GOES-R and JPSS Proving Ground Demonstration Proposal:
Hazardous Weather Testbed – 2016 Spring Experiment

1. **Project Title:** 2016 Geostationary Operational Environmental Satellite R-series (GOES-R) and Joint Polar Satellite System (JPSS) Proving Ground – Hazardous Weather Testbed (HWT) Experimental Warning Program (EWP) and Experimental Forecast Program (EFP) Product Demonstrations

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

3. **Products to be Demonstrated as a GOES-R and JPSS Proving Ground activity at the HWT in 2016:**
    - **a.** GOES-Sounder derived all-sky Total Precipitable Water (TPW), Layer Precipitable Water (LPW), and Derived Atmospheric Stability Indices using GOES-R Legacy Atmospheric Profile (LAP) algorithm (Baseline and Risk Reduction)
    - **b.** GOES-R Convective Initiation (Future Capability)
    - **c.** ProbSevere Model (Risk Reduction)
    - **d.** Total Lightning Detection, Pseudo-Geostationary Lightning Mapper (PGLM) (Baseline)
    - **e.** Lightning Jump Algorithm (Risk Reduction)
    - **f.** GOES-14 Super Rapid Scan Operations for GOES-R (SRSOR) Data (Baseline)
    - **g.** NOAA Unique Combined Atmospheric Processing System (NUCAPS) Temperature and Moisture Profiles (JPSS)

4. **Demonstration Project Summary:**
    - **a. Overview:** As a GOES-R and JPSS Proving Ground (herein, Satellite Proving Ground) activity, GOES-R and JPSS proxy products and capabilities will be demonstrated in the HWT during the 2016 Spring Experiment through activities led by the SPC/HWT Satellite Liaison. Satellite Proving Ground activities during the Spring Experiment will take place 18 April – 13 May 2016, primarily in 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 to advance National Weather Service (NWS) warning operations. Products will be demonstrated within a simulated warning operations environment using a real-time AWIPS-II (D2D) framework within the HWT. NWS forecasters and broadcast meteorologists will be the primary evaluators. Various project scientists will also be in attendance throughout the experiment to provide project expertise and to communicate directly with the user community. The exposure to appropriate pre-operational GOES-R and JPSS products and capabilities 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 algorithms in different stages of their development cycle. For the 2016 Spring Experiment, previously demonstrated products that have received updates, based in part on feedback from the HWT, will be demonstrated.

b. Plan, Purpose, and Scope: The HWT provides the Satellite Proving Ground with an opportunity to demonstrate Baseline, Future Capabilities, and experimental products associated with the next-generation GOES-R geostationary and JPSS polar satellite systems that have the potential to improve short-range hazardous weather forecasting, nowcasting and warnings. 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 Satellite Proving Ground activities at the 2016 Spring Experiment in the HWT/EWP will be as follows:

There will be a total of 16 external participants spanning the four weeks, with four participants (three NWS forecasters and one broadcast meteorologist) in attendance each week. Forecasters will work in pairs participating in real-time simulated short-term forecast and warning operations in County Warning Areas (CWAs) across the CONUS determined via collaboration with the EFP. Using an EWP blog, participants will document their short-term experimental mesoscale forecast updates in real-time, highlighting the impact of the demonstration satellite products on those testbed forecasts. Additionally on the blog, they will record the reasoning behind experimental warnings (issued using AWIPS-II/WarnGen) when possible, once again focusing on how the satellite products influenced those decisions. Participants will be encouraged to provide updates (verification) on the performance of previous experimental issuances using the blog as well.

Each week will begin with an 11 am - 7 pm orientation/forecast shift on Monday, while the Tuesday through Thursday eight hour forecast shifts will begin between 9 am and 3 pm, depending on when the primary convective activity is likely to start. The goal will be to begin Tuesday through Thursday one to two hours before the onset of deep convective development as many of the satellite products being demonstrated are designed to have their greatest utility in helping to increase lead time to initial deep convective development and to the issuance of hazardous weather warnings. Each Mon-Thurs forecast shift will begin with a ~15 minute briefing from the EFP highlighting details regarding the anticipated convective threat (location/timing/mode/severe type) for the day. At the end of the day on Thursday, in collaboration with the NWS Warning Decision Training Division (WDTD), participants will develop presentations sharing their experiences in the Spring Experiment, highlighting appropriate cases and satellite products. These will be presented virtually Friday morning as part of the "Tales from the Testbed" webinar, in which scientists and NWS entities outside of Norman are encouraged to participate.

Participant training for each satellite product will consist of a narrated PowerPoint Articulate presentation sent to participants for completion before their arrival in Norman. Broadcast participants are strongly encouraged to visit their local NWS Forecast Office for AWIPS-II hands-on familiarization prior to the experiment. Feedback will be gathered throughout the experiment in the form of: 1) surveys to be

completed at the end of each day and week, 2) real-time blogging, 3) real-time discussions, 4) daily debriefs during the start of each day, and 5) weekly debriefs Friday morning. Notes from the daily and weekly debriefs will also be posted to the EWP blog. All satellite-related blog posts will be forwarded to the GOES-R HWT blog (http://goesrhwt.blogspot.com/).

c. **Goals:** The main objective of the Satellite Proving Ground demonstrations within the HWT is to demonstrate and evaluate Baseline, Future Capability and experimental products that have the potential to improve short-term forecasts, nowcasts and warnings of hazardous weather across the CONUS. Highlights of forecaster feedback will be organized in a final report which will be submitted to the Satellite Proving Ground 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 Satellite Liaison, project scientists, NWS forecasters, and broadcast meteorologists allow for valuable discussions during real-time hazardous weather events, maximizing research-to-operations-to-research (R2O2R) feedback, a key goal of the Proving Ground. Additionally, the real-time demonstration ensures the algorithms work properly in AWIPS-II. Finally, exposing NWS forecasters and broadcast meteorologists to GOES-R products and capabilities pre-launch increases readiness for their receipt and use, another goal of the Proving Ground.

5. **Participants Involved:**
   a. **Providers:**
      i. GOES-Sounder derived all-sky TPW, LPW, and Derived Atmospheric Stability Indices using GOES-R LAP algorithm (Li – CIMSS)
      ii. GOES-R Convective Initiation (Mecikalski – UAH)
      iii. ProbSevere Model (Pavolonis – NESDIS)
      iv. Total Lightning Detection, PGLM (Stano – SPoRT)
      v. Lightning Jump Algorithm (Carey/Calhoun* – UAH/*NSSL)
      vi. GOES-14 SRSOR 1-min Data (Schmit/Lindsey/Goodman/Rabin* – NESDIS/*NSSL)
      vii. NUCAPS Temperature and Moisture Profiles (Barnet – STC)
   b. **Consumers:**
      i. Hazardous Weather Testbed

6. **Project Schedule/Duration (some dates are preliminary and subject to change):**
   a. Products tested in HWT AWIPS-II system: 28 Mar 2016
   b. Training sent to participants: 28 Mar 2016
   c. Product demonstrations begin: 18 Apr 2016
   d. Product demonstrations end: 13 May 2016

7. **Project Decision Points and Deliverables:**
   a. Proving Ground Operations Plan – First Draft: 17 Mar 2016
   b. Proving Ground Final Report: 25 Jul 2016

8. **Responsibilities and Coordination:**

a. William Line, OU/CIMMS and NOAA/SPC – SPC/HWT Satellite Liaison and Principal Investigator for Satellite Proving Ground activities taking place in the HWT
b. Gabriel Garfield, OU/CIMMS and NOAA/OUN – EWP Coordinator

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

Product Name: GOES-Sounder derived all-sky Total Precipitable Water (TPW), Layer Precipitable Water (LPW), and Derived Atmospheric Stability Indices using GOES-R Legacy Atmospheric Profile (LAP) algorithm

Primary Investigator: Jun Li (CIMSS)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Provides all-sky details about the recent evolution of moisture and instability in the atmosphere, important factors during pre-storm mesoscale analysis.
- Ability to increase forecaster confidence regarding the state of the current thermodynamic environment will be assessed.
- This demonstration will help gauge the operational readiness of GOES-R ABI baseline and risk reduction algorithms.

Product Overview:

- The blended product is a combination of three parts resulting in a single, all-sky product: GOES-R LAP operational retrieval algorithm for GOES Sounder data in clear skies, GOES-R LAP risk-reduction retrieval algorithm for GOES Sounder data in cloudy skies, and GFS NWP model in cloudy skies without successful retrievals.
- Combining GOES-East and GOES-West data results in full-CONUS coverage.
- Various thermodynamic fields are computed, including: TPW, LPW, CAPE, and LI
- The product updates every hour, shortly after the GOES Sounder data are available.

Product Methodology:

- GOES Sounder observations are processed through the GOES-R LAP retrieval algorithms.
- GOES-R cloud mask algorithm is implemented for GOES Sounder clear field-of-view (FOV) detection.
- Cloudy sky retrieval algorithm allows for products under some cloudy sky conditions (GOES-R3).
- TPW, LPW, and various Stability Indices are derived from the GOES Sounder with GOES-R LAP retrieval algorithms.
- GFS NWP information is used where data gaps still exist.

LAP Products:

- TPW, LPW (SFC-0.9, 0.9-0.7, 0.7-0.3), CAPE, LI
- New for 2016, identity of data source (clear retrieval, cloudy retrieval, GFS)

Concept for Operational Demonstration:

- GOES Sounder LAP products will be delivered to the HWT via the LDM and formatted for display in AWIPS-II.

Concept for Operations:

- LAP products from GOES-R are expected to be centrally produced at OSPO/ESPC and delivered by SBN or PDA.

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 any type of convective initiation is likely. New for 2016, the severe component of the product yields 0-2 h probabilistic forecasts for where CI of a future severe storm is likely to occur.
- Ability to increase forecaster confidence and extend lead time to initial convective development, particularly the severe CI component.

Product Overview:

- NWP-satellite fused probabilistic product that serves as a strategic aid for determining areas of convective initiation for both non-severe and severe convective regimes.
- 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.
- A training database of over 500,000 objects has been developed using an objective validation technique, allowing for a much better representation of convective regimes as compared to earlier versions of the CI product.
- A separate training database of more than 10 severe convective days was used to delineate severe CI from non-severe CI. Tornado, wind, and hail reports from NOAA/NWS Storm Data were used as verification for the severe CI product.
- GOES-R proxy cloud products are ingested to diagnose CI under thin cirrus and are also used to significantly enhance the nighttime portion of the algorithm.
- 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 when the NWP environmental data are included compared to the satellite-only CI product.

GOES-R Convective Initiation Products:

- 0-2 h Probabilistic Forecasts of Convective Initiation
- 0-2 h Probabilistic Forecasts of Severe Convective Initiation

Concept for Operational Demonstration:

- GOES-R Convective Initiation 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, a possible path to operation includes for the product to be centrally produced at NESDIS/ESPC, most likely as part of a convective toolbox and run as an AWIPS-II application/procedure.

Product Name: NOAA/CIMSS ProbSevere Model (ProbSevere)

Primary Investigator: Mike Pavolonis (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 next hour.
- Product will be evaluated on its ability to increase forecaster confidence and skillfully extend lead-time to severe hazards for NWS warnings during potential severe weather situations.

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) from satellite, radar, total lightning (new for 2016), and NWP into one easy-to-interpret product, helping to consolidate/reduce the "fire hose" of data during busy weather situations.
- Model output is CONUS-wide and day/night independent.

Product Methodology:

- The model leverages an object-centric approach, whereby satellite-object tracking and radar-object tracking operate simultaneously.
- Spatial and temporal features are extracted and computed from satellite and radar storm objects. Satellite trends are shared with overlapping radar objects.
- A trained statistical model computes the probability that a storm will produce severe weather in the next hour, using data from GOES, NEXRAD, Earth Networks Total Lightning Network™ (ENTLN), and Rapid Refresh (RAP) NWP model.
- Object-centric approach helps keep a history of a storm's development observed by GOES.
- ProbSevere updates approximately every 2 minutes.

ProbSevere 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 ProbSevere 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 in real-time into a shapefile using AWIPS-II.

Concept for Operations:

- The CONOPs for possible implementation of ProbSevere needs further development and is pending Proving Ground evaluations, as well as formal approval by the NOAT.

Product Name: Total Lightning Detection, Pseudo-Geostationary Lightning Mapper (PGLM)

Primary Investigator: Geoffrey Stano (NASA/SPoRT)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- Identify developing deep convection, initial electrification by observing both cloud-to-ground and intra-cloud lightning, and relationship to storm intensity.
- 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 relationship to storm evolution, severe weather, and flooding potential will be evaluated along with relationships to other fields available at HWT.
- Identify product types, visualization techniques, and tools for future GLM observations.

Product Overview:

- Gridded observations derived from ground-based Lightning Mapping Arrays (LMA).
    - Flash extent density at 8 km horizontal resolution.
        - This will be available every 2 minutes (North Alabama and D.C.) or as a running 2 minute summation every minute.
    - Several color curves will be provided as per previous feedback.
- 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.

Product Methodology:

- Takes the raw total lightning observations, or sources, from available ground-based LMA data and recombines them into a flash extent gridded field.
- These data are then re-mapped to a GLM resolution of 8 km. LMA networks offer data at either 1 or 2 minute updates. The two minute networks will provide a 2 minute flash extent density. The one minute networks will provide a running 2 minute summation flash extent density.
- 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:

- Available LMA networks: Colorado (COLMA), Houston (HGLMA), Langmuir Lab, NM (LLLMA), North Alabama (NALMA), North Georgia (NGLMA), Oklahoma (OKLMA), Washington D.C. (DCLMA), and West Texas (WTLMA)
- Possible LMA networks: Southern Ontario (SOLMA), and Wallops Island (WILMA)

Concept for Operational Demonstration:

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

Concept for Operations:

- GLM data are expected to be centrally produced at OSPO/ESPC and delivered by SBN or PDA

Product Name: Lightning Jump Algorithm (LJA)

Primary Investigators: 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 may help forecasters decide on whether or not to issue a warning.

Product Overview:

- The gridded LJA provides the magnitude of a lighting jump for multiple tracked storm objects on the same display.
- The LJA is produced on a moveable domain covering activity across CONUS and can use total lightning data from either Earth Networks Total Lightning Network (ENTLN) or Lightning Mapping Arrays (LMA).
- 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.
- Based on forecaster feedback from 2015, a new 5-min product will be created for 2016 that denotes the max value of the jump for the previous 5 min.

Product Methodology:

- 2016 algorithm uses total lightning data only from the ENTLN for CONUS coverage.
- Using the 1-min storm flash rate, the standard deviation for the previous 10-min period of activity (not including the period of interest) is computed. If the degree of jump (or sigma-level) is more than one standard deviation of the previous 10-min period, it is flagged as a "lightning jump."
- Individual storm clusters are defined by the WDSSII storm tracking algorithms.
- The LJA grid contains the identified storm objects, colorized by the magnitude 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 during storm interrogation and/or warning decisions.
    - If any alterations to the current display, visualization, scale should to be made prior to the product becoming operational in 2017.

Concept for Operations:

- Ultimately, an LJA grid can be produced using GOES-R Geostationary Lightning Mapper (GLM) data or any other total lightning product.
- Final AWIPS-II display and product integration (with radar/satellite) will depend on feedback from HWT operations, but is currently planned for implementation in 2017 following the launch of GOES-R as part of the Multi-Radar/Multi-Sensor product suite.

Product Name: GOES-14 Super Rapid Scan Operations for GOES-R (SRSOR) 1-min Data

Primary Investigators: Tim Schmit, Dan Lindsey, and Steve Goodman (NESDIS), Bob Rabin (NSSL)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- The 1-min satellite imagery allows forecasters to observe atmospheric features and processes - such as subtle boundary location and movement - not seen as easily or at all in current routine imagery.
- The increased temporal frequency and timeliness of the 1-min satellite imagery increases lead time to various convective processes including convective initiation, intensification, and decay, resulting in timelier forecast product issuance.
- Parallax-correction provides more accurate geographic placement of cloud features, allowing for better comparisons with other datasets such as radar and lightning.
- 10-min updating atmospheric motion vectors (AMVs) derived from SRSOR allows for more winds to be generated horizontally and vertically in the atmosphere. This information is important for assessing the pre-convective and near-storm environment.
- This evaluation continues to explore the value added by 1-min imagery and derived products to the severe weather nowcast and warning process. Additionally, forecasters are prepared for a baseline capability of the ABI when operating in Scan Mode 3.

Product Overview:

- GOES-14 SRSOR provides forecasters with 1-min satellite imagery over a roughly 1500x2000 km daily-changing sector.
- 10-min updating AMVs are generated using the visible, infrared-window, and water vapor channel SRSOR data.
- Parallax-corrected 1-min imagery is derived from the SRSOR data.
- GOES-14 SRSOR is expected to be available from April 18 to May 15.

GOES-14 SRSOR Products:

- 1-min visible (1 km) and infrared (4 km) imagery from GOES-14
- New for 2016, parallax-corrected 1-min visible (1 km) and infrared (4 km) imagery from GOES-14
- New for 2016, 10-min updating AMVs derived from GOES-14 SRSOR data

Concept for Operational Demonstration:

- GOES-14 SRSOR imagery, parallax-corrected imagery, and AMVs will be delivered to the HWT via the LDM and formatted for display in EWP AWIPS-II.

Concept for Operations:

- Cloud and moisture data from GOES-R are expected to be centrally produced at OSPO/ESPC and delivered by SBN or PDA.

Product Name: NOAA Unique Combined Atmospheric Processing System (NUCAPS) Temperature and Moisture Profiles

Primary Investigator: Chris Barnet (Science and Technology Corporation, Columbia, MD)

Hazardous Weather Testbed, Experimental Warning Program Relevance:

- NUCAPS provides forecasters with largely observation-based temperature and moisture profiles to aid in severe weather mesoscale analysis.
- NUCAPS profiles help to fill the spatial and temporal gaps that exist in observed vertical temperature and moisture information from radiosondes.
- This evaluation seeks to capture the value added by NUCAPS soundings to the severe weather nowcast and warning process.

Product Overview:

- Of relevance to the HWT/EWP, NUCAPS profiles will be available over the CONUS from EUMETSAT/MetOp-A/B (new for 2016) in the late morning and from JPSS/Suomi-NPP in the early afternoon.
- NUCAPS profile availability provides a plan view of available NUCAPS profiles within a given swath. Quality control flags (new for 2016) indicate profiles that have passed (green) and failed (yellow/red) quality control.
- After selecting a location from the profile availability, the NUCAPS temperature and moisture profile will load on a skew-T diagram in the AWIPS-II/NSHARP application.
- Users can adjust the profile to account for inaccuracies that may exist at the surface and low-levels, identified through comparisons with surface observations.

Product Methodology:

- Product uses an ensemble of microwave-only, regression-based and physical retrieval algorithms to combine Infrared and Microwave measurements to produce temperature, moisture, and trace-gas profiles globally – in both clear and cloudy scenes.

NUCAPS Products:

- NUCAPS Profile Availability (Time/Location) with quality control flags
- NUCAPS Vertical Temperature and Moisture Profiles

Concept for Operational Demonstration:

- NUCAPS from Suomi-NPP is produced at NESDIS/NDE, is delivered over the AWIPS Satellite Broadcast Network (SBN) and has been formatted for display in AWIPS-II.
- NUCAPS from MetOp A/B is produced at NESDIS/OSPO, delivered to the HWT through NASA/SPoRT via LDM, and has been formatted for display in AWIPS-II.

Concept for Operations:

- NUCAPS from JPSS/Suomi-NPP is already being produced at NESDIS/NDE and delivered over the AWIPS SBN operationally. NUCAPS from MetOp-A/B will be added to this operational implementation.
- Future AWIPS-II display and product integration (with radar/satellite/RAOBs/surface observations) will depend on feedback from product demonstrations.