THE EVOLUTION OF THE C4I CENTER

HARRY VAN TREES

BACKGROUND

- B.Sc., United States Military Academy, West Point
- Sc.D. MIT
- Professor of Electrical Engineering, MIT
- Author, three volume series, Detection, Estimation, and Modulation Theory
- Chief Scientist
  - Defense Communications Agency
  - United States Air Force
- Principal Deputy Asst. Secretary of Defense, Acting Asst. Secretary of Defense, C³I
- President, M/A-COM Government Systems

ARRIVAL AT GEORGE MASON IN 1987

➢ **Andy Sage, Dean of Engineering, had authored several books in the detection and estimation area but we had not met**

➢ **Over lunch, offered endowed chair in Electrical Engineering and Systems Engineering – spent the fall getting acclimated**

➢ **Minor issues:**
- **Didn't have an endowment**
- **Didn't consult department heads**

➢ **My objectives:**
- **Create world-class C^{3}I Center**
- **Develop comprehensive C^{3}I curriculum**
- **Finish volume 4 of "*Optimum Array Processing*" of DEMT series**

GEORGE MASON UNIVERSITY IN 1987

➢ **President was George Johnson**

➢ **Solid EE Department focused on teaching**

➢ **Very little external research support**

➢ **Almost no organizational structure**

➢ **Good location**

➢ **Talented workforce in area as potential graduate students**

MOTIVATION FOR C^{3}I CENTER

➢ **Many people working in the C^{3}I area didn't understand C^{3}I**

➢ **Intellectual challenge to put together a coherent development**
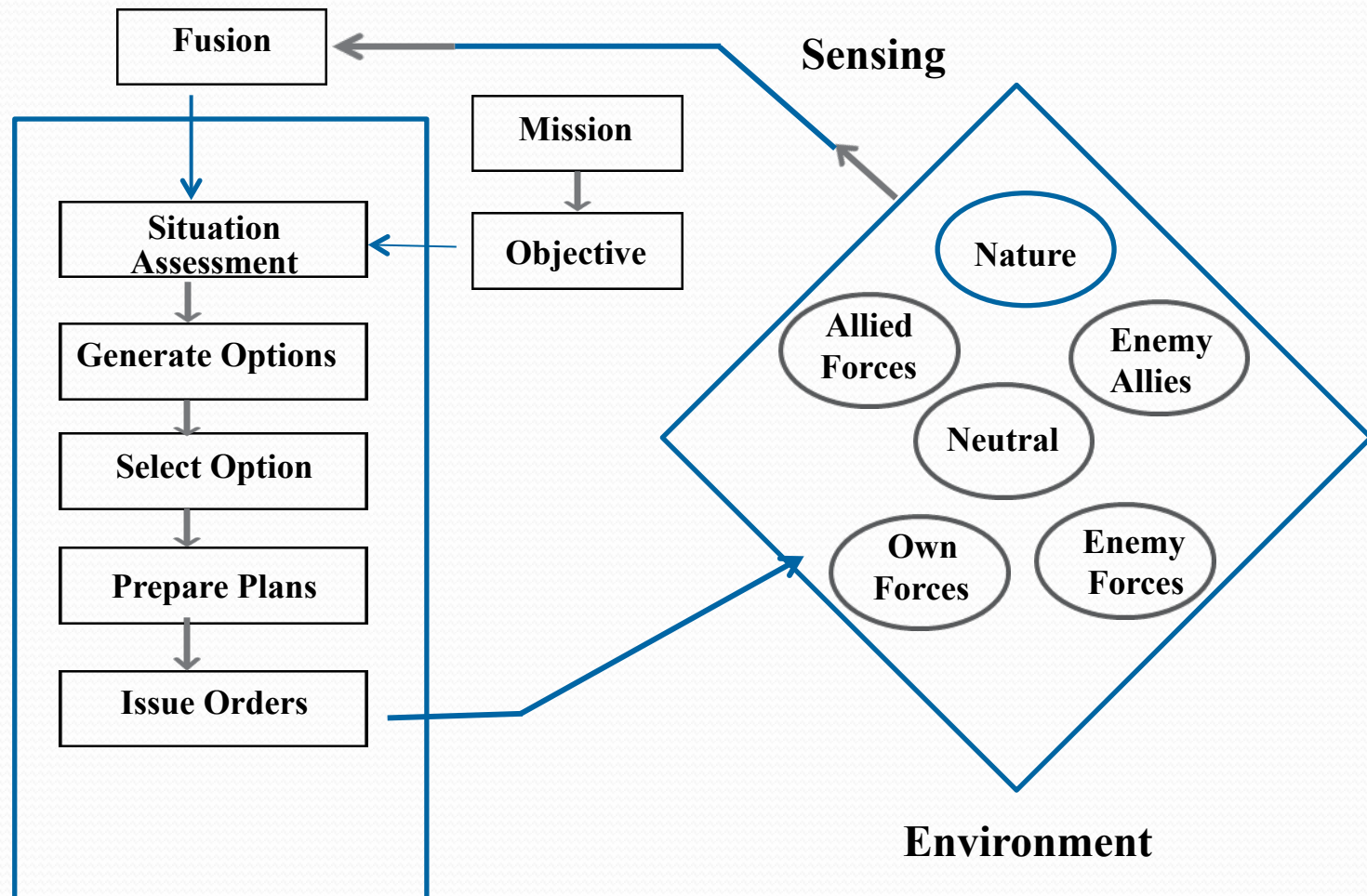
RELATED ACTIVITIES

➢ **In 1982, co-founded with Admiral Jon Boyes, the President of AFCEA, the** *"AFCEA Professional Development Center"*

➢ **Taught the two original one-week classified courses:**

- *Command, Control, and Communications*
- *Military Satellite Communications*

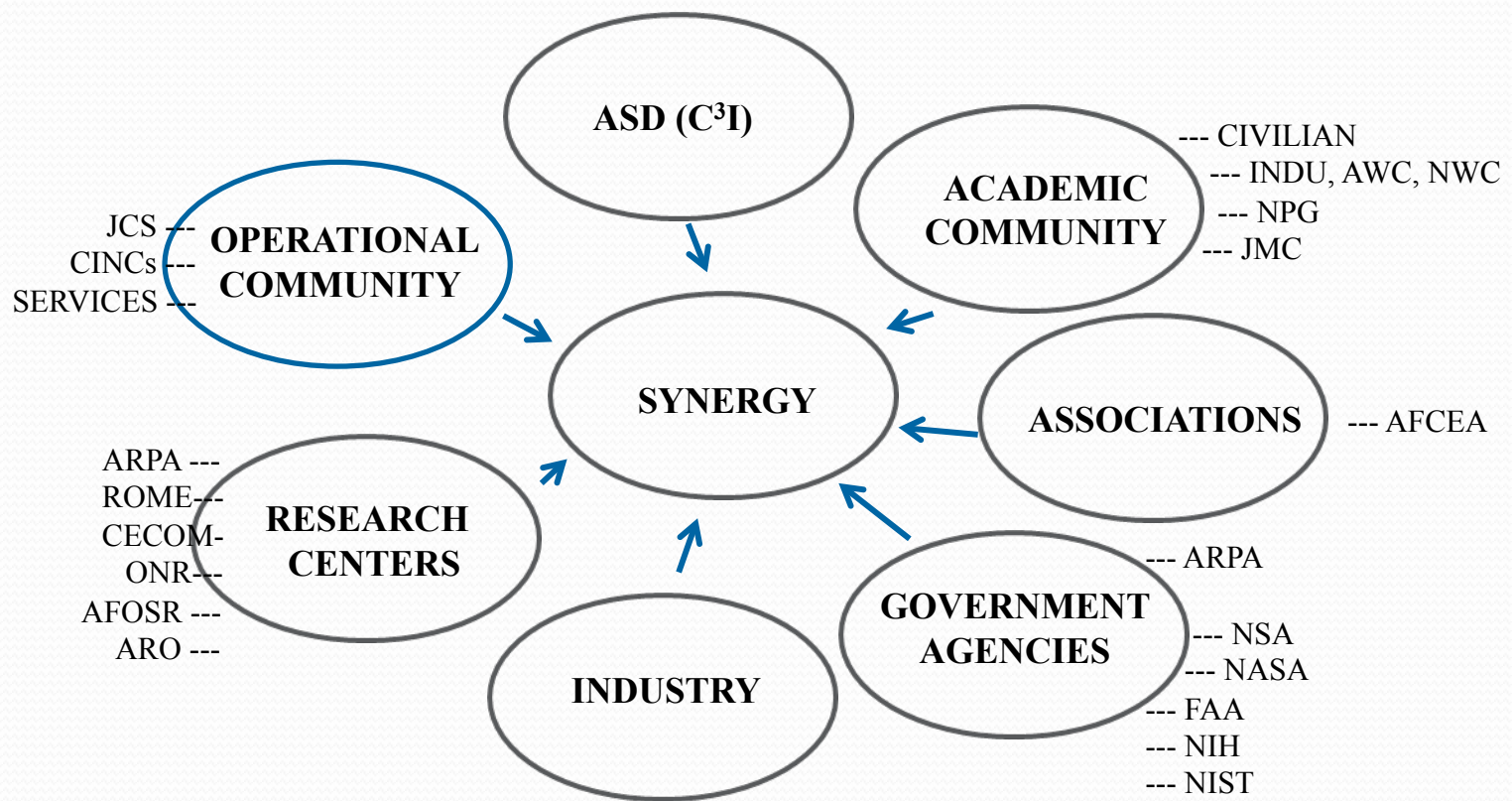➢ **In addition to my** *"day job"*

OBJECTIVES OF THE CENTER

➢ Conduct a broad spectrum R & D program in C^3I

➢ Bring together a diverse collection of talents through an industrial, government and academic fellows-in-residence program

➢ Develop a C^3 curriculum, offer an M.Sc. In C^3I, and act as a focus for doctoral level research

➢ Apply C^3I technologies to non-defense areas

➢ Provide technical support to industry and government in the C^3I area
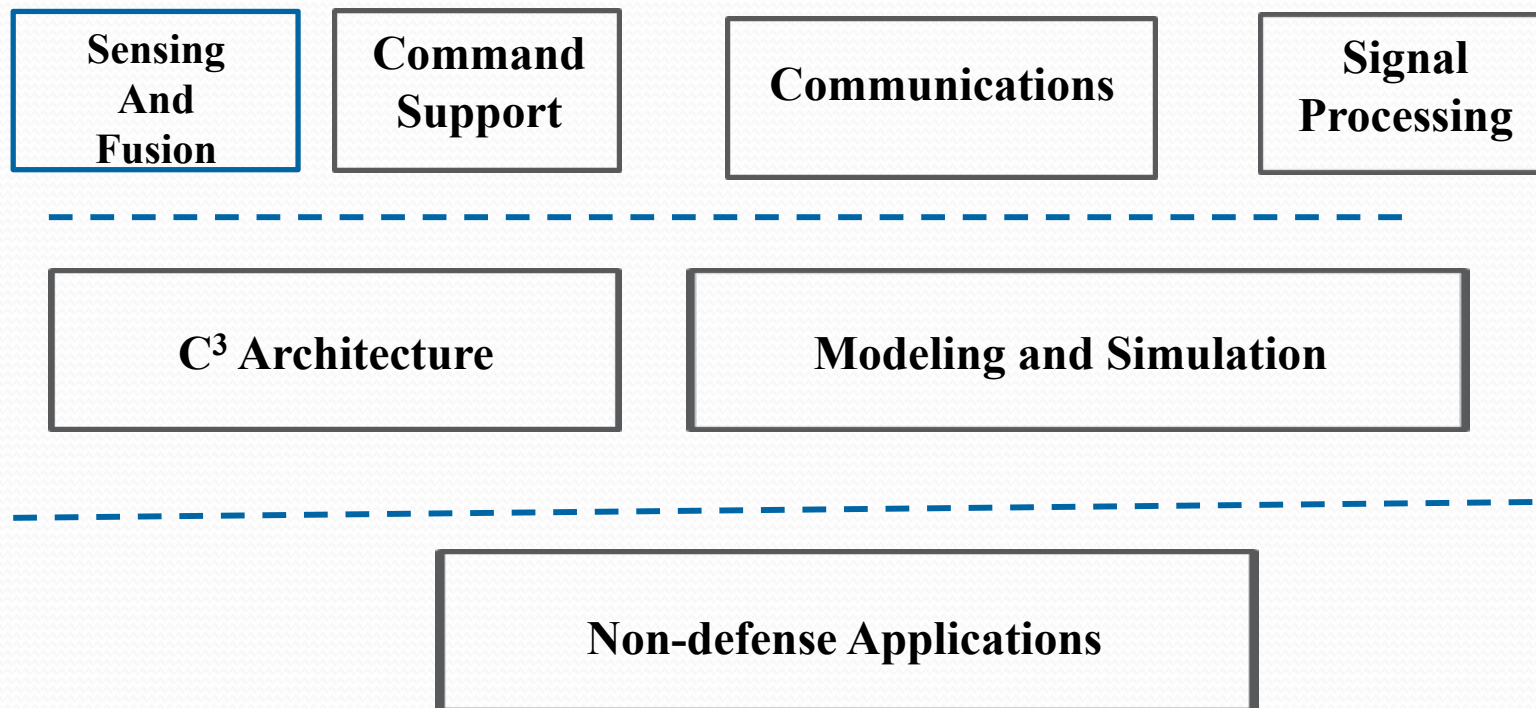
COMMAND AND CONTROL PROCESS MODEL

8

ORGANIZATIONAL PHILOSOPHY

ASD (C³I)

JCS ---
CINCs ---
SERVICES ---
OPERATIONAL COMMUNITY

ACADEMIC COMMUNITY
--- CIVILIAN
--- INDU, AWC, NWC
--- NPG
--- JMC

SYNERGY

ASSOCIATIONS --- AFCEA

ARPA ---
ROME ---
CECOM ---
ONR ---
AFOSR ---
ARO ---
RESEARCH CENTERS

INDUSTRY

GOVERNMENT AGENCIES
--- ARPA
--- NSA
--- NASA
--- FAA
--- NIH
--- NIST

POTENTIAL RESEARCH AREAS

Sensing And Fusion	Command Support	Communications	Signal Processing

C^3 Architecture

Modeling and Simulation

Non-defense Applications

PROBLEMS

➢ **No money**

➢ **Lacked faculty with suitable research interests**

CENTER FOR INNOVATIVE TECHNOLOGY

The Center for Innovative Technology (CIT) creates technology-based economic development strategies to accelerate innovation, imagination and next generation of technology and technology companies. CIT invests in research and commercialization at Virginia colleges and universities, companies, political subdivisions, federal labs, and other research institutions to advance technology and drive economic growth in the Commonwealth.

PROCESS

➢ Proposals submitted in March

➢ Could interact with senior CIT staff in advance

➢ Corporate matching was important factor
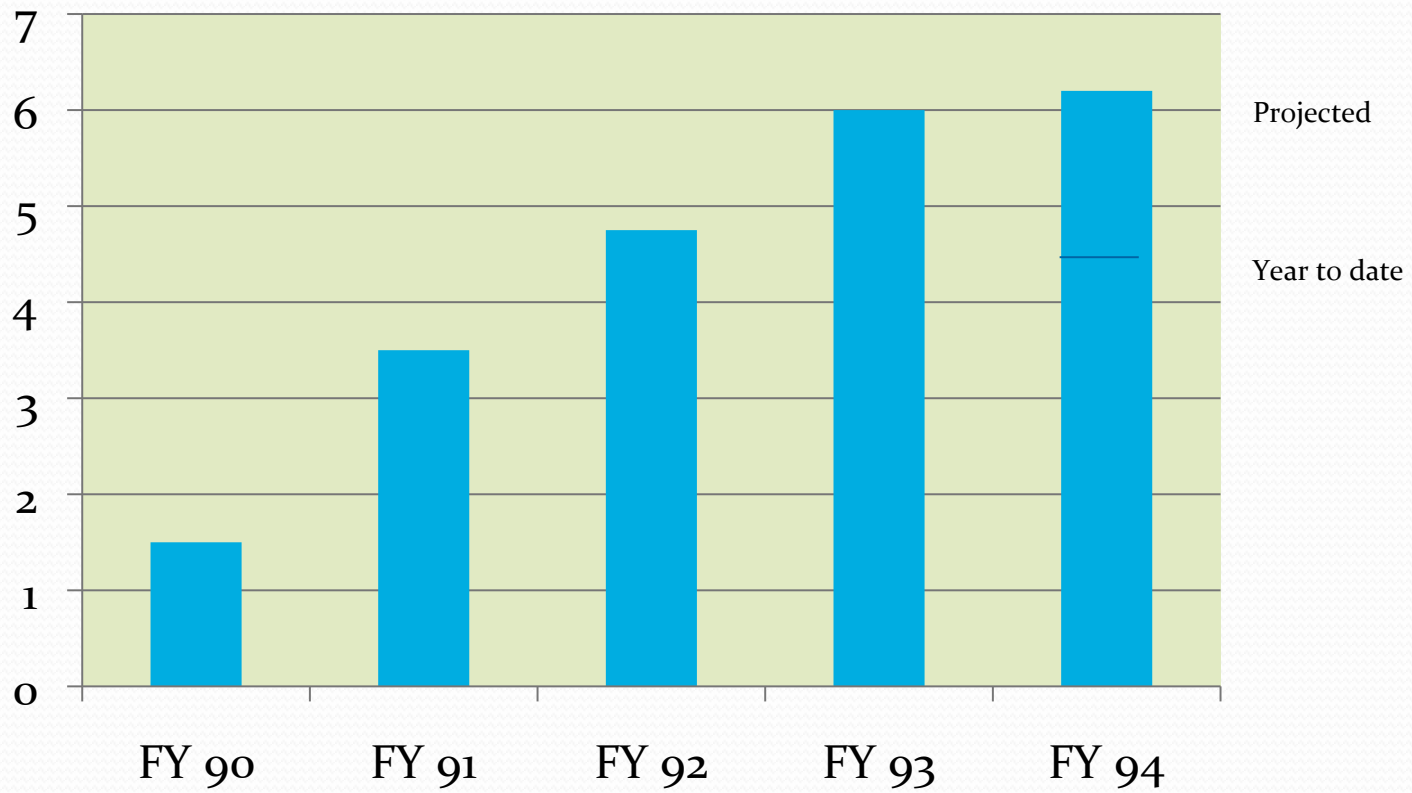
RESULT

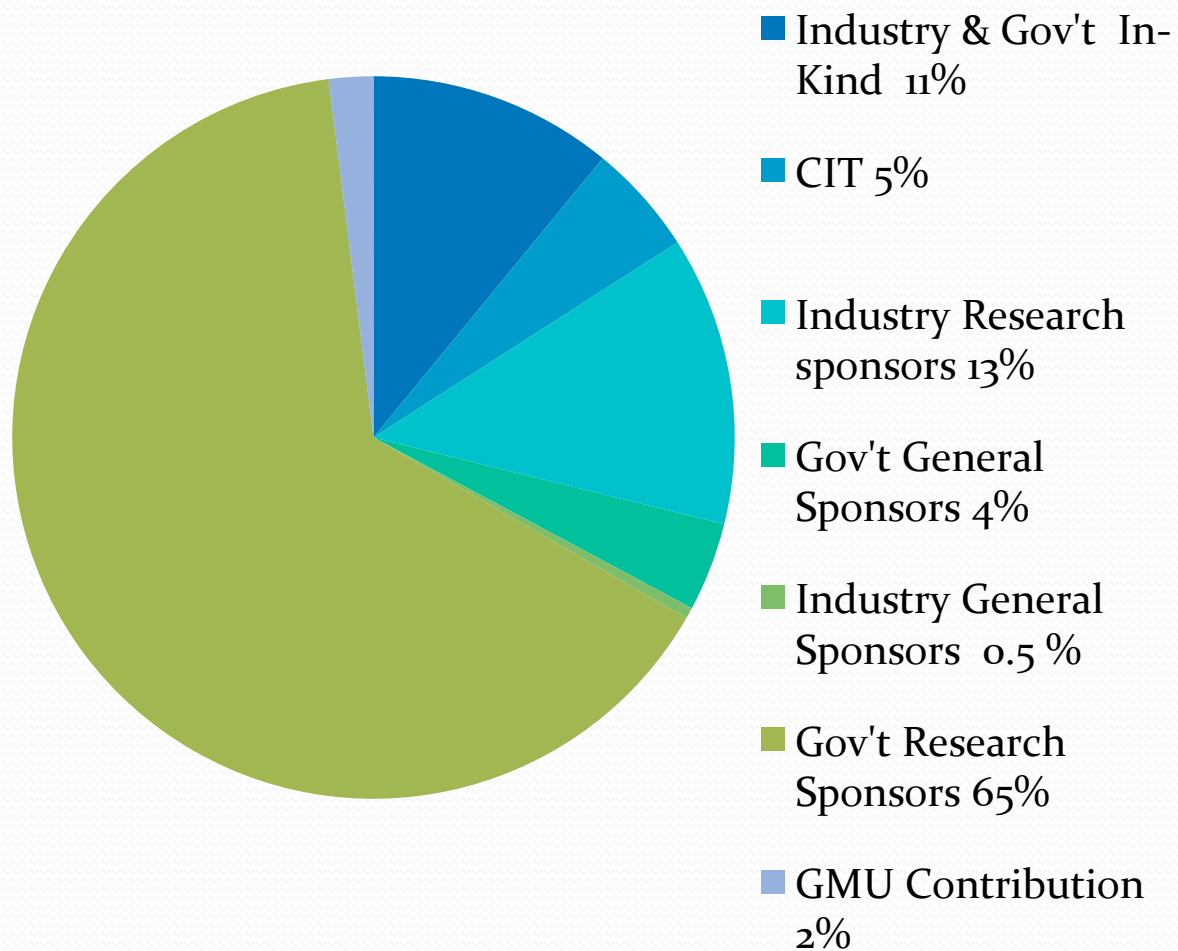➢ Won 500K in one year contract, renewable for 4 years at decreasing value (100K per year)

FACULTY

- Needed experienced faculty interested in DoD problems

- Andy Sage played key role in providing slots and allowing me to pick candidates

- Recruited some stars (in alphabetical order)

  - Dennis Buede, K. C. Chang, Y. Ephraim, Kathryn Laskey, Alex Levis, J. Mark Pullen, Clay Stewart

- Bright young faculty

  - Kristine Bell, Kathleen Wage

- And existing faculty

  - Peter Paris, Ken Hintz, Len Adelman

FIVE YEAR STATUS

PROJECTED 1994 AWARDS

- Industry & Gov't In-Kind 11%
- CIT 5%
- Industry Research sponsors 13%
- Gov't General Sponsors 4%
- Industry General Sponsors 0.5 %
- Gov't Research Sponsors 65%
- GMU Contribution 2%

IMPACT

➢ **BASED on AWARDS**
- **C^3I Center Provides 46.5% of SITE Awards**
- **C^3I Center Provides 24.3% of GMU Awards**

➢ **OVERHEAD RETURN**
- **C^3I Center Provides \$832,089 in Overhead Return to the State and the University**

➢ **FACULTY & STUDENT SUPPORT**
- **C^3I Center Supports 21 Equivalent Faculty and 24 Students**

ISSUES

➢ **Classified research**

➢ **Size and Staff of C³I Center**

- **Research Faculty**

- **GMRI**

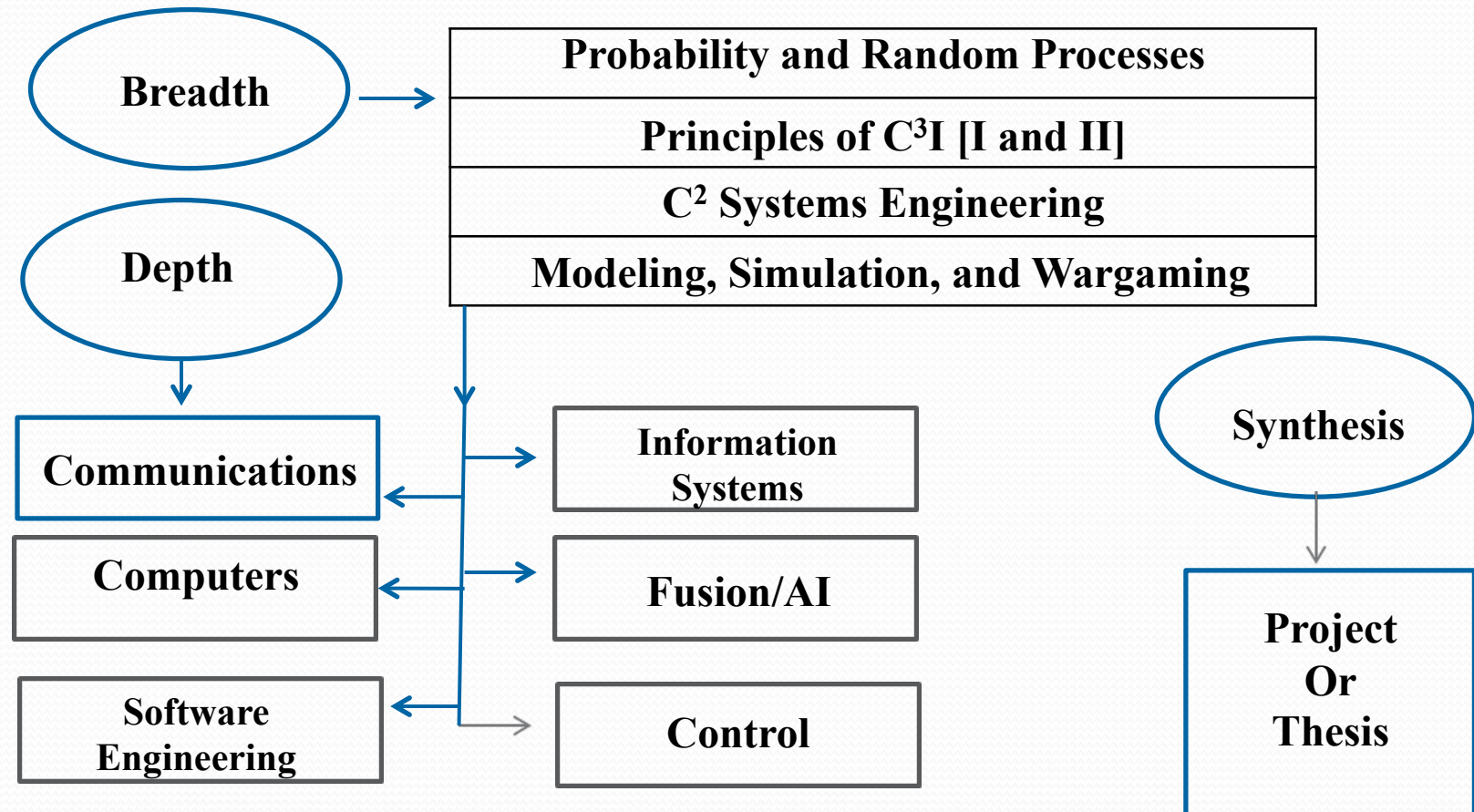➢ **Navy Postgraduate School**

➢ **New President and Dean**

OBJECTIVE OF C^{3}I PROGRAM

➢ **Develop a C^{3}I Curriculum that:**

- **Includes a descriptive approach to C^3**
- **Develops fundamental principles, relevant theories, and useful tools for designing and analyzing C^3 Systems**
- **Provides both depth and breadth across the C^3 area**

AUDIENCE

➢ **Civilian and Military**
- **C^3 Architects**
- **C^2 System Designers**
- **Communications System Designers**
- **Software Developers**
- **Systems Analysts**
- **Program Managers**
- **Operators**
- **Educators**

C^{3}I CURRICULUM

Breadth

Probability and Random Processes
Principles of C^{3}I [I and II]
C^2 Systems Engineering
Modeling, Simulation, and Wargaming

Depth

Communications

Computers

Software Engineering

Information Systems

Fusion/AI

Control

Synthesis

Project Or Thesis

MASTER OF SCIENCE PROGRAMS

➢ **Master of Science in Electrical Engineering with a Certificate in C³I**

➢ **Master of Science in Systems Engineering with a Certificate in C³I**

➢ **Master of Science in C3I Systems Engineering**

The Mature Years . . . 1995 - 2005

➢ **System Architecture Lab . . . . Alex Levis**

➢ **Sensing/Signal Processing . . . . Harry Van Trees, Kristine Bell**

➢ **Modeling and Simulation and Distance Education . . . J. Mark Pullen**

➢ **Command Support . . . . Kathryn Laskey , K. C. Chang**

System Architecture Lab Highlights

➢Developed a methodology and tools for Model Driven Experimentation used in evaluating command center organizations at the Naval Postgraduate School

➢Developed the theory of Timed Influence Nets and produced an application called Pythia that has been used by the Intelligence Community and the Information Operations community for Course of Action development and evaluation

➢Developed a temporal logic application called Temper that allows making inferences from incomplete temporal data; it was used for forensic analysis of terrorist activities

System Architecture Lab Highlights

➢ Developed a comprehensive methodology for designing C^{4}ISR architectures compliant to the DoD Architecture Framework, first using structured analysis and then object orientation. The approach was taught to several thousand students at GMU and through AFCEA

➢Developed the tools and the methodology for evaluating alternative architecture designs using formally derived executable models of the architecture

➢ A.H. Levis served as the Chief Scientist of the Air Force (2001-2004) and edited the book, *"The Limitless Sky: Air Force Science and Technology Contributions to the Nation,"* Air Force History and Museums Program, 2004

Sensing & Signal Processing

➢ **Array signal processing; AEGIS, Israeli Iron Dome counter-fire radar**

➢ **Tracking algorithms for Navy submarines**

➢ **Performance bounds on estimation**

➢ **"Optimum Array Processing, Volume IV of DEMT series," 2002**

➢ **"Bayesian Bounds for Parameter Estimation and Nonlinear filtering/Tracking," 2007**

The Pullen Years
NEW NAME: C4I Center

➢ 2005 to present: some new directions . . .

- US Army M&S + Geospatial Programs
- NATO Coalition Battle Management
- International C2 Research Testbed
- Joint IED Defeat Office support
- IARPA: Crowdsourced forecasting
- Predictive Situational Awareness

US Army M&S + Geospatial Programs

➢ Dr. Michael Hieb

- Simulation to Mission Command Interoperability Overarching Integrated Product Team (SIMCI OIPT)
    - IPT of 30 Army Organizations working on Interoperability
    - Invention of the first version of Battle Management Language (BML) for the US Army
    - Geospatial Initiative for common terrain data between M&S and C4I
- Geospatial Reasoning Integrated with C4I
    - Geospatial BML at the Topographic Engineering Center
    - Common Ground Advanced Concept Technology Demo

International C2 Research Testbed

➢ Drs. Paulo Costa and Michael Hieb

- Collaboration with ITA and visiting scholars from Brazilian Air Force

- Testbed supported by VT-MÄK

- Cyberthreat study support from Brazilian Air Force's Department of Air Space Control (FAA equivalent)

- Serious Gaming & Simulation applied to Cyberwarfare training for ATC personnel (with Dr. Kathryn Laskey and the GMU Simulation and Gaming Institute)

JIEDDO Support

- Drs. Kathryn Laskey, Tod Levitt & Charles Twardy
  - Three year advanced R&D support contract
  - Machine learning models to identify and track threat groups that planted Improvised Explosive Devices (IEDs)
    - Developed and transitioned to operational use by JIEDDO analysts
- Optimized IED patrol route planning algorithms, accounting for historical and predicted IED activities
  - Geo-registration algorithms for aligning IEDs with road networks

IARPA: Crowdsourced Forecasting

➤ Drs. Charles Twardy, Kathryn Laskey and Tod Levitt
- Four year IARPA project ($2-3M/yr) on geo-political and science and technology forecasting

- Crowdsourced prediction market using probabilistic reasoning to continuously aggregate individuals' predictions

- Novel algorithms for enabling predictions to be conditional on each other

- Developed predictive capabilities 35% better than baseline unweighted average

NATO Coalition Battle Management Language (C-BML)

- Drs. Mark Pullen and Michael Hieb
  - Series of projects with DoD and Army sponsors
  - Goal: coalition can "plug and play" their C2 and simulation systems without special preparation
  - Initial work with NPS MOVES: web-based simulation
  - Partnered with France DGA to build interest
  - Ten-nation NATO team proof of principle 2009
    - Won NATO Science Award 2013
- Twelve-nation NATO + PFP proof of concept 2013

Predictive Situational Awareness

➢ Drs. K.C. Chang, Paulo Costa and Kathryn Laskey
- Maritime Decision Support: ONR Prognos Project (2008-2011)

➢ Drs. Paulo Costa and Kathryn Laskey
- ONR Proactive Decision Support Program
  - Special session at STIDS 2013
  - Participation at the PDS Strategic Workshop (July 2014)

SUMMARY

- C^4I Center is unique in academia

- Significant impact on C^4I intellectual base

- Partnership with AFCEA is essential

- The complete C^4I picture is spread through SITE; EECS, architectures, signal processing and communications; CS, cybersecurity

- Outstanding faculty and staff

- Bright future