill the information gap that exists in observation-based atmospheric sounding data by providing forecasters with vertical moisture and stability information at relatively high temporal (at least hourly) and spatial (10 km) resolution.
- Extends the use of satellite-based observations into short-term (0-9 hour) forecasts of the thermodynamic environment.
- Helps to fill the data gap that exists between observation-based nowcasts and longer-range (beyond 12 hours) NWP guidance.
- Stability and moisture indices are used to aid in identifying when and where convection may be more (and less) likely to occur in the near (0-9 hour) future, and to assess whether the downstream environment will support persistence or further growth of existing convective storms.
- The hourly NearCast Model analysis output can be used to monitor the recent evolution of the observed NearCast fields in conjunction with other observed fields (satellite and radar imagery, lightning, etc.) or model analysis data.

Product Methodology:

- Lagrangian model uses GFS model wind and height fields to dynamically project GOES-East/West temperature and moisture retrieval data forward in time nine hours.
- NearCast model output increases the areal coverage of single-time GOES data and retains details (maxima, minima, and extreme gradients) important to the development of convection several hours in advance, even after subsequent infrared satellite observations become cloud contaminated.

NearCasting Model Products:

- Vertical theta-e difference
- 500-mb mean-layer theta-e
- 780-mb mean-layer theta-e
- Vertical precipitable water difference
- 500-mb mean-layer precipitable water
- 780-mb mean-layer precipitable water

Concept for Operational Demonstration:

- NearCast Model products will be delivered to the HWT via the LDM and formatted for display in AWIPS-II.

Concept for Operations:

- The CONOPs for possible implementation into operations need further development (this assumes approval to proceed/ prioritization from NOAT). To date, possible paths to operations include:
    - Centrally produced at NESDIS/ESPC most likely as part of a convective toolbox.
    - Discuss with NCEP/NCO possibility of running at NCO most likely as part of a convective toolbox and deliver to NCO users via NCO-backbone and to non-NCEP users via future AWIPS DDS capability
    - Run as AWIPS-II application and/or procedure.

Product Name: GOES-R Convective Initiation

Primary Investigator: John Mecikalski (UAH/SPoRT)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Provides 0-2 h probabilistic forecasts that highlight where convective initiation is likely.
- Ability to increase forecaster confidence and extend lead time to initial convective development will be part of evaluation.

Product Overview:

- NWP-satellite fused probabilistic product that serves as a strategic aid for convective initiation.
- True probabilistic product because the algorithm incorporates information about the local atmospheric environment.

Product Methodology:

- Convective initiation probabilistic product is produced using a logistic regression framework.
- Convective cloud properties and fields from the Rapid Refresh model are used to create 0-2 h probabilistic forecasts.
- Early verification statistics have much improved skill scores compared to the satellite-only CI product when the NWP environmental data are included.

GOES-R Convective Initiation Products:

- 0-2 h Probabilistic Forecasts of Convective Initiation

Concept for Operational Demonstration:

- GOES-R Convective Initiation product will be delivered to the HWT via the LDM and formatted for display in AWIPS-II.

Concept for Operations:

- The CONOPs for possible implementation into operations need further development (this assumes approval to proceed/ prioritization from NOAT). To date, possible paths to operations include:
    - Centrally produced at NESDIS/ESPC most likely as part of a convective toolbox.
    - Discuss with NCEP/NCO possibility of running at NCO most likely as part of a convective toolbox and deliver to NCO users via NCO-backbone and to non-NCEP users via future AWIPS DDS capability
    - Run as AWIPS-II application and/or procedure.

Product Name: Probability of Severe Model (UWProbSvr)

Primary Investigator: Mike Pavolonis (NOAA/NESDIS)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Assists forecasters in severe weather situations by highlighting storms that are more or less likely to become severe in the near future.
- Product will be evaluated on its ability to increase forecaster confidence and skillfully extend lead time to severe hazards for NWS warnings during low-risk as well as high-risk severe weather days.

Product Overview:

- Model provides probabilistic guidance to forecasters on the likelihood of severe weather occurrence for developing convection in the next hour.
- Algorithm incorporates multiple datasets (data fusion) into one easy-to-interpret product, helping to reduce the "fire hose" of data during busy weather situations.
- Model output can be displayed referenced to storms on radar reflectivity.
- Model output is available over the eastern ¾ of the CONUS (predominantly east of the Rocky Mountains) and is day/night independent.

Product Methodology:

- A statistical model is employed to compute the probability that a storm will produce severe weather in the near-term, using GOES-derived, NEXRAD-derived, and RAP-derived data.
- The model leverages an object-centric approach, whereby satellite-object tracking and radar-object tracking operate simultaneously.
- Satellite growth rates, radar, and RAP-derived metrics are extracted from identified storm objects and the trends from satellite storm objects are shared with spatially overlapping radar storm objects.
- Object-centric approach helps keep a history of a storm's development observed by GOES.
- UWProbSvr updates approximately every 2 minutes.

UWProbSvr Products

- Product is displayed as color contours of severe probabilities around storms on radar.
- Data readout is available by sampling the probability contour. This provides the exact probability of severe and the detailed model predictor values.

Concept for Operational Demonstration:

- An ASCII file (on the order of kilobytes) will be delivered to the HWT via the LDM and converted on-the-fly into a shapefile using AWIPS-II.

Concept for Operations:

- The CONOPs for possible implementation of UWProbSvr needs further development and is pending proving ground evaluations, as well as formal approval.

Product Name: Overshooting Top Detection

Primary Investigator: Kristopher Bedka (NASA)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Product highlights overshooting tops such that the user can quickly spot them in animations of visible and infrared satellite imagery; especially valuable during busy warning situations.
- Presence of a persistent overshooting top feature can signify an especially strong and long-lived storm and early recognition of an overshooting top can raise situational awareness of impending hazardous weather. Similarly, decreasing trends in overshooting top detection may indicate that the cell updraft is weakening.
- Usefulness of monitoring trends in overshooting top detections (individual OTs, OT groups, etc.) and their relationship to overall storm evolution will be part of evaluation.

Product Overview:

- Overshooting convective cloud tops are domelike bulges atop an anvil cloud that indicate a strong updraft within a convective storm system that has vertically penetrated the tropopause.
- Convection with overshooting top signatures is often associated with hazardous weather conditions such as frequent lightning, heavy rainfall, and severe weather.
- Product offers a consistent day/night overshooting top detection capability.
- Product is available everywhere over CONUS, including areas where lightning and radar data are either insufficient or unavailable.

Product Methodology:

- Overshooting top product identifies clusters of 10.7 μm IR pixels significantly colder (>6 K) than the surrounding anvil cloud with a diameter consistent with commonly observed overshooting tops.
- Provides a detection accuracy that exceeds that of an existing overshooting top detection technique based on the water vapor minus infrared window brightness temperature difference.

Overshooting Top Detection Products:

- Overshooting Top Detection

Concept for Operational Demonstration:

- Overshooting top product will be delivered to the HWT via the LDM and formatted for display in AWIPS-II.

Concept for Operations:

- The CONOPs for possible implementation into operations need further development (this assumes approval to proceed/ prioritization from NOAT). To date, possible paths to operations include:
    - Centrally produced at NESDIS/ESPC most likely as part of a convective toolbox.

- Discuss with NCEP/NCO possibility of running at NCO most likely as part of a convective toolbox and deliver to NCO users via NCO-backbone and to non-NCEP users via future AWIPS DDS capability
- Run as AWIPS-II application and/or procedure.

Product Name: Total Lightning Detection (PGLM)

Primary Investigator: Geoffrey Stano (SPoRT)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Can be used to identify convection that may contain significant lightning, both cloud-to-ground and intra-cloud lightning, which can be related to storm intensity.
- Will prepare forecasters to receive data from the Geostationary Lightning Mapper (GLM), baseline GOES-R instrumentation designed to measure total lightning.
- Trends in total lightning and their relationship to storm evolution will be evaluated along with relationships between total lightning magnitude and other fields.

Product Overview:

- Provides an 8km boxed average estimation of total lightning activity within the Lightning Mapping Array (LMA) networks.
- Designed to give forecasters the opportunity to use and critique a demonstration of GLM type data to help improve future visualizations of these data and its trends.
- Serves as reference for comparison with full GLM proxies and derived products.

Product Methodology:

- Takes the raw total lightning observations, or sources, from any of the ground-based LMA available and recombines them into a flash extent gridded field.
- These data are then re-mapped to a GLM resolution of 8 km and are available at a 1 to 2 minute refresh rate, depending on the ground-based network being used.
- With the flash data, when a flash enters a grid box, the flash count will be increased by one and no flash is counted more than once for a given grid box.

GOES-R PGLM Products:

- Likely LMA networks: Oklahoma (OKLMA), Northern Alabama (NALMA), D.C. LMA (DCLMA), Colorado (COLMA), Houston (HGLMA), West Texas (WTLMA), New Mexico (NMLMA), Central Florida (CFLMA), North Georgia (NGLMA) and Wallops Island (WILMA)

Concept for Operational Demonstration:

- The PGLM data will be delivered to the HWT via the LDM and formatted for display in AWIPS-II.

Concept for Operations:

- This topic is still to be discussed, but it is more likely that the lightning density will be generated and displayed via plug-in in AWIPS-II.

Product Name: Total Lightning Tracking Tool (TLTT)

Primary Investigator: Geoffrey Stano (SPoRT)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- AWIPS-II tool designed in collaboration with NASA SPoRT and the Meteorological Development Laboratory (MDL) to generate a time series in real-time of the pseudo-geostationary lightning mapper (PGLM) products.
- Can be used to identify trends in total lightning, particularly to help identify lightning jumps in advance of severe weather. This will use the PGLM as a proxy for the Geostationary Lightning Mapper (GLM), which is a baseline GOES-R instrument.
- Forecasters will evaluate the effectiveness of the TLTT on multiple issues. This includes the timeliness for implementing the tool, effectiveness of the generated time series, ease of use, and the effectiveness of the tool on observations beyond the PGLM.

Product Overview:

- Provides a tool that forecasters can use to manually track storm cells of interest
- The tool then creates a time series in real-time of the PGLM observations for the selected storm cell(s).
- The 2014 version of the tool can be applied to more than total lightning (satellite and radar products, NWP data, etc.) and will be evaluated with other GOES-R Proving Ground products.

Product Methodology:

- Forecasters manually select a storm cell(s) of interest and place two or more cell points
- With the available cell points, the TLTT will then create a storm track which can be modified by the forecaster by adding more cell points.
- The TLTT will then plot, in a new pop-up window, the time series trend of the variable of interest (e.g., PGLM, satellite, radar, gridded product, etc.).
- The TLTT will extend the track as new observations arrive.
- The forecaster can add and delete tracks as necessary.
- The TLTT time series will aid forecasters in determining the trend of the observations in question.

The Total Lightning Tracking Tool Products:

- The TLTT is more appropriately a visualization capability to enhance the analysis of other GOES-R Proving Ground products (e.g., the PGLM).

Concept for Operational Demonstration:

- The TLTT is an AWIPS-II plug-in that will be provided to the HWT prior to the assessment. No further data feed is required to apply the TLTT.

Concept for Operations:

- This topic is still to be discussed, but it is likely it will be generated and displayed via a plug-in in AWIPS-II.

Product Name: Lightning Jump Algorithm (LJA)

Primary Investigator: Larry Carey (UAH) and Kristin Calhoun (CIMMS/NSSL)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- This product can indicate when an updraft is strengthening or weakening on shorter timescales than current radar and satellite.
- LJA can identify when potential for severe or hazardous weather has increased.
- LJA can help forecasters decide on whether or not to issue a warning.

Product Overview:

- The gridded LJA provides a degree of a lighting jump for multiple tracked storm objects on the same display.
- Storm tracking and jumps are completed in the background.
- Currently, the LJA can only be evaluated over Lightning Mapping Array (LMA) domains.
- Unique advantage of total lightning data is its high temporal resolution; lightning flash rates can currently be evaluated every 1-2 min in real-time. The LJA will be updated every minute for the HWT evaluation.

Product Methodology:

- Algorithm uses total lightning data from multiple LMAs covering regions in Oklahoma, Texas, Northern Colorado, Northern Alabama, and Washington DC.
- Using the 1-min storm flash rate, the standard deviation over the previous 10-min period of activity (not including the period of interest) is computed. If the current storm flash rate is greater than twice the standard deviation of the previous 10-min period, it is flagged as a "lightning jump."
- Individual storm clusters and objects are defined by the KMeans/SegMotion storm tracking algorithm.
- The LJA grid contains the identified storm objects, colorized by the degree of "jump" (1-sigma, 2-sigma, etc) for that time period.

Concept for Operational Demonstration:

- The LJA grid is produced at NSSL and has been formatted for display in AWIPS-II.
- Forecasters will be asked to determine:
    - If the LJA grid (in current state) was useful in their storm interrogation and/or warning decision.
    - What could be enhanced in either the display or content to increase the products utility in operations.

Concept for Operations:

- Ultimately, an LJA grid can be produced on GOES-R GLM data or any other total lightning product (such as the Earth Networks Total Lightning Network).
- Final AWIPS-II display and product integration (with radar/satellite) will depend on feedback from HWT operations in 2014/2015.