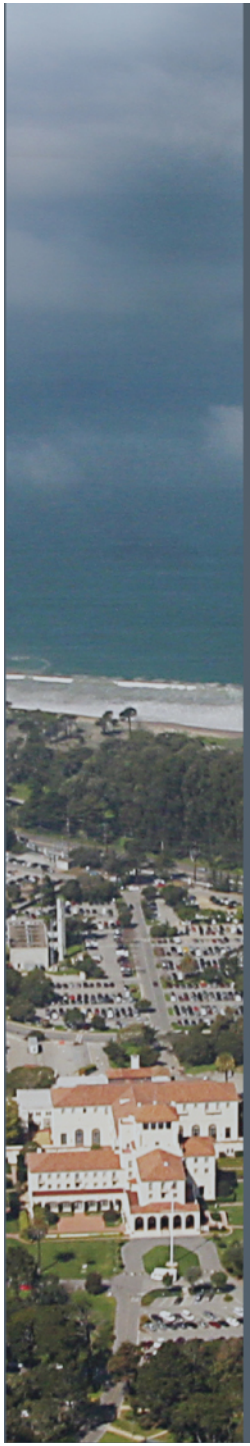

NAVAL
POSTGRADUATE
SCHOOL

Department of Electrical and Computer Engineering Overview of Research, Education and Distance Learning

Roberto Cristi, Ph.D.
Professor & DL Manager
(831) 656-2223

August 2009

Outline

- Why the NPS ECE Department?
- Faculty and Staff
- Laboratories
- Courses for Competency
- Certificates
- Master's Degree Programs
- EE and Ph.D. Degree Programs
- Research Program

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Why the NPS ECE Department?

- World class faculty
- Full spectrum graduate education
  - nanoMEMS – Circuits – Devices – Systems
  - DC - Light
  - Courses - Certificate Programs - Degree Programs
  - Underwater – Surface – Air – Space – Cyberspace
- Programs tailored to customer requirements
- Emphasis on defense and national security
  - In our courses
  - In our research
- Courses with classified content (SECRET & TS/SCI)

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Why the NPS ECE Department?

- **Program Quality Assurance**
  - Programs have defined objectives and outcomes
  - Programs are assessed for educational effectiveness
  - Assessment data are applied for program improvement
- **Flexible, State-of-the-Art Course and Program Delivery**
  - Video Tele-education – two way audio/video, non-resident students take course synchronously with resident students
  - Streaming video
  - Desktop-to-Desktop delivery (Elluminate)
  - Resident/Non-Resident equivalent lab experience
  - Blackboard online course management system
  - On-site instruction (typically 1 week), if desired

Our ECE Faculty

- 22 Tenure Track Faculty (Includes Chair, 3 Assoc. Chairs, ½ Time Assoc. Dean and 3 Academic Associates)
  - 15 Professors
  - 4 Associate Professors
  - 3 Assistant Professors
- 10 Non-tenure Track Faculty
  - 2 Professors of Practice (Space Systems & Computers; Cyber Warfare)
  - 2 Research Professors (1 Assistant; 1 Associate)
  - 3 Research Associates
  - 2 Senior Lecturers
  - 1 Visiting Instructor
- 4 Active Emeritus Faculty
- 3 Contract Instructors

Visit http://www.nps.edu/ece for list of faculty and areas of expertise

Our ECE Faculty

- **IEEE Fellows**
  - **Prof. Jon Butler (Computers)**
  - **Prof. Michael Morgan (Electromagnetics)**
  - **Prof. Tri Ha (Communications)**
  - **Prof. Charles Therrien (Signal Processing)**
  - **Prof. Xiaoping Yun (Controls & Robotics)**
- **Book Authors**
  - 10 Tenure track faculty members have published 14 textbooks

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CY 2007 Faculty Productivity (1)

- 15 Journal Articles Published (2)
- 63 Conference Papers Published (2)
- 13 Presentations (No Publication)
- 5 Technical Reports Published
- 1 Book Chapter Published
- 100 Theses Advised or Co-advised
- 5 Ph.D. Dissertations Supervised
- 116 Course Sections Taught (AY2007) (3)
- External Service: Journal Editors, Conference Steering Committees, Technical Program Committees, Conference Session Chairs, Journal Reviewers, Navy and DoD Panels & Committees

(1) Data for CY2007 collected during winter quarter 2008
(2) Co-authored papers counted for both authors

(3) Inculdes 4 distance learning sections and 4 course sections taught for other departments

Our ECE Staff

- Administrative Staff
  - Administrative Assistant
  - Office Assistant
- Technical Staff
  - Lab Manager
  - 3 Electronics Technicians
    - Circuits Lab and Signals Lab
    - Radar, EW and Secure Computing Labs
    - Microelectronics Lab & Calibration Lab
  - 3 Engineers (2 in Ph.D. Program)
    - Controls & Robotics Lab, Optical Electronics and Laser Lab
    - Electromagnetics (Microwave, Antenna) Lab, DSP Lab, Networking Lab
    - Digital Systems Lab, Ship Electric Power Lab

ECE Laboratories (1)

- EC01 Microelectronics Lab
- EC02 Circuits, Signals and Digital Systems Lab
- EC03 Academic Computing Lab
- EC04 Optical Electronics & Lasers Lab
- EC05 Electromagnetics Lab (Microwave, Antenna)
- EC06 Radar & EW Systems Lab
- EC07 Controls & Robotics Lab
- EC08 Power Lab (Electric Ship Power Systems)
- EC09 Digital Signal Processing Lab

ECE Laboratories (2)

- EC10 Computer Communications and Networking Lab
- EC11 Secure Computing Lab
- EC12 Cryptologic Research Lab
- EC13 Flash X-Ray Lab
- EC14 Signals Enhancement Research Lab
- EC15 Calibration and Repair Lab

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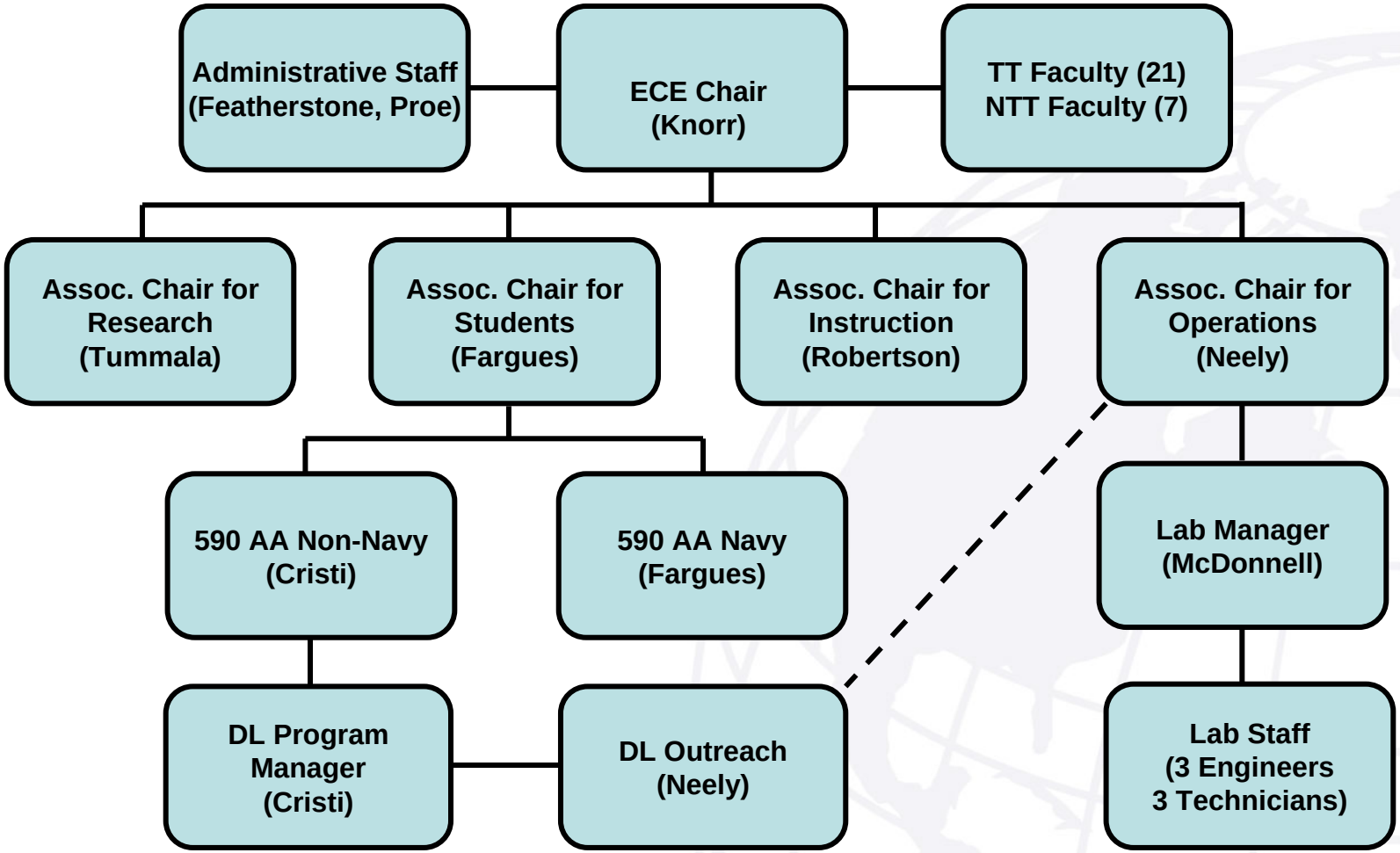
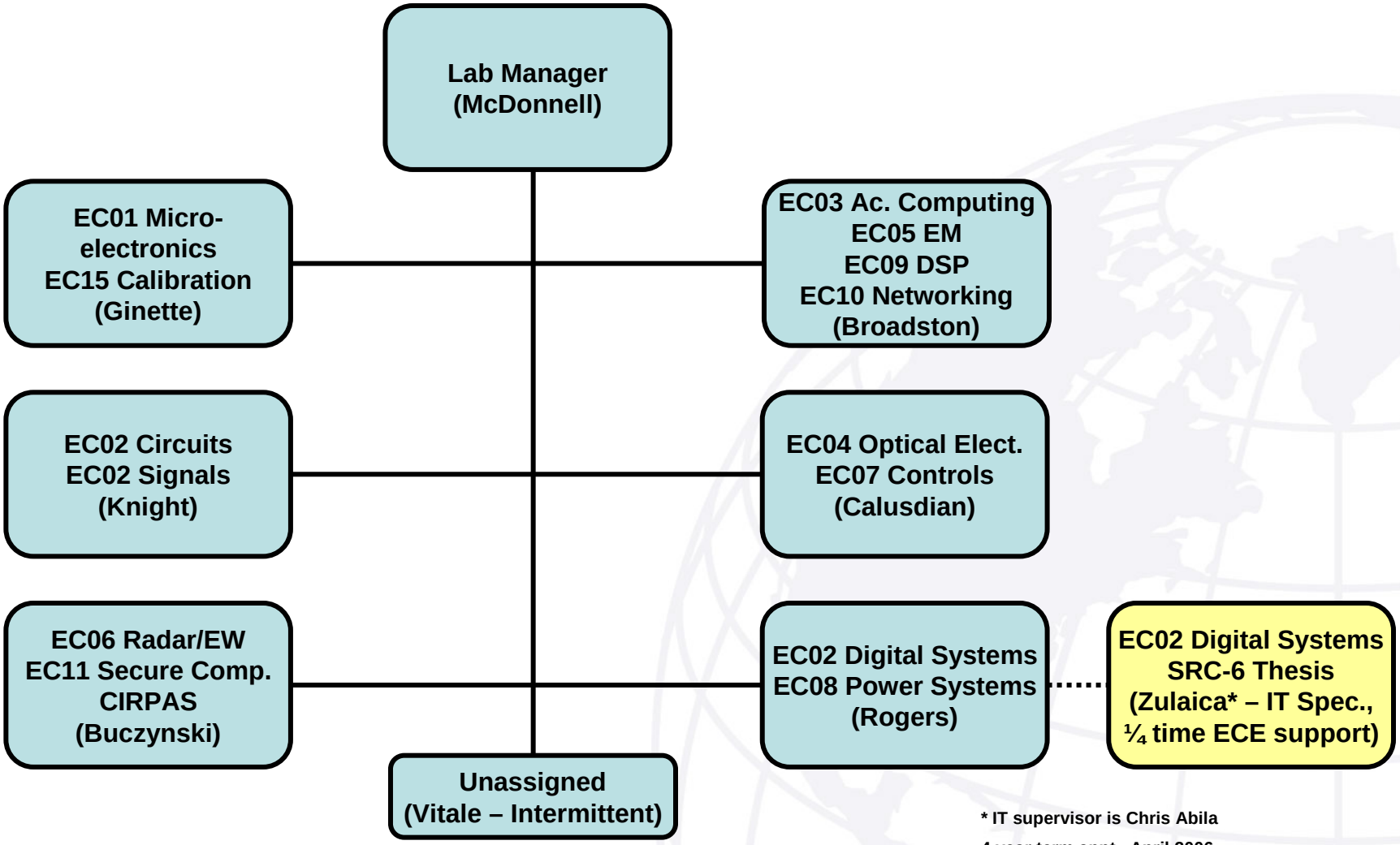
ECE Department Organization



ECE Department Organization



* IT supervisor is Chris Abila

4 year term appt., April 2006

Courses For Competency

- **Courses Are Available in all Core Competency Areas**
  - **Electric Power (power electronics, electric drive)**
  - **Nano/Microelectronics**
  - **Computer Systems**
  - **Network Engineeering (includes cyberspace)**
  - **Guidance, Navigation and Control**
  - **Signal Processing**
  - **Communications**
  - **Sensor Systems Engineering (sonar, radar, IR/EO, EW)**
  - **SIGINT**

Certificate Programs

- ECE Department Certificate Programs: Focused, Graduate Level Education
  - Electric Ship Power Systems
  - Signal Processing
  - Electronic Warfare
    - EW Engineer
    - Journeyman EW Engineer
    - Senior EW Engineer
  - Digital Communications
  - Network Engineering
    - Network Engineering
    - Cyber Warfare
  - Computer Systems
    - Reconfigurable Computing
    - Fault Tolerant Computing
  - Guidance Navigation and Control

- Typical Certificate Program
  - 2 - 4 Graduate Level Courses
  - Minimum of 12 credit hours, 9 at graduate level
  - Must be completed within 3 years of admission
  - GQPR > 3.00 required
  - Courses may be applied toward a degree

EE & CE Degree Programs

- ECE Degree Programs
  - MSEE - Research based; ABET accredited
  - MSES(EE) – Research based
  - MEng(EE) – Course based
  - MSCE - Research based; ABET criteria must be satisfied
  - MSES(CE) – Research based
  - MEng(CE) – Course based
  - Electrical Engineer – Research based
  - Ph.D. – Research based

MSEE Degree Program

- Requirements
  - Satisfy ABET undergraduate program criteria
  - 36 credit hours of course work
  - Satisfy course requirements for a specialty track
  - 16 credit hours of thesis research
  - Deliver thesis presentation and submit written thesis

- Program Duration
  - 1 year (full-time) for BSEE direct input
  - 2 years for students 5-7 years after undergraduate degree

- Program Specialty Tracks
  - Communications Systems
  - Signal Processing Systems
  - Computer Systems
  - Network Engineering
  - Sensor System Engineering
  - Guidance, Control and Navigation Systems
  - Solid State Microelectronics & Power Systems

NAVAL POSTGRADUATE SCHOOL

MSES(EE) Degree Program

- Requirements
  - 36 credit hours of course work
  - Satisfy course requirements for a specialty track
  - 16 credit hours of thesis research
  - Deliver thesis presentation and submit written thesis

- Program Duration
  - 1 year (full-time) for BS direct input
  - 2 years for students 5-7 years after undergraduate degree

- Program Specialty Tracks Same as MSEE

- Courses are the same as those in the ECE Department's ABET accredited MSEE Degree Program

- Students do not need to satisfy ABET baccalaureate or master's level engineering criteria

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MEng(EE) Degree Program

- Requirements
  - 32 credit hours of course work
  - Minimum of 3 courses and 10 credit hours at advanced level (EC4XXX)
  - Minimum of 5 ECE Department courses
  - May include capstone project (customer option)

- Program Duration
  - 3-4 quarters (full-time) for BSEE direct input
  - 2 years for students 5-7 years after undergraduate degree

- Program aimed at practicing engineers

- Courses are the same as those in the ECE Department's ABET accredited MSEE Degree Program

- Students do not need to satisfy ABET baccalaureate or master's level engineering criteria

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Computer Engineering Programs

- Program Overview
  - Electrical & Computer Engineering; Computer Science; Mathematics
  - Three degree paths: MSCE, MSES(CE), MEng(CE)
- Program Requirements
  - 36 credit hours of course work (~10 courses)
  - Five core courses + electives from three groups;
    - Hardware group
    - Software group
    - System group
  - Research and thesis for MSCE or MSES(CE)
- Program Duration
  - 3-4 quarters (full-time) for BSCE direct input
  - 2 years for students 5-7 years after undergraduate degree
- MSES and MEng students do not need to satisfy ABET baccalaureate or master's level engineering criteria

ECE Ph.D. Program

- Goal
  - Provide scholastic background and education necessary to conduct original research in the field of electrical and computer engineering
- Eligibility
  - Sponsored military officers, government employees
  - DoD contractor employees
  - Internationals from selected countries
  - Approved NPS employees
- Timeline Based on Preparation
  - BSEE/MSEE – 3 years
  - BS/MSEE – 3.5 years
  - BSEE – 4 years

ECE Ph.D. Program Entry Process

- Students outside NPS apply through Director of Admissions
  - Online: http://www.nps.edu/Academics/Admissions/ApplyOnline/Index.html
  - GRE/TOEFL required
  - Registrar's office reviews
  - International office reviews (internationals only)
  - ECE Ph.D. Committee reviews

- Students at NPS apply through ECE Ph.D. Committee and Program Officer
  - ECE Ph.D, Committee reviews
  - Registrar's office reviews
  - Military officers must typically seek approval for extension of their tour at NPS

ECE Ph.D. Program Phases

- Preliminary Phase (4-5 Quarters in Residence)
  - Take courses
  - Pass screening exam
  - Form dissertation committee (5 or more faculty)
  - Pass written and oral qualifying exam
  - Satisfy NPS 1 year residency requirement
- Research Phase (7-8 Quarters; may be off-campus)
  - Complete research proposal
  - Conduct research
  - Write dissertation
  - Defend dissertation

Resident Student Enrollment

ESE Students Jan 09	
43	U.S. Navy
12	USMC
14	International
5	US Civilian
1	Other US
75	Total

ECE DL Programs

Two Categories:

- **Synchronous**
  - Regularly Scheduled NPS Classes
  - Regularly Scheduled Exams
- **Asynchronous**
  - Completely selfpaced
  - Faculty “in the loop” for questions, assessments

ECE DL Programs: Synchronous (1)

- Programs Previously Delivered
  - MSEE Degree Programs (10 Qtrs, 1 course/quarter + thesis)
    - NSWC Dahlgren (1 cohort)
    - NSA (2 cohorts)
  - Courses for Competency
    - AFIWC San Antonio
    - NSWC Crane

ECE DL Programs: Synchronous (2)

- Current Programs
  - Electric Ship Power Systems Certificate Program
    - NAVSEA
    - Pear Harbor Naval Shipyard
  - MEng(EE) - Electronic Warfare Certificate Program
    - NAWC/WD Point Mugu and China Lake (two cohorts)
  - MEng(EE) – EW/IO/Cyber Focus
    - NSWC Crane
  - MSES(EE) - Electric Power & Signal Processing Certificate Program
    - Nuclear Reactors
    - Ongoing, new cohorts every two years

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ECE DL Programs: Synchronous (3)

- Future Programs Under Discussion
  - MEng(EE) – SIGINT/Cyberspace/Space Systems
    - SPAWAR Space Field Activity (NRO)
  - MEng(EE) – Electric Ship Power Systems & Systems Engineering
    - Northrop-Grumman (Sunnyvale)
  - Certificate Program for Tactical Networking Engineers
    - Tactical Networking Center of Excellence, SSC San Diego
    - Software Defined Radio (SDR) Focus
    - TNCoE Sponsored by JPEO JTRS

ECE DL Programs: Asynchronous (1)

- Self Paced Courses
- Under development
- Current Offering:
  - EC2450 Signals and Systems as part of ASW Certificate to NSWC (Newport, RI) and others;
- Future Offerings:
  - Signal Processing with Matlab and Simulink: Summer 09
  - DSP Certificate (4 courses): under development

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ECE Campus Short Course Program

- NETWARCOM Short Courses
  - Resident 5 Day Courses, 25 Officers/Course
  - Four Course Program
    - Wireless Communications
    - Applied Antennas
    - Packet Switched Networks
    - Sensor Networks

- Technologies for Information Operations Short Course
  - Resident 3 Week Course
  - Swedish War College Students and Others

- Classified Advanced Technology Update Short Course

- SIGINT Applications, Software Defined and Cognitive Radio Technology Workshop

- Special Ops Maritime Advanced Research & Technology (SMART) Workshop

ECE Research Program

- **Research Program Purpose**
  - Provide cutting edge solutions for project sponsors
  - Provide creative, meaningful student thesis research opportunities: research is an integral part of graduate education
  - Recruit and retain world class faculty
  - Maintain courses at the leading edge of knowledge
- **Research Program Sponsors**
  - ONR, ARO, AFOSR, DARPA, NSF
  - Navy Labs and Warfare Centers
  - Industry (CRADAs)
  - Other DoD (NSA, NRO, etc.)

ECE Research Thrust Areas

- Research Thrust Areas Support Sea Power 21
  - Communications and Signal Processing
  - Nanoelectronics and Computers
  - Sensor Systems Engineering
  - Network Engineering
  - Ship Electric Power and Controls

Visit http://www.nps.edu/ece for list of faculty and areas of expertise

ECE Research Centers

- Center for Signal Processing
  - Prof. Roberto Cristi, Director
- Center for Joint Services Electronic Warfare
  - Prof. Phillip Pace, Director
- Center for Cyber Warfare (planned, not yet approved)
  - Director TBD

ECE Research Alignment With Sea Power 21

Defensive Capabilities
Missile Defense
Directed Energy Weapons
AUVs
Data Fusion
Distributed Weapon Coordination

Enabling Education
Lifelong Learning
Skilled Naval Professionals

Enabling Technologies
Sensors
Communications
Networking
Computers
Controls
Signal Processing

Offensive Capabilities
Intelligence
Surveillance
Reconnaissance
Precision Attack
EW & IO

ECE Alignment with Sea Power 21 Major Enabling Technologies				
Sensor Systems Engineering	Communications and Signal Processing	Network Engineering	Nanotechnology, Microelectronics and Computers	Electric Power and Control

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Research Project Examples

- Silicon Carbide Switch for Solid State Power Substation
- High Speed Numeric Function Generators
- Spacecraft Adaptive Pointing Control
- Reconfigurable Computing for Electronic Warfare
- Weather Signal Processing for Tactical Radars
- Covert Communications using IEEE 802.XX
- Wirelessly Networked Integrated Digital Phased Array
- Digital Image Synthesis for Imaging Radar Countermeasure
- Software Defined Radio for Cognitive SIGINT
- High Speed A/D Conversion for Electronic Warfare
- Rail Gun Power Supply Design

Research Project Examples

- Practical BW Efficient Modulation for Satellites Using TWTs
- Configurable Fault Tolerant Processor for Space Applications
- Maritime Domain Awareness System Demonstration
- Integration of Smart Dust Technology into JTWS
- QoS, Call Management and Handoff for VoIP
- Modeling & Optimization of High Efficiency, Multi-Junction Solar Cells
- Optimal Design of Impulse Antennas
- Detection & Classification of LPI Radars

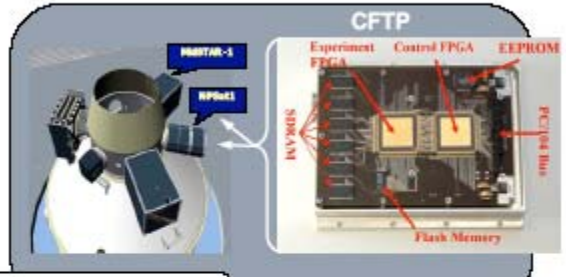
Research Project Examples

- Ballistic Missile Defense Research
- Analysis of Frequency-Hopped Waveforms
- X-Ray Impulse Prediction
- High Mobility GaN Transistor Development
- Counter RF IED Research
- Reduced Crew Size Metrology Using Wireless LANs and Wearable PCs
- Motion Tracking Using Inertial Sensors

Research Project Examples

Configurable Fault-Tolerant Processor for Space Applications

Project Goals
- Demonstrate feasibility of using FPGAs for spacecraft computer processing
- Provide test bed for on-orbit evaluation of various fault-tolerant concepts



STP-1 to launch November 2006 with CFTP on Midstar-1 and NPSat1

Operational Payoff
- Reconfiguration of computers in space fights obsolescence
- Protection against random data and configuration errors

Deliverables
- CFTP delivered to MidSTAR July 2006
- CFTP to be delivered to NPSat September 2006

Technical Basis and Achievments
- Triple-modular redundancy and reduced-precision redundancy used to achieve immunity to single-event effects on data.
- Configuration-error detection/correction techniques developed and tested.
- Configuration-error simulation and visualization techniques developed and tested.
- Cyclotron testing (protons) – both data and configuration error correction techniques – tested in August and November 2005.

Prof. Hersch Loomis, hloomis@nps.edu Space Systems Academic Group, ECE Department, GSEAS
Prof. Alan Ross, aross@nps.edu Space Systems Academic Group, GSEAS
www.nps.edu

Counter– Radio-Controlled, Improvised, Explosive-Device (RC-IED) Research

Project description:
A Marine Corps Systems Command sponsored research effort focused on developing a unique jamming technology utilizing specially developed digital signal processing hardware in order to provide combat vehicle protection by preventing RC-IED detonation.

Cost and Schedule:
Initial funding provided by MARCORSYSCOM for design, construction, and testing of single channel system to be completed by Fall '06. Follow-on funding required for multi-channel system construction and testing.

Current Lab Testing At NPS

Technical Objective: Design, build, and test a counter-RC-IED system capable of defeating specified threats with a high degree of success to be considered for future integration into Marine Corps ground electronic attack systems.

Technology Challenge: RC-IED systems operate at a wide range of frequencies, power levels, and transmission schemes, making the design of an effective defensive system complex.

Technical Approaches: Specially designed receiver technology coupled with unique digital signal processing hardware provides a means to effectively counter RC-IED detonation.

Electrical and Computer Engineering
Graduate School of Engineering and Applied Sciences
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Contact Information
Dr Richard Adler
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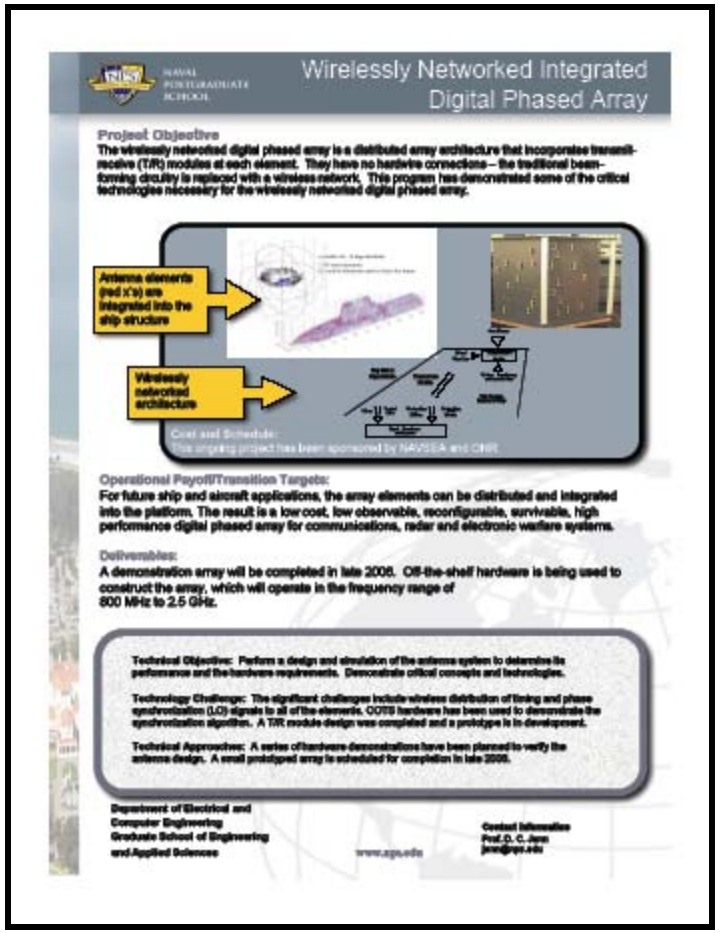
Research Project Examples



Wirelessly Networked Integrated Digital Phased Array

Project Objective

The wirelessly networked digital phased array is a distributed array architecture that incorporates transmit-receive (T/R) modules at each element. They have no hardwire connections – the traditional beam-forming circuitry is replaced with a wireless network. This program has demonstrated some of the critical technologies necessary for the wirelessly networked digital phased array.

Antenna elements (red x'o) are integrated into the ship structure

Wirelessly networked architecture

Cost and Schedule: This ongoing project has been sponsored by NAVSEA and ONR

Operational Payoff/Transition Targets:

For future ship and aircraft applications, the array elements can be distributed and integrated into the platform. The result is a low cost, low observable, reconfigurable, survivable, high performance digital phased array for communications, radar and electronic warfare systems.

Deliverables:

A demonstration array will be completed in late 2008. Off-the-shelf hardware is being used to construct the array, which will operate in the frequency range of 800 MHz to 2.5 GHz.

Technical Objective: Perform a design and simulation of the antenna system to determine its performance and the hardware requirements. Demonstrate critical concepts and technologies.

Technology Challenge: The significant challenges include wireless distribution of timing and phase synchronization (LO) signals to all of the elements. COTS hardware has been used to demonstrate the synchronization algorithm. A T/R module design was completed and a prototype is in development.

Technical Approaches: A series of hardware demonstrations have been planned to verify the antenna design. A small prototyped array is scheduled for completion in late 2008.

Department of Electrical and Computer Engineering
Graduate School of Engineering and Applied Sciences

www.nps.edu

Contact Information
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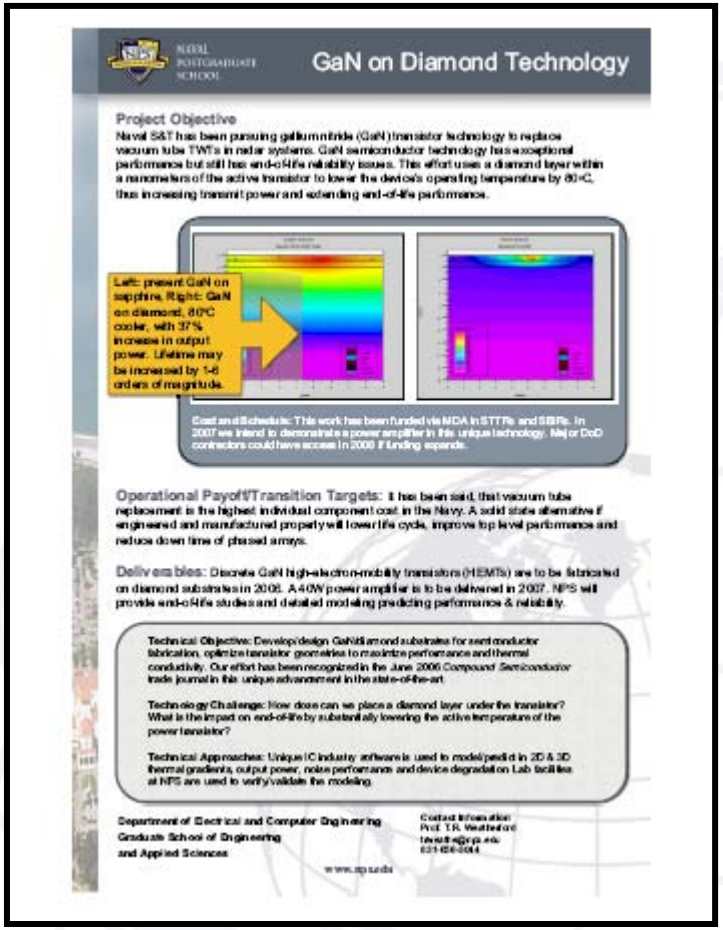

GaN on Diamond Technology

Project Objective

Naval S&T has been pursuing gallium nitride (GaN) transistor technology to replace vacuum tube TWTs in radar systems. GaN semiconductor technology has exceptional performance but still has end-of-life reliability issues. This effort uses a diamond layer within a nanometers of the active transistor to lower the device's operating temperature by 80+C, thus increasing transmit power and extending end-of-life performance.

Left: present GaN on sapphire, Right: GaN on diamond, 80°C cooler, with 37% increase in output power. Lifetime may be increased by 1-6 orders of magnitude.

Cost and Schedule: This work has been funded via MDA in STTRs and SBIRs. In 2007 we intend to demonstrate a power amplifier in this unique technology. Major DoD contractors could have access in 2008 if funding expands.

Operational Payoff/Transition Targets: It has been said, that vacuum tube replacement is the highest individual component cost in the Navy. A solid state alternative if engineered and manufactured properly will lower life cycle, improve top level performance and reduce down time of phased arrays.

Deliverables: Discrete GaN high-electron-mobility transistors (HEMTs) are to be fabricated on diamond substrates in 2006. A 40W power amplifier is to be delivered in 2007. NPS will provide end-of-life studies and detailed modeling predicting performance & reliability.

Technical Objective: Develop/design GaN/diamond substrate for semiconductor fabrication, optimize transistor geometries to maximize performance and thermal conductivity. Our effort has been recognized in the June 2006 *Compound Semiconductor* trade journal in this unique advancement in the state-of-the-art.

Technology Challenge: How does can we place a diamond layer under the transistor? What is the impact on end-of-life by substantially lowering the active temperature of the power transistor?

Technical Approaches: Unique IC industry software is used to model/predict in 2D & 3D thermal gradients, output power, noise performance and device degradation. Lab facilities at NPS are used to verify/validate the modeling.

Department of Electrical and Computer Engineering
Graduate School of Engineering and Applied Sciences

www.nps.edu

Contact Information
Prof. T.R. Weatherford
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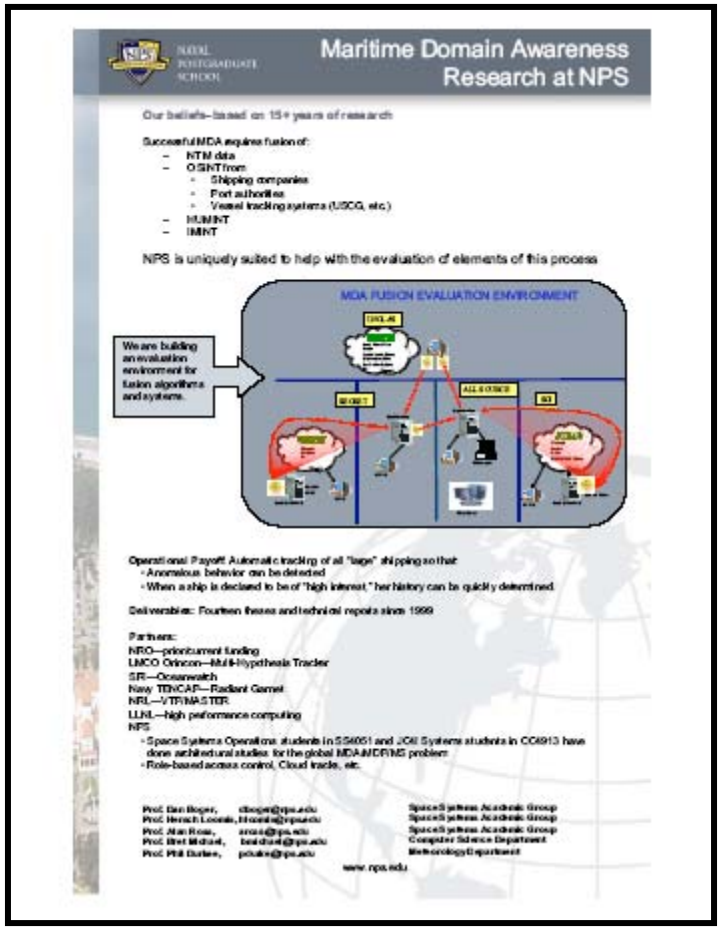
831-656-3044

Research Project Examples



Maritime Domain Awareness Research at NPS

Our beliefs–based on 15+ years of research

Successful MDA requires fusion of:
- NTM data
- OSINT from
  - Shipping companies
  - Port authorities
  - Vessel tracking systems (USCG, etc.)
- HUMINT
- IMINT

NPS is uniquely suited to help with the evaluation of elements of this process

MDA FUSION EVALUATION ENVIRONMENT

We are building an evaluation environment for fusion algorithms and systems.

Operational Payoff: Automatic tracking of all "large" shipping so that:
- Anomalous behavior can be detected
- When a ship is declared to be of "high interest," her history can be quickly determined

Deliverables: Fourteen theses and technical reports since 1999

Partners:
NRO—prioritizement funding
LMCO Orincon—Multi-Hypothesis Tracker
SR—Oceanwatch
Navy TENCAP—Radiant Gamet
NRL—VTP/MASTER
LLNL—high performance computing
NPS
- Space Systems Operations students in SS4051 and JOE Systems students in CC4913 have done architectural studies for the global MDA/MDPMS problem
- Role-based access control, Cloud tracle, etc.

Prof. Dan Boger, dboger@nps.edu — Space Systems Academic Group
Prof. Hersch Loomis, hloomis@nps.edu — Space Systems Academic Group
Prof. Alan Ross, aross@nps.edu — Space Systems Academic Group
Prof. Bret Michael, bmichael@nps.edu — Computer Science Department
Prof. Phil Durbin, pdurbin@nps.edu — Meteorology Department

www.nps.edu

Radar Weather Processing

Project Objective
The NPS Weather Radar Project objective is to develop the technology for adding a parallel weather processing capability to tactical military radars and to develop an advanced scientific instrument for investigation of atmospheric phenomena.

Operational Payoff:
The payoff for the military will be the integration of current weather data into the tactical radar picture. The payoff for the scientific community will be the availability of an advanced instrument for investigation of atmospheric phenomena.

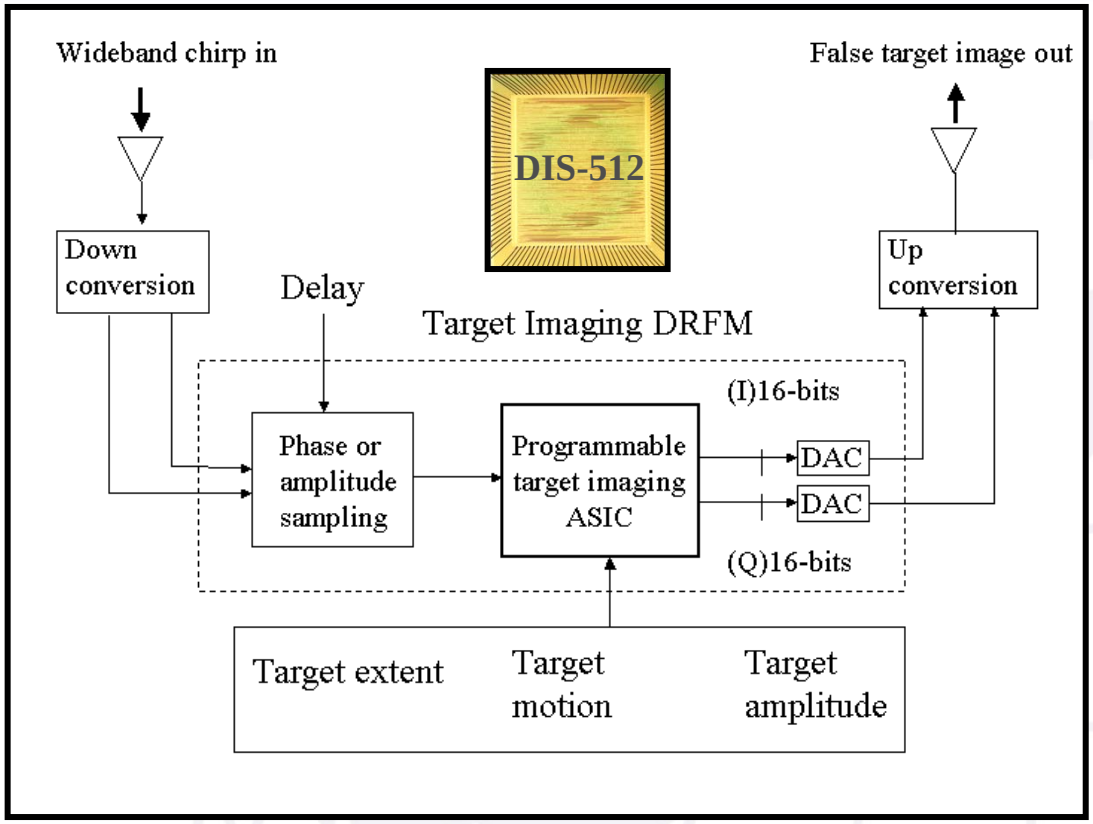
NPS Project Contributions:
System Integration and Maintenance - NPS integrated the radar and generators onto the mobile platform and performs ongoing system maintenance.
Theoretical Analysis – NPS derived and will experimentally verify calibration and parameter estimation algorithms for frequency agile, phased array radars.
System Calibration – NPS is calibrating the radar.
System Operation, Test and Evaluation – NPS operates the radar, uses the radar in on-going experiments and evaluates results to identify new research problems.
Publication – NPS publishes research results of archival value to the scientific community.

Prepared for: Executive Business Course Reception
Prepared by: Department of Electrical & Computer Engineering
Graduate School of Engineering & Applied Sciences
August 16, 2006

Research Project Examples

IMAGING RADAR DECEPTIVE ECM

- Expected 600-800 MHz clock speed
- Contains 512 fully-programmable range bin processors (512 tapped delay line)
- Dynamic range 16-bits (96 dB)
- Capable of system integration and field testing in FY05
- Scalable/generic mask design compatible with 0.18 um CMOS process



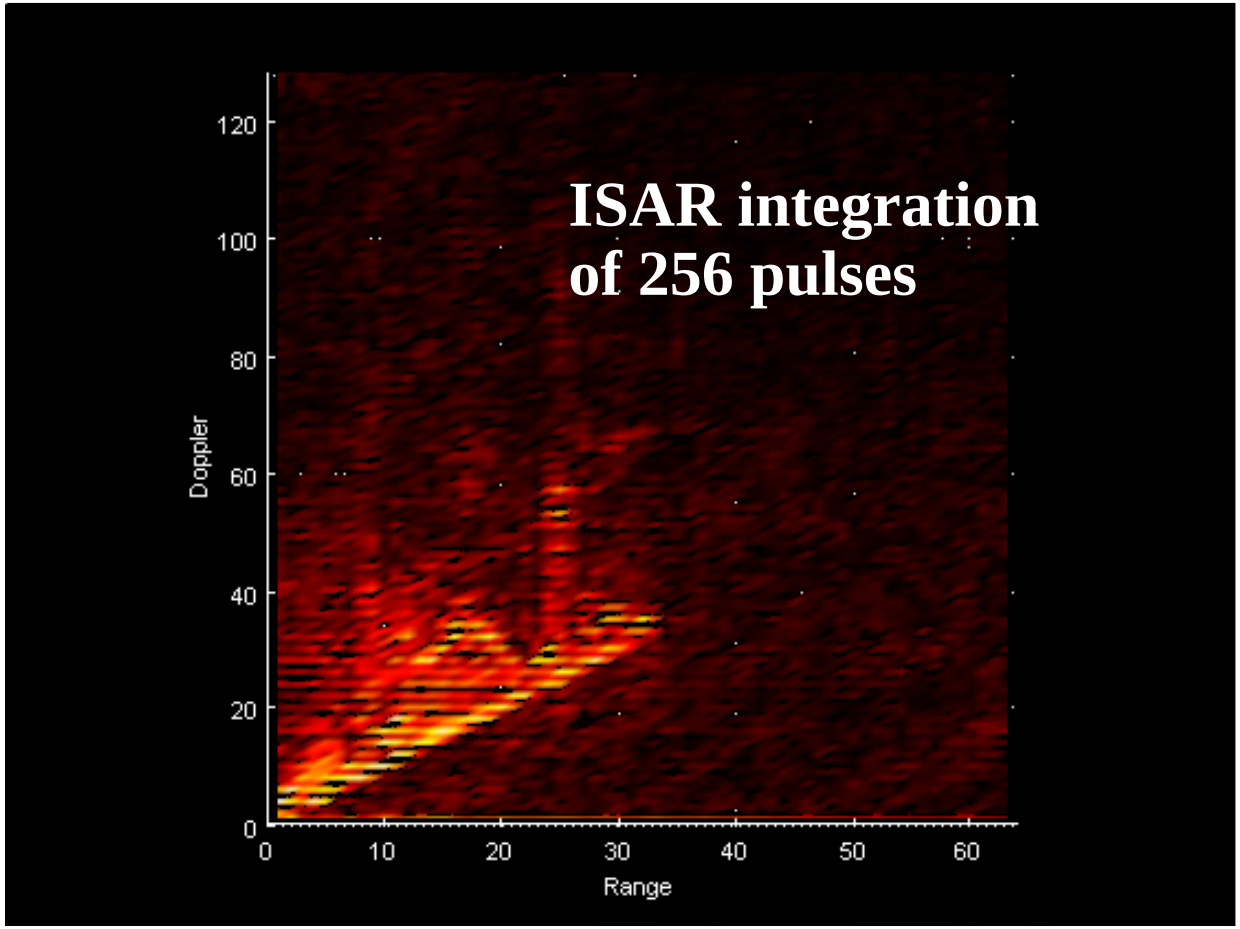
- Range resolution: dependent on clock

$$R_R = (f_{clk} * 2\text{e-}9\ \text{s/ft})^{-1} = 0.7\text{ft (@700MHz)}$$

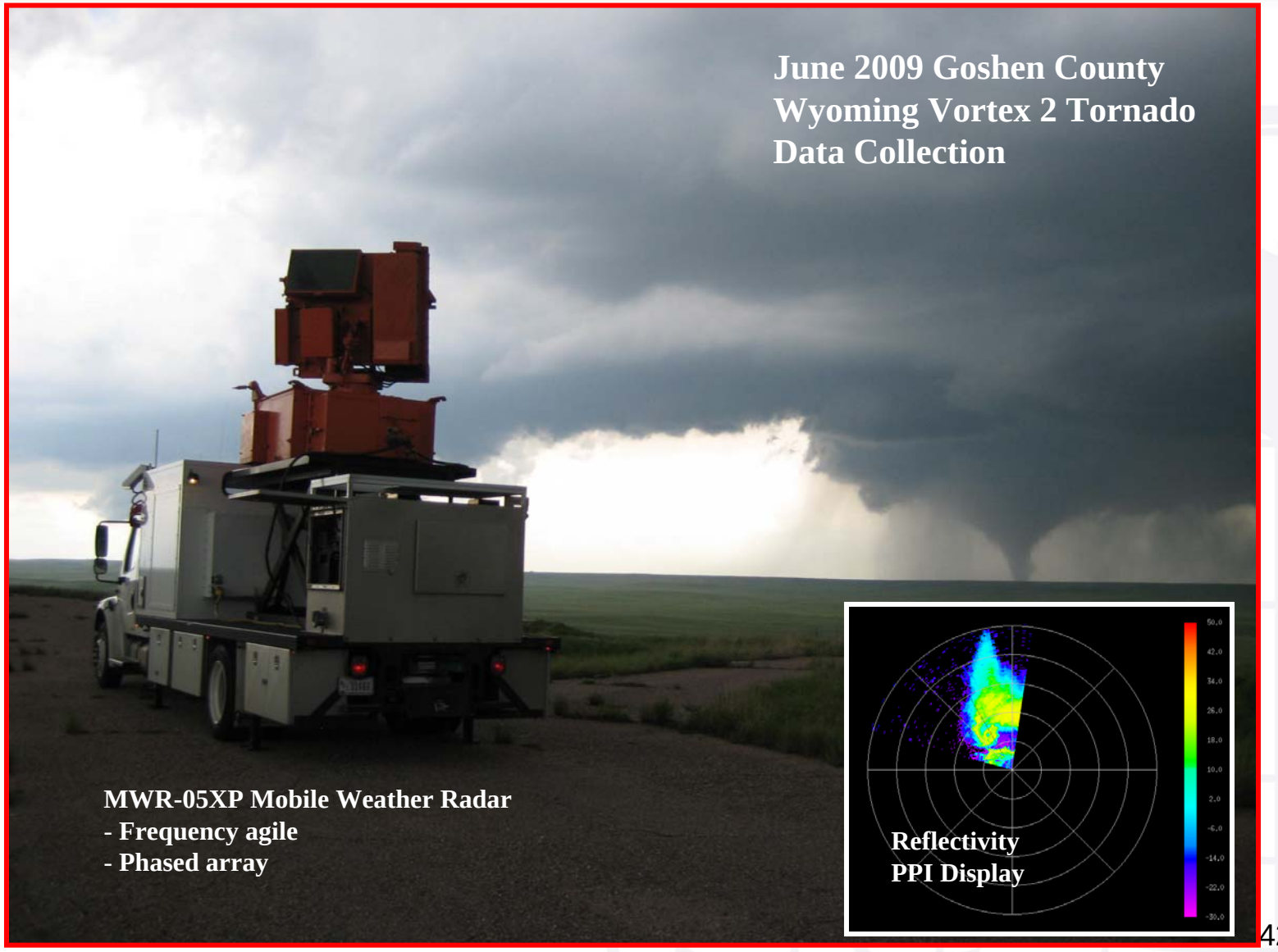
- Doppler resolution: depends on ISAR integration factor

Research Project Examples

DIS-512 False-Target Simulation Results



Radar Weather Signal Processing



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GIFC Operational Concept – Multiple Threats