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**Supporting Military Decision Makers with Efficient Computational Experimentation:**  
*An overview of the SEED Center for Data Farming*

Tom Lucas and Susan Sanchez  
 Operations Research Department  
 Naval Postgraduate School  
 Monterey, CA.




Naval Operations Research Workshop,  
 Vina Del Mar, Chile, 03 December 2009

<http://harvest.nps.edu>

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## Agenda


- Introduction and Overview of SEED Center
- Recent Applications
  - Critical infrastructure protection
  - System performance analysis, requirements definition, and development of TTPs



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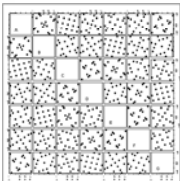
## SEED Center in a nutshell...

**SEED Center mission:** Advance the development and use of simulation experiments and efficient designs to provide decision makers with timely insights.



<http://harvest.nps.edu>

- **Harnessing Enabling Technologies**
  - High-performance computation
  - New Design of Experiments (DOE)
  - (Emerging) models
  - Data mining and visualization
- **Revolution in analysis capabilities**
  - Quick turnaround...
  - Address uncertainties...
  - Robust solutions
  - “Better than a petaflop”

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## The people of the SEED Center

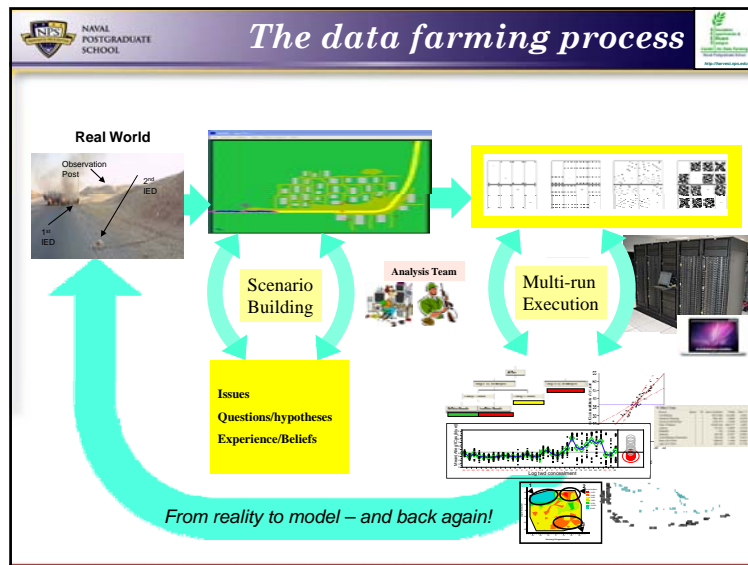
- **Co-Directors**
  - Susan Sanchez
  - Tom Lucas
- **Outreach and sponsored programs**
  - Gary Horne
- **Main NPS personnel**
  - Paul Sanchez, Ed Lesnowicz, Rachel Johnson, Susan Heath, Keebom Kang, Mark Nissen, Tom Hoivik, Dan Nussbaum
  - Steve Upton, Mary McDonald, Ted Meyer, Adam Larson, Meredith Thompson, Andrea Hernandez
  - TRAC-Monterey
  - Other faculty from several academic units across campus
- **Visiting faculty**
  - Jack Kleijnen, David Kelton, Enver Yucesan, Hong Wan, Stefan Pickl
- **Thesis students**
  - Over 90, from all the services and half a dozen countries
- **Other collaborators**
  - Partners in Australia, Austria, Canada, France, Finland, Germany, Mexico, Netherlands, New Zealand, Portugal, Singapore, Spain, Sweden, Turkey, United Kingdom, United States









**Why (computer) simulation?**

- Complexity of many real world issues
  - Too often people make “over-simplifying assumptions”—resulting a **Type III error** (using a bad (e.g., too simplistic) model)
  - Complex problems often require complex models

“We use simulations to avoid making Type III errors—i.e., working on the wrong model!”—W. David Kelton

**Why experimental design: Petaflop computing is not enough!**

“Forever” may sound overblown, but any length of time longer than that which we have available to us, because of nature or of orders from our superiors, is effectively forever. This fact has been delightfully dramatized by Major General Jasper Welch in the phrase,  **$10^{30}$  is forever.** (Hoerber [1981])

**Petaflop = 1000 trillion ops/second  
Cost of “Roadrunner”= \$133 million**

“To put the performance of the machine in perspective...if all six billion people on earth used hand calculators and performed calculations 24 hours a day and seven days a week, it would take them 46 years to do what the Roadrunner can in one day...Petaflop machines like Roadrunner have the potential to fundamentally alter science and engineering...perform experiments that would previously have been impractical.”

**$10^{30}$  is approximately  $2^{100}$  — or the number of combinations of 100 factors, each at only 2 levels.**

**Even with a petaflop computer and a simulation that runs as fast as a single operation, running a single replication of this experiment would take over 40 million years!**

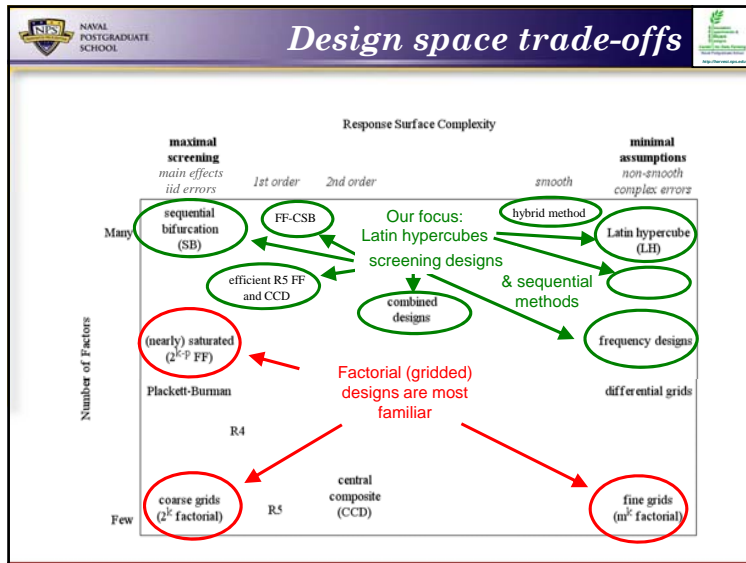
**DOE: Better than a petaflop**

- **Efficient design of experiments (DOE)** can break the “curse of dimensionality.”
- Fewer assumptions needed than made *de facto* by those unaware of the power of DOE.
- New methods, such as those developed by NPS faculty and their colleagues (see: <http://harvest.nps.edu>), move the exploration of complex computer models from the impossible to the practical.

**For example, we can study 100 factors and all their two-way interactions: on a desktop computer with a simulation that takes a full second to run, each replication of the experiment takes under 9.5 hours!**

**Even if the simulation takes a more reasonable one minute to run, we can do this experiment on an 8-core desktop (under \$3000) in 2.85 days!**

**Other designs are even more efficient, and provide more detailed insights into the simulation model’s behavior!**



### Our portfolio of designs...

- Kleijnen, J. P. C., S. M. Sanchez, T. W. Lucas, and T. M. Cioppa (2005), "A User's Guide to the Brave New World of Designing Simulation Experiments," *INFORMS Journal on Computing* 17(3): 263-289.

Motivation, our philosophy, examples, and an extensive list of references

### Our portfolio of designs...

- Sanchez, S. M. 2000. Robust Design: Seeking the Best of All Possible Worlds," *Proceedings of the 2000 Winter Simulation Conference*, 69-76.

Use experimental design to identify robust settings of decision factors

### Our portfolio of designs...

- Cioppa, T.M., and T.W. Lucas (2007), "Efficient Nearly Orthogonal and Space-filling Latin Hypercubes," *Technometrics* 49(1): 45-55.

Great designs for up to 29 quantitative factors

low level	1	1	1	1	1	1	1
high level	17	17	17	17	17	17	17
decimals	0	0	0	0	0	0	0
factor name							
6	17	14	7	5	16	10	
2	5	15	10	1	6	11	
3	8	2	5	11	14	17	
4	11	6	17	10	3	13	
13	16	8	3	6	1	14	
17	6	7	14	2	13	15	
11	4	17	6	15	8	16	
10	15	13	16	14	11	12	
9	9	9	9	9	9	9	
12	1	4	11	13	2	8	
16	13	3	8	17	12	7	
15	10	16	13	7	4	1	
14	7	12	1	8	15	5	
5	2	10	15	12	17	4	
1	12	11	4	16	5	3	
7	14	1	12	3	10	2	
8	3	5	2	4	7	6	

**Latin hypercube advantages**

- Efficient and space-filling
- Flexible for design
  - few restrictions on # factors, # levels, sampling budget
- Flexible for analysis
  - screening, many cameras on the landscape
  - "accidental VV & A"
  - fit many metamodels to multiple MOEs
- Orthogonal and nearly-orthogonal are better

NAVAL POSTGRADUATE SCHOOL **Our portfolio of designs...**

- Sanchez, S. M. and P. J. Sanchez (2005), "Very Large Fractional Factorials and Central Composite Designs," *ACM Transactions on Modeling and Computer Simulation* 15(4): 362-377.

Lets you easily construct designs for main effects & two-way interactions for up to 443 factors – not just a dozen!!

Fractional Factorial or Factorial + Star Points = Central Composite Design

NAVAL POSTGRADUATE SCHOOL **Our portfolio of designs...**

- Sanchez, S.M., H. Wan, and T.W. Lucas (2009), "Two-Phase Screening Procedures for Simulation Experiments," *ACM Transactions on Modeling and Computer Simulation* 19(2), Article 7.

Screening procedures use a divide-and-conquer approach to winnow hundreds of factors down to the most influential subset

NAVAL POSTGRADUATE SCHOOL **Our portfolio of designs...some new ones**

- Shen, H., Wan, H., and Sanchez, S.M., 2009, "A Hybrid Method for Simulation Factor Screening," to appear in *Naval Research Logistics*.
- Hernandez, A.S., M. Carlyle, and T.W. Lucas, 2009, "Breaking Barriers to Design Dimensions in Nearly Orthogonal Latin Hypercubes," under review.
- Oh, R.P.T., S.M. Sanchez, H. Wan, M.E. Nissen, and T.W. Lucas, 2009, "Efficient Experimental Design Tools for Exploring Large Simulation Models," to appear in *Computational Organizational Theory*.
- Sanchez, P. J., 2009, "Efficient Generation of Resolution VII Fractional Factorial Designs," in preparation.

NAVAL POSTGRADUATE SCHOOL **Research sponsors & research areas**

**RESEARCH SPONSORS**

- Joint IED Defeat Organization
- Netcentric Systems Test / TRMC OSD
- Joint Test and Evaluation Methodology / M&SCO
- Marine Corps Installations and Logistics
- Army Training & Doctrine Command Analysis Center
- Joint Operational Effects Federation
- Marine Corps Combat Development Command
- Marine Corps Warfighting Lab
- Marine Corps Systems Command
- Air Force Research Laboratory
- Naval Systems War College - Carderock
- OASD Network & Information Integration
- Office of Naval Research

**RESEARCH AREAS**

- State-of-the-art design of experiment (DOE) methods
- DOE infrastructure
  - Rapid Scenario Generation
- JIEDDO Analysis Support
- Joint System-of-System Testing and Analysis
- Irregular Warfare
  - Modeling Population Dynamics

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- Current operations and system analysis
- Counter terror / irregular warfare
- Peace support and stability operations
- DOE and simulation methodological advances
- Simulation experiments supporting live tests
- Critical infrastructure protection
- Future forces & Network-enabled warfare
- Unmanned vehicles (air, ground, surface, subsurface)
- Non-lethal weapons
- Modeling intangibles in warfare and civilian populations
- Logistics

NAVAL POSTGRADUATE SCHOOL *SEED Center activities...*

- **Research: Developing and implementing better DOE algorithms for breadth of models**
  - A portfolio of designs to explore high-dimensional models
  - Refereed journal and proceedings publication
  - Implement new designs and new models in data farming environments
  - New application areas
  - Numerous awards for methodological and applied work
- **Education**
  - Experimental design classes, thesis students
  - International scholars / Ph.D. students
- **Outreach**
  - International Data Farming Workshops (twice/year)
    - IDFW19 November 09 in New Zealand, IDFW20 March 2010 in Monterey
  - Proceedings / Bulletin of the International Data Farming Community
  - Short courses / conference attendance / tutorials
  - Memoranda of understanding (Germany, Singapore, New Zealand, Sweden,...)

*Spiral development of new methods and new applications... and building the infrastructure to facilitate their broader use*

NAVAL POSTGRADUATE SCHOOL *International Data Farming Workshops*

**Insights into questions...**

- What is the role of trust, or other so-called 'intangibles', on the battlefield?
- What impact will net-centric warfare and complete information sharing have on the effectiveness of military units?
- How can we best protect our homeland from a martyr-based offense?
- How can a bio-terrorist attack be mitigated in a free society?
- What system characteristics are important in military convoy protection systems?
- What factors are most important in defeating improvised explosive devices?

**Sharing and knowledge transfer...**

- IDFW17 (Sep 2008) Garmisch-Partenkirchen, Germany
- IDFW18 (March 2009) Monterey, California, USA
- IDFW19 1-6 Nov 2009 Auckland, New Zealand
- IDFW20 **22-25 March 2009** Monterey, USA

NAVAL POSTGRADUATE SCHOOL *Resources on SEED website*

<http://harvest.nps.edu>

Check here for updates on:

- lists of student theses (available online)
- spreadsheets & software
- pdf files for several publications, reference info for the rest
- links to other resources (e.g., *Scythe*)

or contact Tom Lucas (twlucas@nps.edu), Susan Sanchez (ssanchez@nps.edu), or Gary Horne (gehorne@nps.edu) for more information

*All models are wrong, but some are useful—George Box*

*It's the analyst, not the model, that produces important useful results. Improve the former before the latter — Seth Bonder*


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# Recent applications



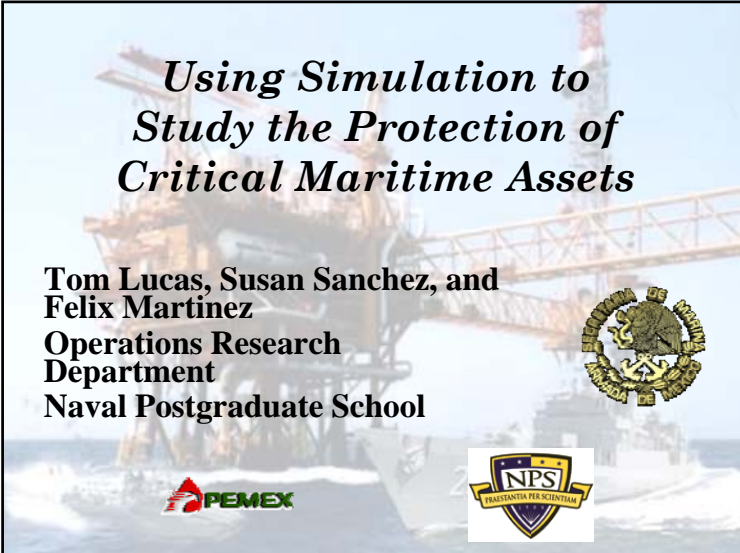



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- **MANA**
- Pythagoras
- IWARS
- ASC-Q
- JDAFS
- Log Battle Command
- PAX
- ISAAC/EINstein
- SOCRATES
- TLCM-AT
- **NSS**
- JCATS
- EADSIM
- SEAWAY
- TRAC's Cultural Geographies
- **PSOM**
- Stanford's Hierarchy organizational model
- RAND info model
- Dewar model
- Special purpose Java and ARENA and other developed...



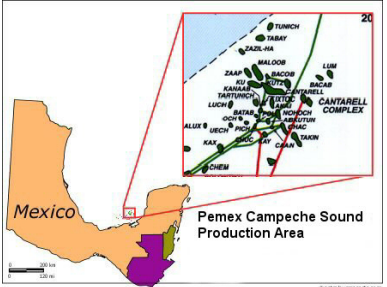
*Using Simulation to Study the Protection of Critical Maritime Assets*

Tom Lucas, Susan Sanchez, and Felix Martinez  
Operations Research Department  
Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL *The Campeche Sound*

- More than 83 percent of hydrocarbon exported in Mexico is extracted from this area.
- During 2004, PEMEX exported a daily average of 1,844,000 petroleum barrels, of which 78 percent was sent to the United States.
- The marine area, where PEMEX is active includes a total surface of 518,390 km<sup>2</sup>.
- There are 243 marine platforms and 2,274 kms of subsurface pipes.

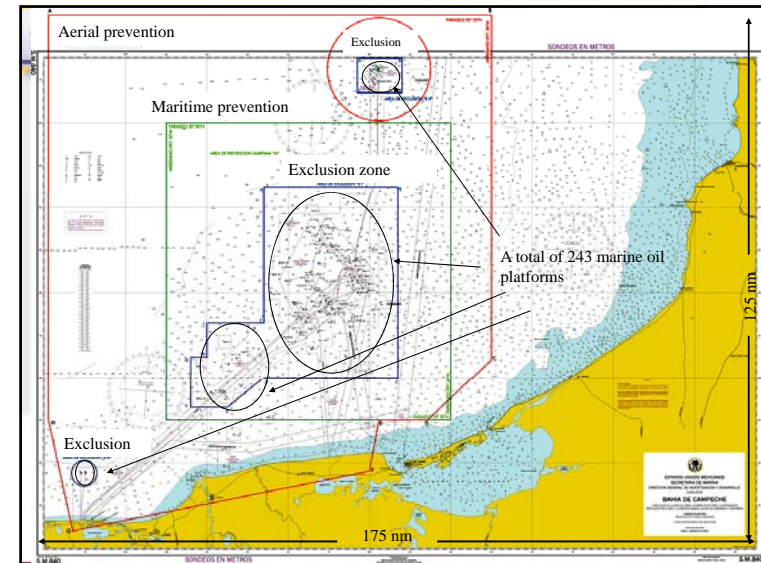


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## Motivation

- The *USS Cole* bombing was a suicide boat attack
  - bombing attack against (DDG 67) on October 12, 2000
- One of the 2000 millennium attack plots, the attempted bombing of *USS The Sullivans*
  - This attack failed when the bombers' boat, overloaded with explosives, began to sink.
- During OIF, there were cases of suicide bombers on boats attacking Iraq's oil facilities.

*csmonitor.com* A Saudi Arabian terrorist group with ties to Al Qaeda [calls for jihadists to] attack oil installations--including those in Canada, Venezuela, and Mexico--in order to stop the flow of oil to the United States.



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## Mexican Navy Resources

- 2 HURACAN-class missile ships, SAAR 4.5, with a helicopter
- 4 POLARIS-class interceptor boats (90H)
- 1 E-2C HAWKEYE Airborne Early Warning aircraft
- 1 C-212 AVIOCAR Maritime Patrol Aircraft
- 2 MI-17 helicopters
- 1 patrolling aircraft L-90 TP REDIGO

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## The Threat


- **Red Force:** One to three synchronized terrorist fast-boats, each of which is attempting to destroy an oil platform with explosives (kamikazes)

- **Measure:** P(at least one terrorist success | resources, threats)


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## Distractions

- Fishing boats constantly try to penetrate the preventive zone to fish



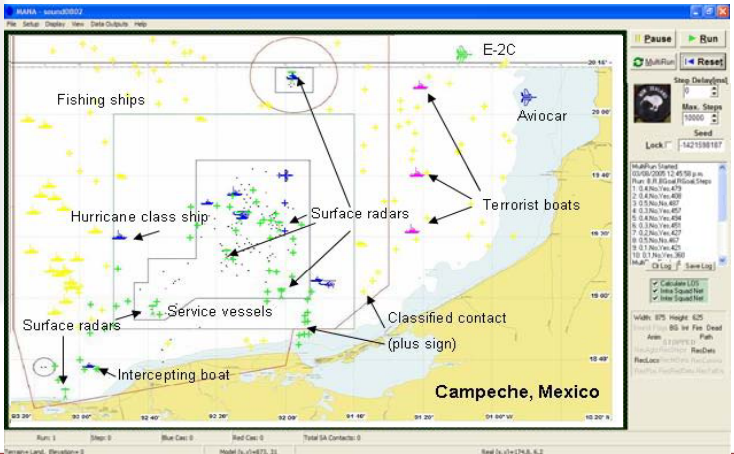
- Service vessels working in the area



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## Simulation Tool

Map in MANA (Map Aware Non-uniform Automata)



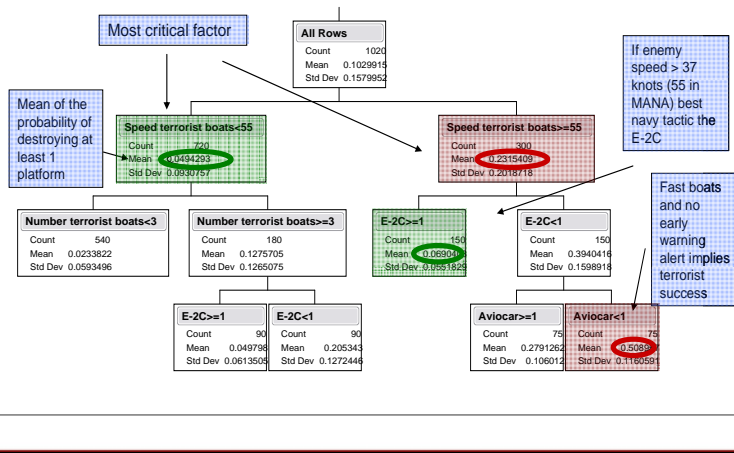
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## Design of Experiment

- 60 combinations of Mexican Navy resources
- 17 possible combinations of the uncontrollable factors:
  - Number of terrorist boats
  - Speed of the terrorist boats
  - Number of fishing ships entering the prevention area during a terrorist attack
- 50 replications
- $60 \times 17 \times 50 = 51,000$  simulated attacks

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## Regression Tree (all factors)



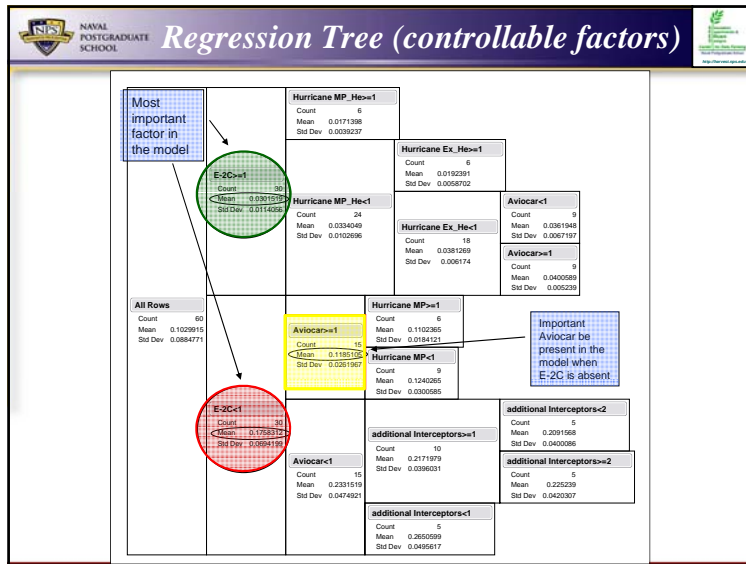
**Most critical factor**

**Mean of the probability of destroying at least 1 platform**

**If enemy speed > 37 knots (55 in MANA) best navy tactic the E-2C**

**Fast boats and no early warning alert implies terrorist success**

Node	Count	Mean	Std Dev
All Rows	1020	0.1029915	0.1579952
Speed terrorist boats <= 55	730	0.0942293	0.0949757
Speed terrorist boats >= 55	290	0.2315409	0.2018716
Number terrorist boats < 3	540	0.0233822	0.0593496
Number terrorist boats >= 3	190	0.1275705	0.1265075
E-2C >= 1	159	0.09304	0.1251325
E-2C < 1	150	0.3940416	0.1598916
Aviocar >= 1	75	0.2791262	0.106012
Aviocar < 1	75	0.50891	0.1160591



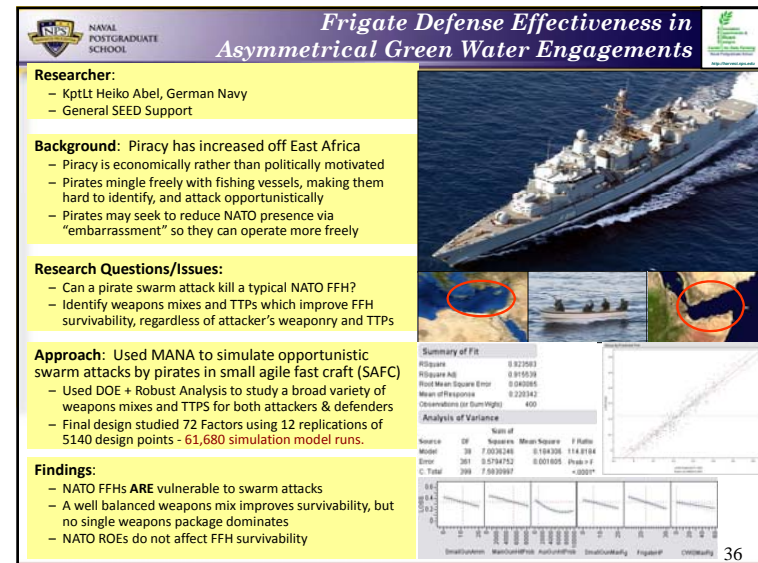
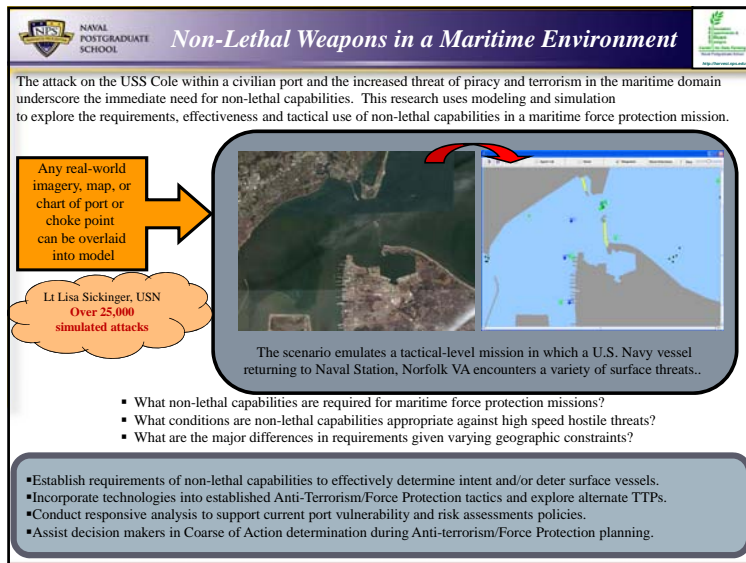
## Analysis of the Effectiveness of Weaponized Kamikaze Unmanned Aerial Systems Against an Aegis Destroyer

Chad S. Kaiser, Lieutenant USN

LT Kaiser's work gives a clear picture of what the Fleet can expect from this threat... His analysis points to new technologies, tactics, and mindsets to effectively defend against a UAS saturation attack.



> 100,000 simulated attacks in NSS



## Peace Support Operations Model

**"It is DoD policy to recognize that IW [irregular warfare] is as strategically important as traditional warfare." -- DoDD 3000-7.**

**US Stakeholders**

- Joint IED Defeat Organization
- OSD-Simulations Analysis Center
- J-8 War Fighting Analysis Division
- TRADOC Analysis Center
- U.S. Army III Corps
- MNF-I CJ9 STRATCOMM
- Center for Army Analysis

**Population determines success**

- Iraq 2006 scenario created and vetted by DSTL
- 37 Coalition maneuver battalions
- 75 Sunni Anti-Iraqi units
- 47 UN IGOs
- 535 Sunni population agents

## Design/Results/Impact

**Design**

- Efficient DOE & computing cluster
- Over 75,000 simulated operations
- Over 100 factors varied

**Results**

- The operational tasks, ROE, and risk tolerance prove significant and are analogous with current doctrine
- Only a handful of parameters are overly sensitive
- PSOM's strength is as a human-in-the-loop wargame, which provides a suitable environment for staff training

Summary of Fit	
RSquare	0.951374
RSquare Adj	0.94864
Root Mean Square Error	0.007902
Mean of Response	2.474794
Observations (or Sum Wgts)	264

**Impact**

- OSD PA&E is now using SEED developed tools to analyze PSOM
- DSTL is incorporating our work to their PSOM VV&A
- U.S. Army III Corps has begun use of PSOM as a training tool
- CAA, TRAC, MNF-I, and J-8 WAD will use this research in their analysis of PSOM

MARLIN, BENJAMIN J., Major, U.S. Army, "Ascertaining Validity in the Abstract Realm of PMESH Simulation Models: An Analysis of the Peace Support Operations Model (PSOM)," MS in OR, March 2009.

## Enhancing the Effectiveness of G-BOSS

**Researchers:**

- Captain (P) Will Midgette
- Mary McDonald
- General SEED Support

**Background:** G-BOSS...in response to Universal Need Statement

- Directed by MCCDC & CDIB for immediate persistent surveillance capability to mitigate loss of life due to IEDs

**Problem/questions:** Rapid deployment...

- No uniform TTPs (stand-alone or coordinate)
- How can deployed forces best use current system?
- What factors most influence SA?
- Benefits of additional sensors (motion detection)

Summary of Fit	
RSquare	0.951374
RSquare Adj	0.94864
Root Mean Square Error	4.708613
Mean of Response	72.91462
Observations (or Sum Wgts)	750

**Approach:** Simulate MCOTEA Operational Test (at 29 Palms) in MANA

- Use DTED Level 2 terrain & Falcon View
- 12 Factors varied in over 20,000 simulated tests

**Findings:**

- Most critical factor is placement of towers, followed by enemy stealth
- With MSTAR coordination enhances SA, little benefit from coordination without MSTAR
- Simulation consistent with MCOTEA test results

## Integrating New ISR Systems into a Marine Rifle Company

**Researchers:**

- Major Dan Zappa
- Mary McDonald
- General SEED Support

**Background:** Lots of new ISR systems (Cameras on stick and micro UAVs) being pushed to theater

- No standardized TTPs
- No Company-level ISR cell exists

**Problem/questions:** How are detection and classification improved in an urban company-level security environment by integrating tower systems and micro-UAV?

**Approach:** Simulate Mojave Viper Mission Rehearsal Exercise (at 29 Palms) in MANA

- Use DTED Level 2 terrain & Falcon View
- Varied Blue systems and capabilities and red tactics and civilians in over 8,000 simulated exercises

**Findings:**

- Having a micro-UAV is more important than its employment or sensor performance
- The height of the G-BOSS tower has min practical affect on classifying enemy agents, especially after 7 meters
- Use micro-UAV to focus on deadspace.
- Integrating ISR cell into the COC reduces enemy attacks

**SEED Center student theses through September 2009**

<p><b>1999 Kulac (LTJg, Turkish Navy)</b> A Comparative Analysis of Active and Passive Sensors in AAW Area Defense</p> <p><b>1999 Morgan (LCDR, USN)</b> Exploratory Model Analysis of the Space Based Infrared System Low Global Scheduler Problem, <i>MORS/Tisdale Finalist</i></p> <p><b>1999 McGinnigle (LT, USN)</b> An Exploratory Analysis of the Military Value of Information and Force, <i>MORS/Tisdale Finalist</i></p> <p><b>2000 Johnston (LT, USN)</b> An Analysis on the Survivability of Land Attack Missiles (LAM)</p> <p><b>2000 Brown (Capt., USMC)</b> Human Dimension of Combat</p> <p><b>2001 Vinyard (Maj., USMC)</b> Reducing Non-monotonicities in Combat Models, <i>MORS/Tisdale Winner, MORS Walker Award</i></p> <p><b>2002 Erlenbruch (CAPT, German Army)</b> German Peacekeeping Operations, <i>MORS/Tisdale Finalist</i></p> <p><b>2002 Pte (Singapore DSTA)</b> Information Superiority and Battle Outcomes, <i>MORS/Tisdale Finalist</i></p> <p><b>2002 Wan (MAJ, Singapore Army)</b> Effects of Human Factors on Combat Outcomes</p> <p><b>2002 Dickie (MAJ, Australian Army)</b> Swarming Unmanned Vehicles, <i>MORS/Tisdale Finalist</i></p>	<p><b>2002 Ipecki (1st LT, Turkish Army)</b> Guerrilla Warfare, <i>MORS/Tisdale Winner</i></p> <p><b>2002 Wu (LT, US Navy)</b> Spectral Analysis and Sonification of Simulation Data</p> <p><b>2002 Cioppa (LTJG, US Army, PhD)</b> Experimental Designs for High-dimensional Complex Models, <i>ASA 3<sup>rd</sup> Annual Prize for Best Student Paper Applying Stat. to Defense</i></p> <p><b>2003 Efinba (LT, US Navy)</b> Littoral Combat Ships Protecting Expeditionary Strike Groups</p> <p><b>2003 Wolf (Capt., USMC)</b> Urban, Humanitarian Assistance/ Disaster Relief Operations, <i>MORSS Best Presentation Award, MORS Barelli Prize Finalist</i></p> <p><b>2004 Milton (LCDR, US Navy)</b> Logistical Chain of the Seabase, <i>MORS/Tisdale Finalist</i></p> <p><b>2004 Allen (LT, US Navy)</b> Navigational Accuracy of REMUS Unmanned Underwater Vehicle, <i>MORS/Tisdale Finalist</i></p> <p><b>2004 Steele (ENS, US Navy)</b> Unmanned Surface Vehicles</p> <p><b>2004 Hakola (Capt., USMC)</b> Convoy Protection</p> <p><b>2004 Lindquist (CAPT, US Army)</b> Degraded Communication in the Future Force, <i>MORS Tisdale Winner</i></p> <p><b>2004 Aydin (1<sup>st</sup> LT, Turkish Army)</b> Village Search Operations</p>	<p><b>2004 Raffetto (Capt., USMC)</b> UAVs in Support of IPB in a Sea-Viking Scenario, <i>MORS/Tisdale Finalist, Marine Corps Association Superior Service Award</i></p> <p><b>2004 Cason (Capt., USMC)</b> UAVs in Support of Urban Operations</p> <p><b>2004 Brennan (LCDR, US Navy)</b> Multiple UAVs in Maritime Search and Control</p> <p><b>2004 Tan (Singapore S&amp;T)</b> Checkpoint Security</p> <p><b>2004 Nesbitt (LT, USN)</b> Defending High Value Homeland Units Against the Low Slow Flyer</p> <p><b>2004 Rhoads (Maj, USA) &amp; Gilman (Capt, USA)</b> Wargaming and Simulation as Tools for CONOPS Development</p> <p><b>2004 Haug (LT, USN)</b> Using Hughes' Salvo Model to Examine Ship Characteristics in Surface Warfare</p> <p><b>2005 Bahlot (Capt., USMC)</b> Distributed Operations versus Traditional Force in Urban Terrain</p> <p><b>2005 Bain (Capt., USMC)</b> Logistics Support for Distributed Ops, <i>MORS/Tisdale Finalist</i></p> <p><b>2005 Kramlich (Capt., USA)</b> The Effects of Posture, Body Armor, and Other Equipment on Rifleman Lethality, <i>MORS/Tisdale Winner</i></p> <p><b>2005 Gan (1st Lt, Turkish Army)</b> Sunni Participation in Iraqi Elections</p>
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**SEED Center student theses through September 2009 (cont.)**

<p><b>2005 McMIndes (Maj USMC)</b> UAV Survivability</p> <p><b>2005 Sanders (Capt USMC)</b> Marine Expeditionary Rifle Squad</p> <p><b>2005 Ang (Singapore Tech Eng)</b> Increasing Participation and Decreasing Escalation in Elections</p> <p><b>2005 Chang (Singapore DSTA)</b> Edge vs. Hierarchical Organizations for Collaborative Tasks</p> <p><b>2005 Liang (Singapore DSTA)</b> Cooperative Sensing of the Battlefield</p> <p><b>2005 Martinez-Tiburcio (LT Mexican Navy)</b> Protecting Mexico's Oil Well Infrastructure</p> <p><b>2005 Sulewski (CAPT USA)</b> UAVs in Army's FCS Family of Systems</p> <p><b>2006 Lehmann (Maj, German Army)</b> A Discrete Event-driven Simulation of Peacekeeping Operations</p> <p><b>2006 Roginski (MAJ, US Army)</b> Emergency Response to a Terrorist Attack</p> <p><b>2006 Alt (MAJ, US Army)</b> TTPs for a Future Force Warrior Small Combat Unit, <i>TRAC-MRY Director's Award for Research Excellence</i></p> <p><b>2006 Wittwer (MAJ, US Army)</b> Non-Lethal Weapons in a Future Force Warrior Small Combat Unit</p>	<p><b>2006 Nannini (MAJ, US Army)</b> Dynamic Scheduling of FCS UAVs, <i>MORS/Tisdale Finalist</i></p> <p><b>2006 Vaughan (Capt, USMC)</b> Force Size Transitions in Stability Ops</p> <p><b>2006 Michel (Maj, USMC)</b> Evaluating the Marine Corps' Artillery Triad in STOM Operations</p> <p><b>2006 Richardson (Capt, USMC)</b> Distributed Capabilities in a Future Force Warrior Small Combat Unit, <i>Marine Corps Association Superior Service Award</i></p> <p><b>2006 Sickinger (LT, US Navy)</b> Non-Lethal Weapons in a Maritime Environment, <i>MORS/Tisdale Finalist, Surface Navy Association Award for Academic Excellence</i></p> <p><b>2006 Ang (CAPT, Singapore Army)</b> Extending Orthogonal Latin Hypercubes, <i>Outstanding Thesis recognition</i></p> <p><b>2006 Pfeiffer (CAPT, German Army)</b> C4ISR in Convoy Protection</p> <p><b>2006 Ho (CAPT, Singapore Army)</b> Ground Swarm Robotics, <i>Outstanding Thesis recognition</i></p> <p><b>2007 Waldron (LCDR, US Navy)</b> Sustaining Afloat-stages, Special Operations Forces through an LPD-17 Class Single-ship Seabase, <i>MORS/Tisdale finalist</i></p>	<p><b>2007 Lalis (LT, Hellenic Navy)</b> Naval Tactics using UAVs in an Island Complex</p> <p><b>2007 Freye (LT, US Navy)</b> Joint Allocation of Fires &amp; Sensors</p> <p><b>2007 Lovelace (Capt, USMC)</b> Ground-based Fire Support Capabilities of the Marine Expeditionary Unit</p> <p><b>2007 Kent (MAJ, US Army)</b> Effects of Situational Awareness on Infantry in an Urban, Chemical Environment, <i>Outstanding Thesis recognition</i></p> <p><b>2007 Wegner (Maj, US Air Force)</b> System-of-Systems Test Planning in a Joint Environment, <i>MORS/Tisdale Finalist</i></p> <p><b>2007 Oliver (Maj, US Air Force)</b> Assignment Scheduling Capability for UAVs, <i>Outstanding Thesis recognition</i></p> <p><b>2007 Park (CPT, Republic of Korea Army)</b> Interactions of Logistics Components of Tracked Vehicles in the ROC Army</p> <p><b>2007 Musselman (LCDR, US Navy)</b> Robustness: A Better Measure of Algorithm Performance</p> <p><b>2007 Costa (LCDR, US Navy)</b> Dynamic Sustainment</p> <p><b>2007 Peters (CAPT, US Army)</b> Implementing Simulation Design of Experiments and Remote Execution on a High Performance Computing Cluster</p>
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**SEED Center student theses through September 2009**

<p><b>2007 Brown (CAPT, US Army)</b> Exploring the Capabilities of the Platoon Sized FFW SCU</p> <p><b>2007 Oh (Singapore DSO)</b> Efficient Screening through Divide and Discard, <i>MORS Tisdale finalist</i></p> <p><b>2008 Abbott (LT, USN)</b> Littoral Combat Ship mission packages, <i>MORS/Tisdale Winner, Surface Navy Association Award for Academic Excellence</i></p> <p><b>2008 Azimell (1st LT, Turkish Air Force)</b> Simulation of Flight Operations and Pilot Duties in LANTRN Squadrons</p> <p><b>2008 Baez (MAJ, USA)</b> Combat Service Support Soldier Network-enabled Operations</p> <p><b>2008 Geren (MAJ, USA)</b> Small, Unmanned Ground Vehicles in Urban, Chemical Environments</p> <p><b>2008 Ferris (Maj., USMC)</b> Representing Urban Cultural Geography in Stabilization Operations: Economic Model</p> <p><b>2008 Jackson (Maj., USMC)</b> The Importance of Information Superiority to the Decision Maker</p> <p><b>2008 Midgette (Capt., USMC)</b> Ground-based Operational Surveillance Systems, <i>MORS/Tisdale finalist</i></p> <p><b>2008 Richkowski (MAJ, USA)</b> Impact of Small, Unmanned Ground Vehicles on Combat Effectiveness</p>	<p><b>2008 Seitz (CDR, German Navy)</b> Representing Urban Cultural Geography in Stabilization Operations: Social Network Model</p> <p><b>2008 Young (Maj., USMC)</b> Total Life-Cycle Management Assessment Tool</p> <p><b>2008 Garcia (LCDR, USN)</b> Total Life-Cycle Management Assessment Tool</p> <p><b>2008 Kaiser (LT, USN)</b> Air Defense Against UAS Kamikaze Saturation Attack, <i>MORS/Tisdale Winner, Surface Navy Association Award for Academic Excellence</i></p> <p><b>2008 Foo (CPT, Singapore Army)</b> Civilian Responses to a Chemical IED in an Agent-based Simulation</p> <p><b>2008 Ong (CPT, Singapore Army)</b> Effects of Terrain on Systems of Systems, <i>MORS/Tisdale Winner</i></p> <p><b>2008 Hernandez (Col, US Army, PhD)</b> Breaking Barriers to Design Dimensions in Nearly Orthogonal Latin Hypercubes</p> <p><b>2009 Almanza (LCDR, USN)</b> Resupplying T-ARs during a military contingency in Asia, <i>MORS/Tisdale Finalist</i></p> <p><b>2009 Ranberg (LT, USN)</b> Capability Requirements for Military, Auxiliary, and Commercial Vessels Operating in a Confined Environment</p>	<p><b>2009 Phillips (Capt., USMC)</b> Total Life Cycle Management and the JLTV</p> <p><b>2009 Zappa (Maj., USMC)</b> Integration of Tactics with the Employment of Multiple ISR Capabilities to Counter IEDs</p> <p><b>2009 Marlin (Maj., US Army)</b> Data Farming the Peace Support Operations Model</p> <p><b>2009 Featherstone (Capt., USMC)</b> Unmanned Casualty Evacuation</p> <p><b>2009 Yildirci (LT, Turkish Army)</b> Border Protection</p> <p><b>2009 Ozdemir (LT, Turkish Navy)</b> Frigates Defending Against Swarming Attacks in Constrained Waters</p> <p><b>2009 Valdez (LT, USN)</b> Modeling Cultural Geographies</p> <p><b>2009 Abel (LT, German Navy)</b> NATO Frigate Response to Swarm Attacks Near Somalia</p>
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**Simulations Running Overnight**

Mac hosts will auto-logout upon completion.  
If machine is not logged in, expected shutdown.  
If you need the terminal, pls. hardware it.

Simulation started Mon 6/15/09 1:20:00pm  
Expected End by Mon 7/13/09 09:00:00pm

Thank you for your understanding. Thanks, Reggie Ols

**Questions, Comments...**

