L. Patents and Cooperative Research and Development Agreements (CRADAs) with industry (1i)

Subject of CRADA	Effective Period	Partnering Company
Improving Estimates of Size and Spatial Coverage of Hail	5/2012-5/2017	Willis Re
Radar data provide a new potential source of information to insurance industry	11/2010-11/2015	Atmospheric Environmental Research
Hazardous Weather Algorithm Development	5/2006-5/2011	Weather Decision Technologies
Development, enhancement, and commercialization of severe storm algorithms	4/2003-4/2005	Weather Services International (a Division of Landmark, Inc.)

Patents in Place

1. Simultaneous Differential Polarimetric Measurements and Co-Polar Correlation Coefficient Measurement. Application #8282630. Patent #5500646. Type of patent, utility. Status, expired 7/29/14. Full patent file date, 7/29/1994. Full patent issue date, 3/19/1996. Inventor, Dusan Zrnic.

2. Efficient Estimation of Spectral Moments and the Polarimetric Variables on Weather Radars, Sonars, Sodars, Acoustic Flow Meters, Lidars, and Similar Active Remote Sensing Instruments. Application #9819682. Patent #6448923. Type of patent, utility. Status, expires 3/29/2021. Full patent file date, 3/29/2011. Full patent issue date, 9/10/2002. Inventors, Dusan Zrnic and Sebastian Torres.

Software Disclosures in Partnership with the University of Oklahoma

Several software copyrights have been disclosed through the University of Oklahoma Office of Technology Development (OU/OTD). Intellectual property jointly developed by NSSL staff and Joint Institute partners are managed by the OU/OTD and royalties generated by license fees are distributed to CIMMS for project development needs.

1.The Warning Decision Support System – Integrated Information (WDSS-II) is the second generation of a suite of weather applications and tools for weather analysis and prediction. WDSS-II includes the a) infrastructure to develop, test, and deploy collaborating weather applications on networked, distributed systems; b) tools to ingest data from a variety of weather sensors such as weather radars, satellites, surface observations, lightning mapping arrays, numerical models (such as RUC2), algorithms and systems of weather analysis algorithms such as the ORPG; c) a suite of weather detection, diagnosis and prediction algorithms for many weather phenomena including hail, mesocyclones, tornadoes, precipitation; d) a suite of tools used by such algorithms including tools for accumulation, tracking, clustering, fusing, filtering, quality-control; and e) the 4D display of ingested data and the intermediate and final products of the weather algorithms organized to help both the researcher and the forecaster. The WDSS-II software was disclosed in several parts as shown below:

- OU Disclosure No. 04NOR047C entitled "The Warning Decision Support System – Integrated Information (WDSS-II) Display" authored by Thomas Vaughan, Robert Toomey, V. Lakshmanan, Kurt Hondl, Jeff Brogden, Charles Kerr, Lulin Song, Travis Smith, Gregory Stumpf, and Kevin Scharfenberg; and
- OU Disclosure No. 04NOR048C entitled "The Warning Decision Support System – Integrated Information (WDSS-II) Infrastructure", which provides the tools to ingest data from a variety of weather sensors, authored by Kurt Hondl, V. Lakshmanan, Travis Smith, and Gregory Stumpf; and
- OU Disclosure No. 05NOR007C entitled "The Warning Decision Support System – Integrated Information (WDSS-II) Multi-Radar Algorithms" authored by Kurt Hondl, V. Lakshmanan, Travis Smith, Gregory Stumpf, Jian Zhang, and Robert Rabin; and
- OU Disclosure No. 05NOR008C entitled "The Warning Decision Support System – Integrated Information (WDSS-II) Single-Radar Algorithms" authored by Kurt Hondl, V. Lakshmanan, Travis Smith, Gregory Stumpf, and Kim Elmore; and
- OU Disclosure No. 05NOR009C entitled "The Warning Decision Support System – Integrated Information (WDSS-II) Multi-Sensor Inputs to Algorithms" authored by Kurt Hondl, V. Lakshmanan, Travis Smith, and Gregory Stumpf.

2.The National Radar Mosaic and Quantitative Precipitation Estimation Using Multiple Sensors (QPESUMS) software is a suite of algorithms/processes to obtain a CONUS product of reliable precipitation estimates. The technique integrates the radar data with other observational datasets (satellite, rain gage)
- OU Disclosure No. ####### entitled "QPESUMS"
- OU Disclosure No. ####### entitled "National Mosaic"

The OU/OTD has negotiated several licenses for the commercial use of intellectual property jointly developed at NSSL.
- Weather Decision Technologies Incorporated (WDT):
  - National Mosaic and QPESUMS software
- Weather Services International (WSI), Incorporated:
  - Licensed "Warning Decision Support System – Integrated Information" software (Oct 2005). The licensed system included single radar algorithms and display software for internal use at WSI for ten years.
- Weather Decision Technologies (WDT), Incorporated:
  - Licensed "Warning Decision Support System – Integrated Information" software (Oct 2005). The license agreement provides for the internal use, product generation and distribution, and sublicensing of WDSS-II software. The initial agreement was for 18 months, but was later extended for three additional years.

3. Real-time Digital Beamforming for Cylindrical Phased Arrays
- G. Zhang, D. Zrnic, and L. Borowska: "Joint Signal Processing for
- High Efficiency in MPAR Development and Development" OU Intellectual
- Property Disclosure (#15NOR003), 14 July 2014.

- G. Zhang: "MPAR Scan Strategy with Hybrid Waveforms" OU
- Intellectual Propoerty Disclosure (#14NROR014), 11 October 2013.

4. Hazardous Weather Testbed Spring Experiment

Chris Karstens: Technology disclosure filed with the University of Oklahoma (March 2014).

5. Radar Signal Processing

CIMMS Scientists at NSSL David Warde and Sebastian Torres were awarded University of Oklahoma Invention Disclosure 10NOR002-WARDE for their work "Clutter Environment Analysis using Adaptive Processing: The CLEAN-AP Filter."

Reimbursable Agreements:
- Colorado Water Conservation Board - Hydrometeorology
- Federal Aviation Administration - NexGen Demonstration
- University of Leeds, UK
- Salt River Project - Hydrometeorology
- National Weather Service
- NESDIS
- University of Oklahoma

Salt River Project Formal Reimbursable Agreement:

An agreement was created Oct 10, 2001 and expired April 15, 2003. The collaboration with the Salt River Project (SRP) (electric utility serving Phoenix, AZ) concerned the research and development of rainfall-from-radar estimations and severe weather products for the southwest desert region. Field experiments for studying the North American Monsoon using C-band dual-polarization mobile radar have been carried out. Specific severe storm algorithms (e.g., "haboob" and lighting warning algorithms) have been developed and used at the SRP.

Memorandum of Understanding (MOU) or Memorandum of Agreement (MOA)
- Desert Research Institute
- National Centre for Atmospheric Science
- United Kingdom Meteorological Office
- Univ of Nebraska - Lincoln (Unmanned Aircraft System)

Other Interaction with Industry

National Weather Radar Testbed (NWRT):

The Spy-1 based NWRT Phased Array Radar was developed by 10 partner organizations including two private companies, Basic Commerce and Industries (BCI) and Lockheed Martin. Lockheed Martin estimates its in-kind contribution to be over $1 M.