GMU C4I & Cyber Center

Dr. Mark Pullen

Dr. Michael Hieb

Center of Excellence in Command, Control,
Communications, Computing, Intelligence & Cyber

http://c4i.gmu.edu

George Mason University

- Enrollment is 33,000, with students studying in 198 degree programs at the undergraduate, master's, doctoral and professional levels.

- Mason is distributed across three campuses – Fairfax, Arlington and Prince William counties.

- In 2012, U.S. News & World Report named Mason the number one university to watch on its Up and Coming School list.

- The Times of London named Mason among the Top 100 Under 50, which identified the top 100 universities in the world that are under 50 years old.

Volgenau School of Engineering

- Founded in 1985
  (as the School of Information Technology and Engineering)
- First PhD in Information Technology in the USA
- Also, the only civil institution with a C4I Center

Volgenau School of Engineering

- Faculty
  - 105 Tenured or Tenure Track
  - 56 Term, Instructional, and Research
- Students
  - 2,986 undergraduate
  - 1,795 graduate
- Degrees
  - 8 undergraduate and 21 graduate
  - Alumni: 15,997 – 85% live in DC Metro Area
- No. 28th in the US in MS degrees awarded
- Also No. 28 nationwide in graduate enrollments (rankings from ASEE)

Volgenau School of Engineering

Departments

- Systems Engineering & Operations Research
- Computer Science
- Electrical & Computer Engineering
- Civil Environmental & Infrastructural Engineering
- Applied Information Technology
- Statistics
- Bioengineering

Volgenau School of Engineering

- Centers (~ 40% of research expenditures)
  - C4I
  - Secure Information Systems
  - Air Transportation Systems
  - Learning Agents

- Top-30 ranking for the Systems Engineering & Operations Research Dept. (US News, 2013)

- Computer Science No. 53 in US (47th in funding)

C^{4}I Center Goals

- Provide an intellectual basis for C4I

- Integrate theories and results across multiple disciplines to increase understanding at C4I systems level

- Synthesize and Analyze C4I systems, applications and tools

- Bridge cultural gaps among government, industry and academia in C4I

C⁴I Center Mission

- Perform advanced research in Military Information Technology
  - Be recognized as premier source of knowledge and innovation
  - Provide advice and assistance to military and civil authorities
- Serve as a bridge between military requirements and faculty who possess relevant expertise

C^{4}I Center Focus Areas

Broad spectrum of research and education across:

- Sensing and Fusion
- Command Support
- Communications and Signal Processing
- Information System Architectures
- Modeling and Simulation
- Distributed Education and Training
- Cyber in all of the above

Recent Sponsors

- Air Force Research Lab (AFRL)
- Defense Advanced Research Projects Agency (DARPA)
- Defense Information Systems Agency (DISA)
- Defense Intelligence Information Enterprise (DI2E)
- Defense Threat Reduction Agency (DTRA)
- Intelligence Advanced Projects Agency (IARPA)
- Joint IED Defeat Organization (JIEDDO)
- Lockheed-Martin Corp. (LMCO)
- Office of Naval Research (ONR)
- Raytheon
- Saab Corporation (Sweden)
- US Army Engineer R&D Center (ERDC)
- US Army G3/G6 (under subcontract to BAH)
- US Army SIMCI (PM-Mission Command and PM-Simulation)
- US Joint Forces Command J7 and J9 (JFCOM)
- USMC PM Intel (under subcontract to ManTech)

Staffing

- ~20 tenured/tenure-track faculty members affiliated
  - from across IT&E, based on expertise/experience
  - about half will be PIs or Co-PIs leading projects
- ~20 research faculty
  - most often work with tenure/tenure-track project leaders
- ~10 administrative & technical support staff (full or part-time)
  - roughly half in general support of the center
  - remainder attached to specific projects
- Most of the faculty and staff hold security clearances
  - several hold SCI clearance
- About 30 graduate students (including research faculty)
  - roughly half doctoral students and half Master's students
  - Computer Science; Computer, Electrical, Software and System Engineering; Operations Research; Engineering Statistics
- One or two visiting researchers

Partnerships

Many projects performed cooperatively with other organizations, e.g.:

- Industry/academic teams, either as the lead or as a member
- Industry, as a subcontractor
- Other universities, in academic studies
- Other units of GMU, particularly other Centers
- Government organizations and FFRDCs, in policy or technology studies

Currently have ten Industry Partners

- Large and small

External Activities

- Web page
  - http://c4i.gmu.edu

- Seminars by C4I Center faculty and visitors
  - All C4I Center faculty and visitors
  - Online and recorded for playback
  - Many co-sponsored by departments

- Annual symposium
  - "Critical Issues in C4I" Symposium with AFCEA
  - Next occurrence: 21-22 May 2013 Johnson Center

- Advisory group
  - Nationally-recognized senior leaders
  - Organized by Director Emeritus Van Trees

- C4I Center Fellows from government and industry

- Industry partners

Relationships Within Volgenau School and GMU

- The C4I Center's activities cut across all elements of the Volgenau School of IT&E in synergistic relationships
  - benefits from expertise of Departments
  - provides value to them by bringing in external resources to support projects.

- The Center is affiliated with other IT&E activities
  - System Architectures Laboratory
  - Evolutionary Computation Laboratory
  - Center for Secure Information Systems
  - Center for Distributed and Intelligent Computation
  - Learning Agents Center
  - Sensor Fusion Laboratory

- And with the GMU Department of Geography and GeoInformation Science (GGS)

Academic Activities

- The Center is associated with the C4I Specialization of the MS in Systems Engineering
  - Looking for growth and additional breadth in this program
  - Will recruit and build on military graduate students

- Partnership with NPS in C4I and Modeling/Simulation to strengthen the Center
  - Web-based Virtual Simulation
  - Agile Acquisition of C4I Systems

- The Center has a Symposium in May (co-sponsored with AFCEA), a Seminar Series and many Publications that address current Critical Issues in C4I
  - Access through our webpage http://c4i.gmu.edu

Recent Major Projects

- DARPA Megacities Simulation Study
  - Analysis for developing a next generation simulation environment

- Inference Enterprise Multi-Modeling
  - Integrating multiple models to evaluate and forecast performance of enterprises at detecting insider threats

- Battle Management Language (BML)
  - Command & Control – Simulation Interoperation
  - Joint, Coalition (NATO), Geospatial, Multi Agency"

- US Army Simulation to Mission Command OIPT
  - Developing Interoperability between Army Simulations and C2 Systems

- Close Air Support Experimentation
  - Supporting US Air Force effort to shape new technologies while "bending the cost curve"

C4I Center Key Personnel

- Dr. Mark Pullen, Professor of Computer Science
  - Director of the C4I Center and recognized Expert in Internet Technologies applied to C2 and Simulation
- Dr. Kathryn Blackmond Laskey, Professor of Systems Engineering & Operations Research
  - Long-term cornerstone of C4I Center; applies information technology to support better inference and decision making
- Dr. Michael Hieb, Research Associate Professor
  - C2 & Simulation expert, in demand by DoD; International Projects
- Dr. Paulo Costa, Associate Professor
  - Semantic Technologies expert; retired Brazilian AF Lt Col
- William Roeting, Research Professor
  - Systems Interoperability Prototyping; retired USN Captain
- Dr. Tod Levitt, Research Professor
  - Pattern Recognition & Artificial Intelligence; Designated firefighter

Sample of Research Projects
in the
C4I & Cyber Center

Cyber-ARGUS Framework - Measuring Cyber-Impact on the Mission

PhD Candidate: Alexandre de Barros Barreto - ITA
Advisor: Edgar T. Yano - ITA

# Cyber Impact Evaluation for Critical Infrastructure

The **Cyber-ARGUS Framework** Links Mission Information to Network Information to Assess Cyber Impacts

ADS-B Cyber Security

GPS Track

GPS Track

GPS Track

ADS-B
Radio Station Relay

ATC Center
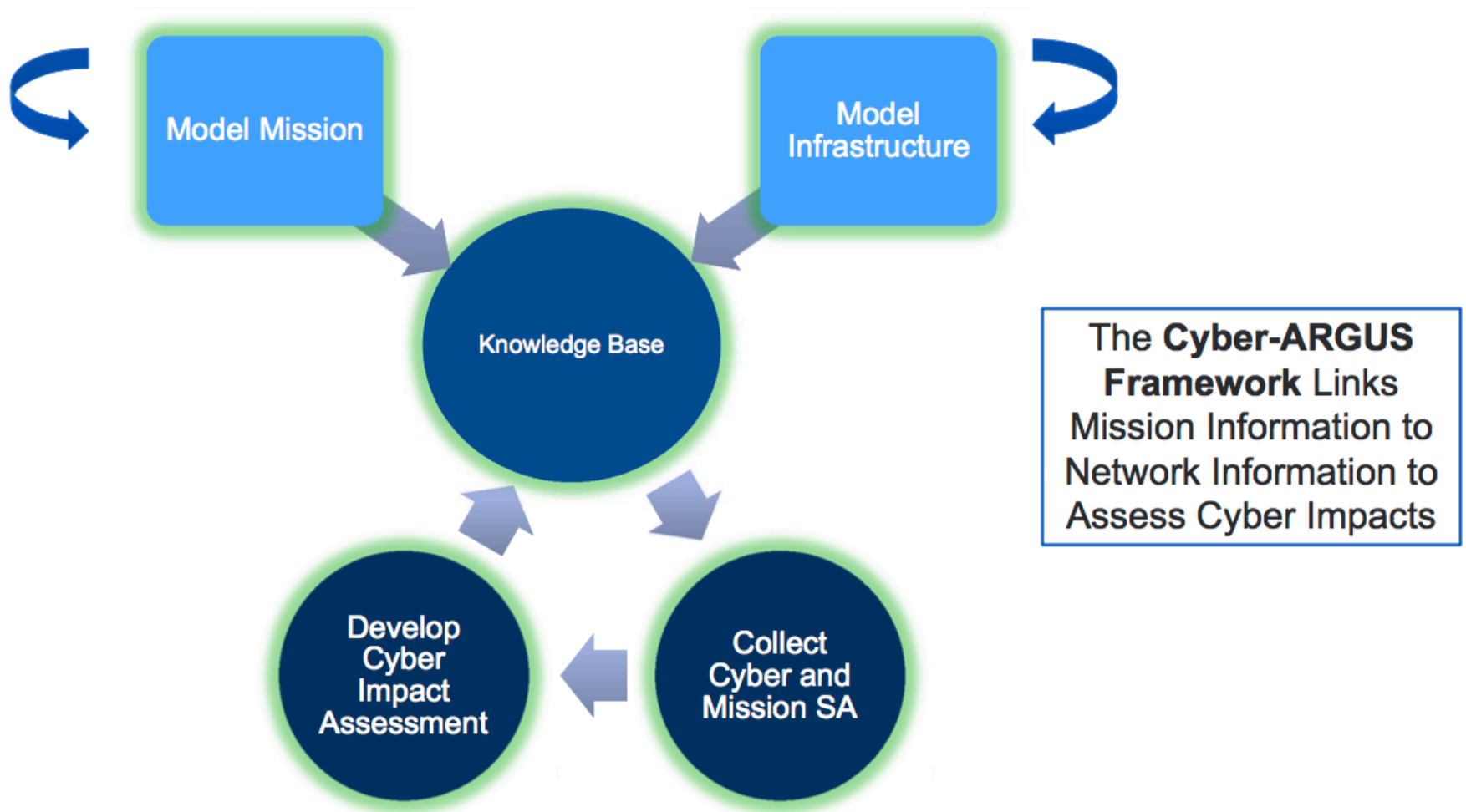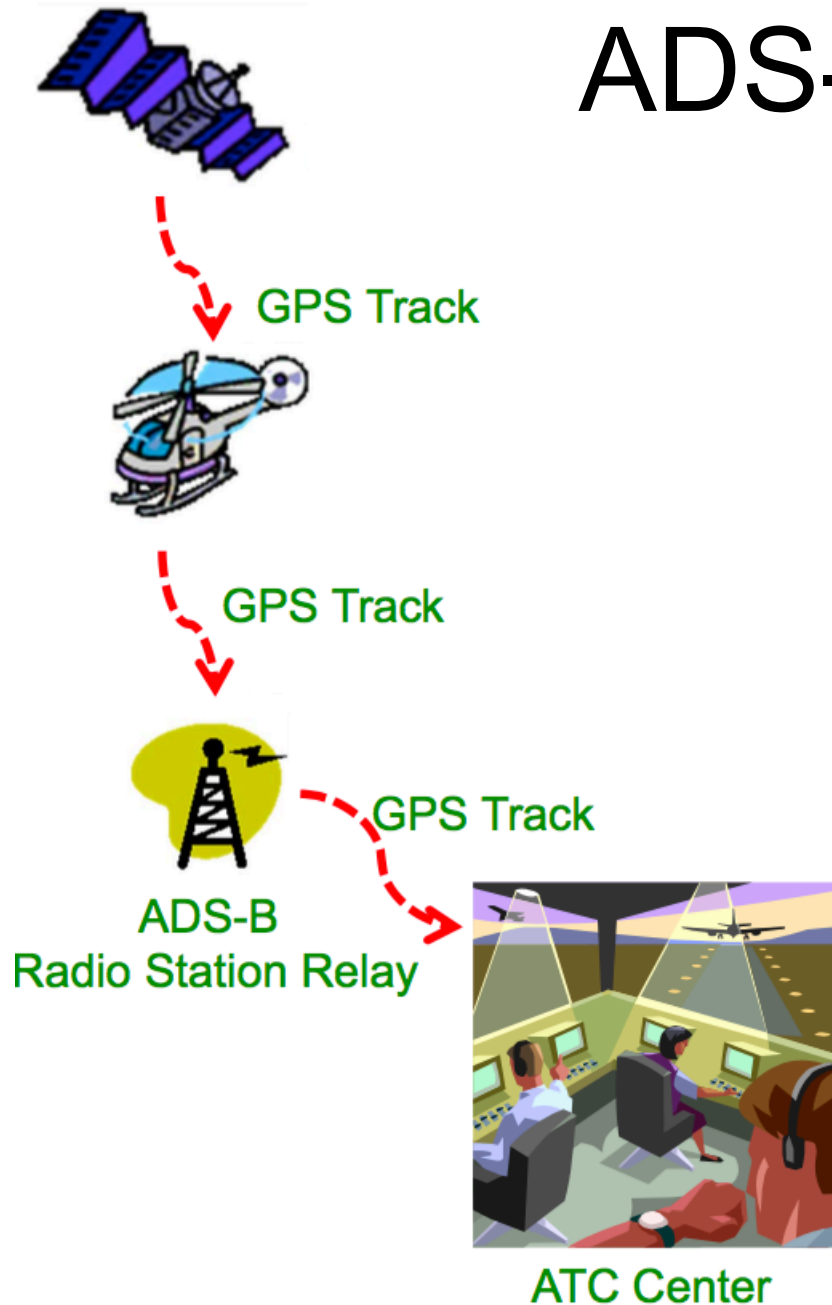
- ADS-B is an emerging software defined radar technology.
  - ✓ Already deployed in Europe and Australia.
  - ✓ Deployment in the US is underway as part of the Next Generation Transportation Systems (NextGen).

- In spite of its benefits, this technology has been widely criticized for being designed without security in mind,
  - ✓ It is vulnerable to numerous attacks.
  - ✓ Most approaches addressing this issue are not organized in a systematic way and often try to solve only part of the problem, e.g.. detecting or mitigating attacks at the radio or the networking layer.

- Our approach: Security from the ground-up, based on misuse cases that can build customized resilient software defined RADAR applications.

C2 Collaborative Research Testbed
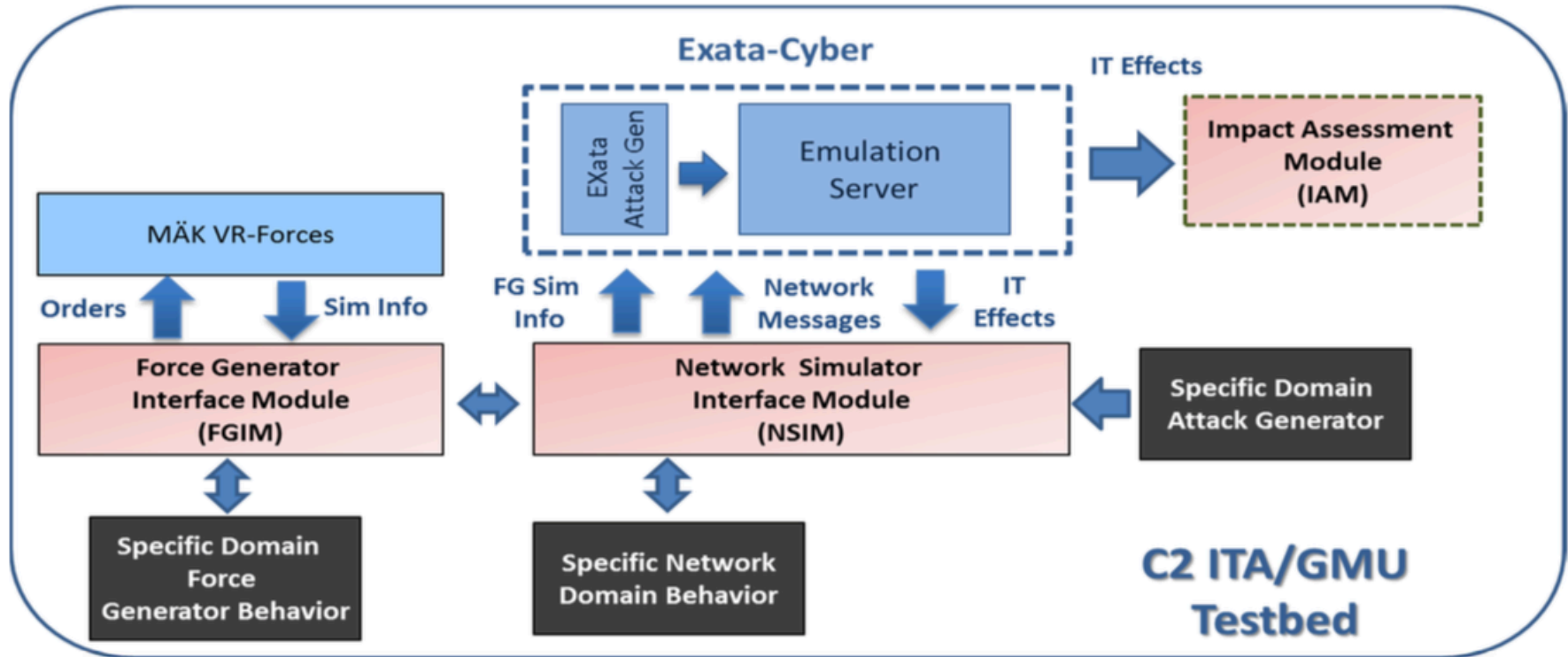
The C2 Collaborative Research Testbed is a set of Commercial Off-the-Shelf (COTS) tools that provides a realistic and complex simulation environment to conduct C2 research experiments.

ITA
Instituto Tecnológico de Aeronáutica (Technological Institute of Aeronautics) is a Brazilian Top Tier Engineering School.
http://www.ita.br/ingles/ingles.htm

NATO BML
Group
Established
In 2006

12 Nations
Currently
Attending
Meetings

Predecessor
won NATO
Science award
2013

Standardization for C2 Simulation Interoperation

Modeling Command Intent

We developed our C2 Grammar such that it includes Command Intent, Tasking and Coordination.

Tasking → Command_Intent   OB   Coord_Space   Coord_Time

OB is a basic order expression by which tasks are assigned to units. OB consists of a tasking verb and constituents.

The production rules (OB) for the **basic expressions** have the following general form:

OB → Verb Tasker Taskee (Affected | Action)
       Where Start-When (End-When) Why Label (Mod)*

"Verb" is an action, normally a task

"Tasker" is a "Who", the unit which commands the task

"Taskee" is a "Who", the unit which executes the task

"Affected" is a "Who", the unit which is affected by the task

"Action" is another action/task affected by the task

"Where" is a "location phrase"

"When" is a "time phrase"

"Label" is a label given to a task to allow it to be referred in other basic expressions

"Mod" refers to conditional modifiers

SciCast

- Crowdsourced forecasting platform for S&T
- Distributed cloud-based user interface aggregates expertise of diverse participants from around the world
- Unique *combinatorial prediction market* exploits interdependencies among events
- Substantially improved accuracy over baseline
- Currently transitioning to internal Department of Energy site
- 10,000+ forecasters made 125,000+ forecasts on 1200+ questions
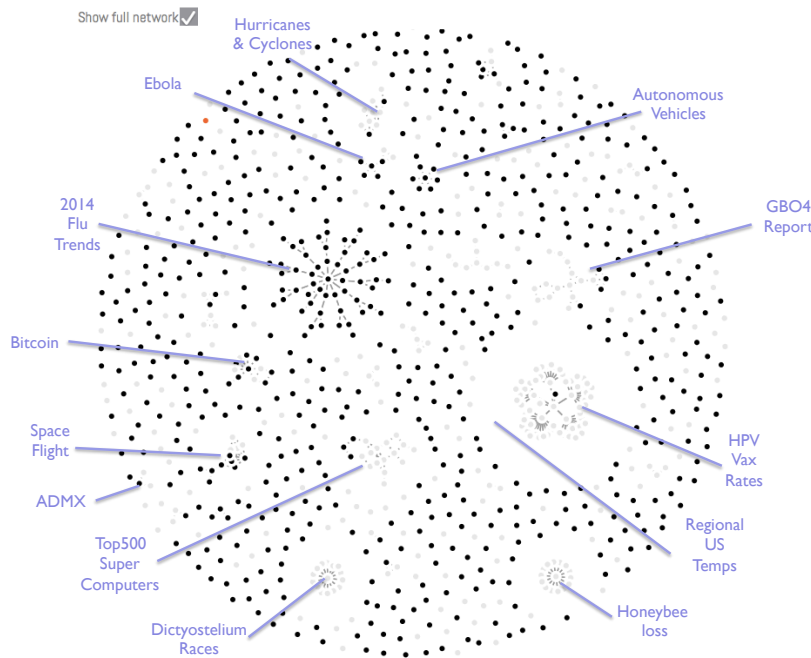
The SciCast Question Network

Situation Understanding via TND Exploitation

- Identify and track all telecommunications and network capable devices (TNDs) in a region of interest (ROI)
- Detect all militarily relevant comms by active exploitation of TNDs in ROI
- Infer roles, activities and intent of TND users
- Utilize rainbow-civilian TNDs for military purposes
- Coordinate TND-level exploitation with national asset exploitation
- Massively concurrent, undetected TND exploitation

Academic Plugfesting

- Grew out of work with AFCEA and Esri to demonstrate rapid integration solutions

- Hosted HQ USAF "Bending the Cost Curve" plugfest January 2015

- Sponsored by Defense Intelligence Information Enterprise and hosted their Plugfest 2013/14/15

- Built an open source integration of Common Map API outside of Ozone Widget Framework

  - Successful agile development completed May 2014
  - Aumented with new features for DI2E Plugfest 2015

Backups