Expeditionary Operations

INITIAL PROGRESS REVIEW #2

This brief is UNCLASSIFIED

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POSTGRADUATE
SCHOOL

Conducting Expeditionary Operations in the Contested Littorals

Systems Engineering Analysis Integrated Project Team 21B

Project Advisor: Prof Gary Langford, Ph.D

POC: MAJ Juan Carleton (USA)

jfcarlet@nps.edu

Agenda

1. IPR 1 Review
2. SE Process: where we were, where we are now and where we plan to go
3. Requirements Analysis
4. Functional Analysis
5. Initial team system designs
6. Initial team system design direction
7. MOEs, MOPs
8. Initial Models

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IPR 1 Review

- Problem Statement
- Concept of Operations
- Assumptions and Constraints
- Stakeholders

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Problem Statement

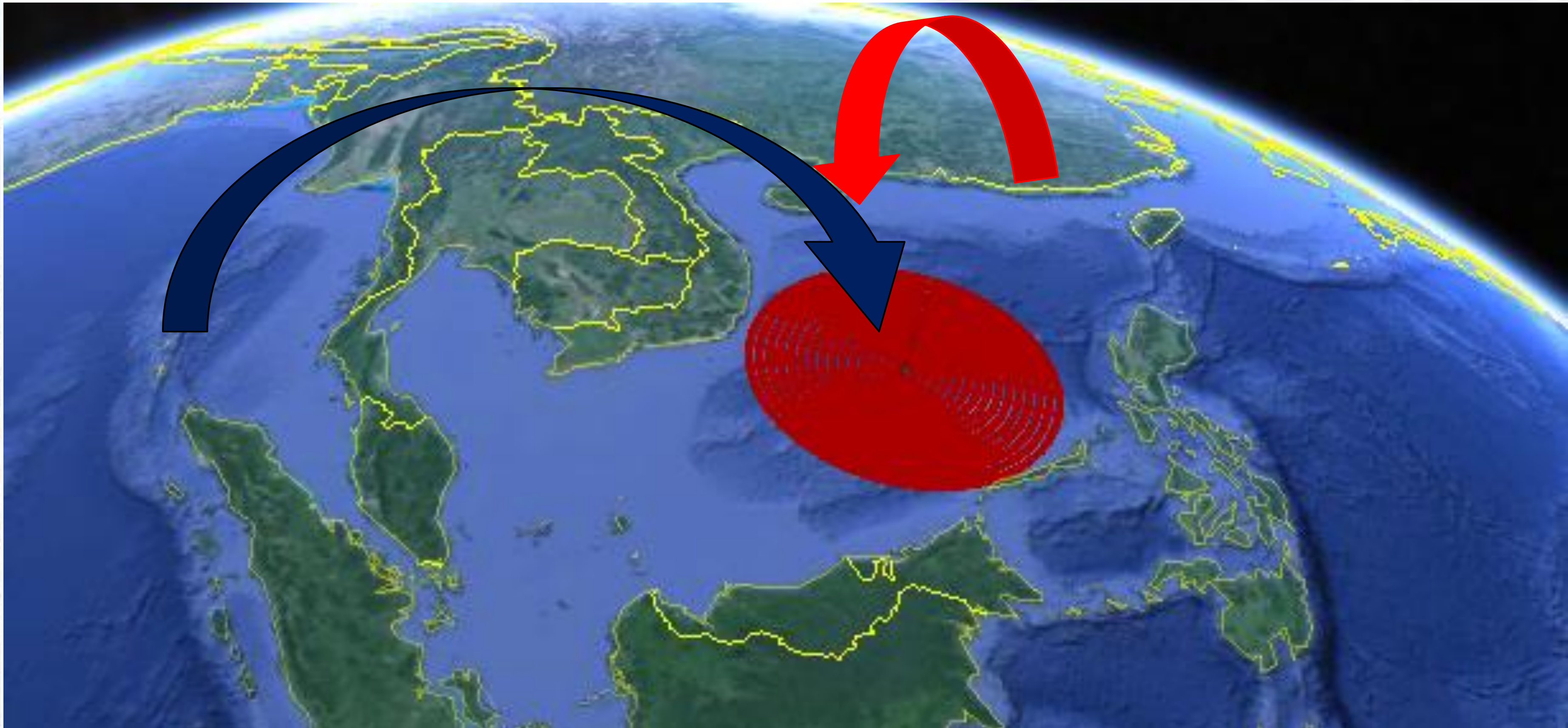
Design a fleet system of systems, concept of operations, potential force packages, and command and control to ***deploy and support company-sized, rapid-response expeditionary assets in a contested littoral region in the 2025-2030 timeframe***. Consider current fleet structure and funded programs as the baseline system of systems in developing gaps, requirements and concepts of operations, then develop alternative architectures for platforms, manning, command and control, communication/network connectivity, and operational procedures. Incorporate manned and unmanned offensive, as well as transport, systems to execute any necessary missions or neutralize potential threats. Evaluate the value, cost, and effectiveness of your architecture and alternatives as applies to larger campaigns, including an assessment of the value of an adaptive mission package concept in your alternatives.

Bottom line:
How do we conduct over-the-horizon amphibious operations in an A2AD environment?

N9I→

Problem Concept of Operations

Key Task: Deploy Assets to island(s) in threat areas in order to deter adversarial forces from establishing a claim.



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Assumptions and Constraints

- Assumptions
  - Diplomatic friendly situation stays the same
  - Near peer advisory (China)
  - China does not attack islands with USA personnel
  - We are invited by a friendly nation to this island
  - Objective is to deter enemy action
- Constraints
  - Timeline
  - Budget
  - Geographic Area

Stakeholders

- Primary
  - Mr. Novak, Deputy N9I
  - Prof. Jeff Kline, CAPT (Ret), SEA Chair
  - Dr. Gary Langford, Advisor
  - SEA-21B Team
- Secondary
  - Rick Williams, RADM (Ret), Mine and EXWAR Chair
  - Jerry Ellis, RADM (Ret), USW Chair
  - NPS Faculty
  - LCSRON 1
  - EWTGPAC
  - LTC Smith USA - TRADOC, Monterey
- Common Stakeholder Needs
  - Capability gap analysis
  - Threat and countermeasure identification
  - Viable set of recommendations

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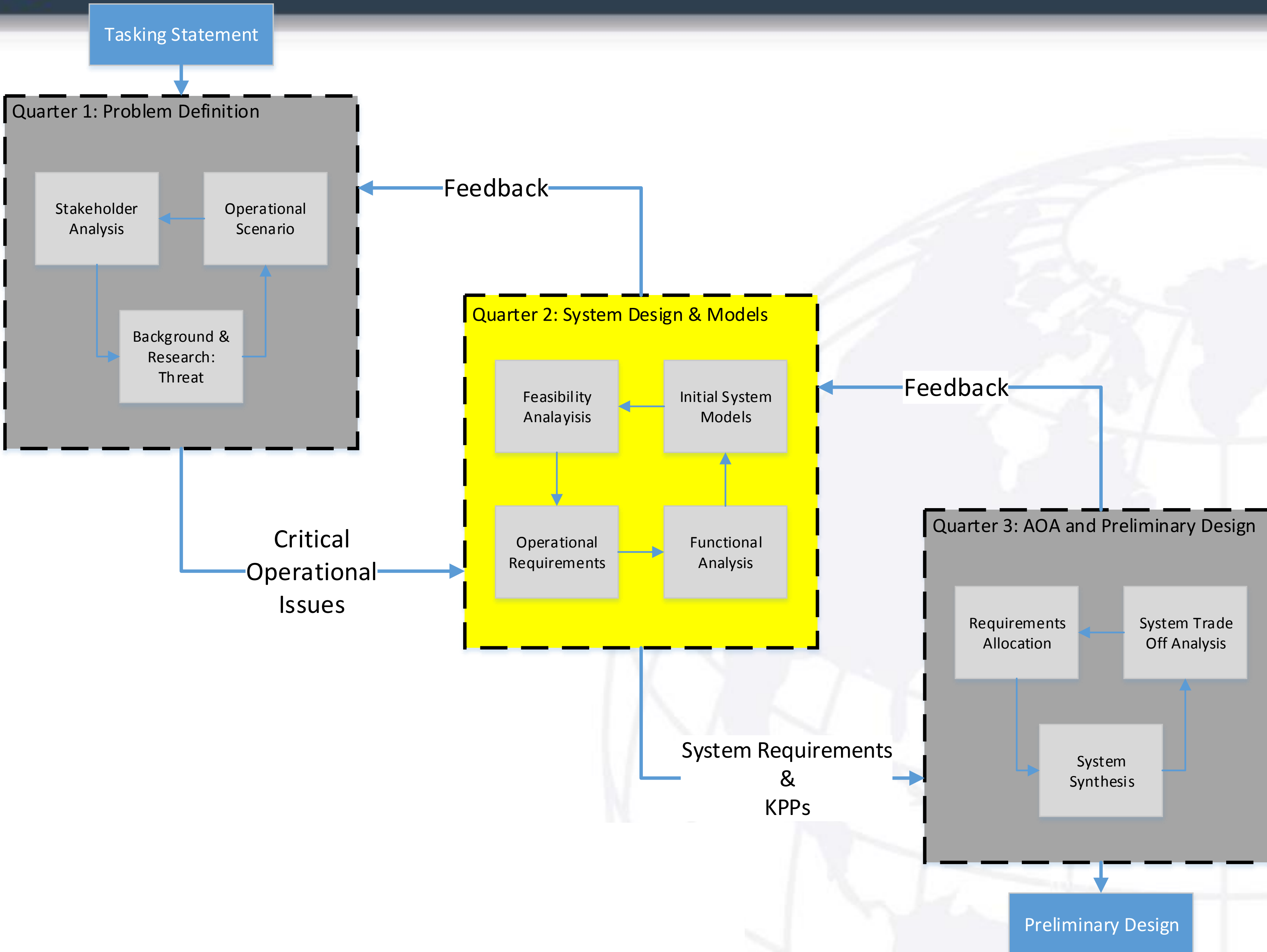
IPR 2

Systems Engineering Process



Traceability: Stakeholder to System

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- **Stakeholders**
  - Primitive Needs
  - Operational Scenario
- **Critical Operational Issues**
  - Operational Effectiveness
  - Operational Suitability
- **Operational Requirements**
  - What the System Must Do
- **System level Requirements**
  - How the system should do it
- **Operational Activities**
  - Doctrinal Tasks and Modes of Operation
- **System Functions**
  - Functions Required to meet requirements
- **Subsystem Functions**
- **Functional Packaging**
  - Component level
- **MOE, MOP, TPM**
  - Tradeoff Analysis

A One to Many Relationship

Stakeholder→COI→OpReqs→SysReqs→

OAs→Function→subFunctions→MOE→

MOP→TPMs

Red Forces

Possible Ingress Routes

Blue vs. Red (Broad View)

- Blue Force Tactics
  - Shallow Water Operations
  - Heli-Insertion
  - Air-Drop
  - Forward Operating Bases
  - Continuous Surveillance

- RED Force Counter Tactics
  - Anti-Ship Missiles
  - Anti-Aircraft Missiles
  - SAMs
  - DF-21/Cruise Missiles with Cluster Bombs
  - Show of Presence with Assets

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Red Force Assets

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Critical Operational Issues (COI)

1. DEPLOYABLE: Can we beat the adversary to an island with our system?
2. SUSTAINABLE: Can we deliver initial troops and supplies?
3. DEFENDABLE: Can we defend the island?
4. RELIABLE: Can we use this system on short notice, when and where we want to with all available functionality?
5. AFFORDABLE: Can we afford the system?

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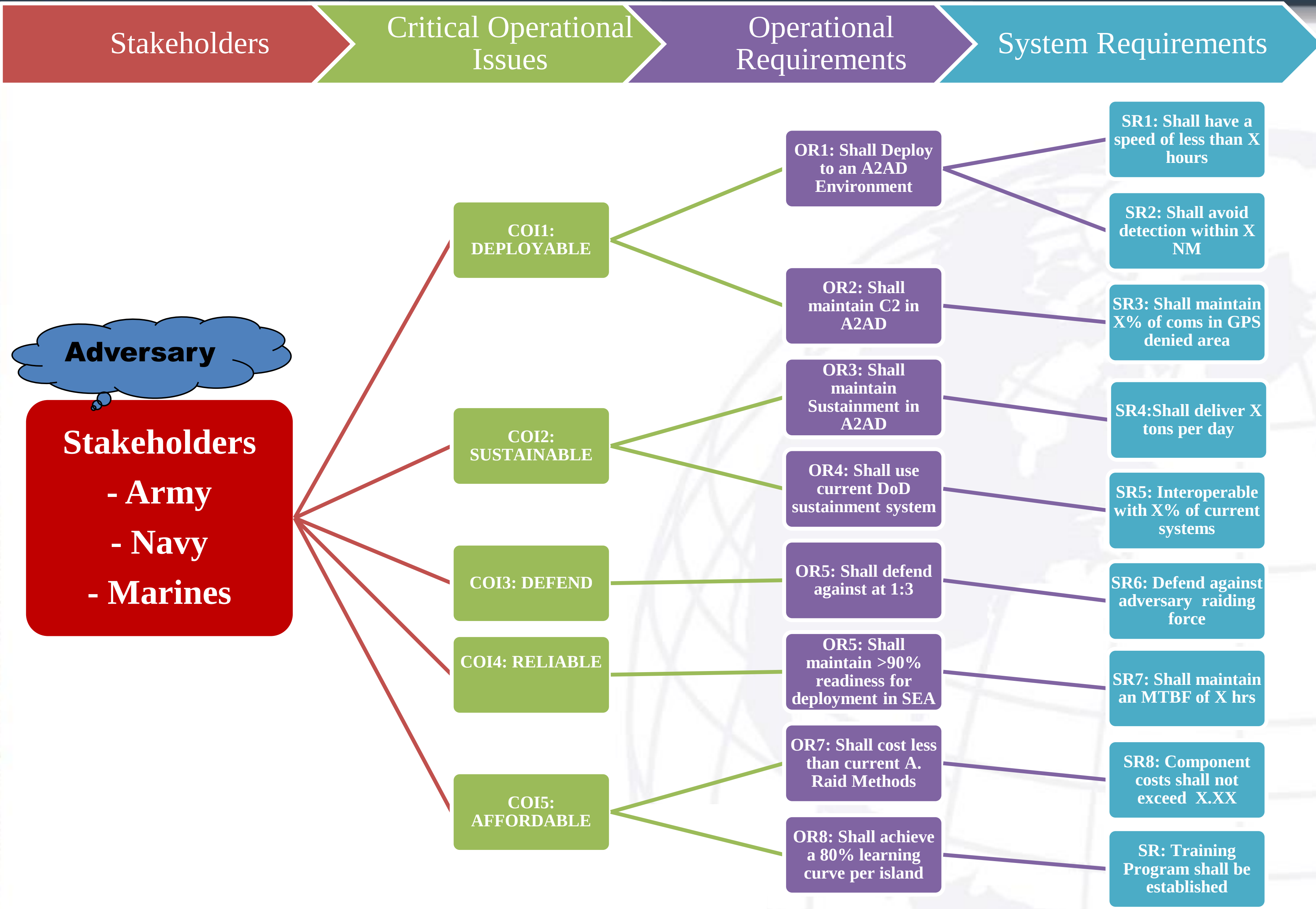
Requirements – Marine Example

- The system shall deter adversary from occupying an island– COI 3
- The system shall defend against credible threats (DF-21, Cruise missile, Land mines, aircrafts, ships, EW & GPS, SWARM, UAV) – COI 3
- The system shall be able to effectively defend against 1x company of enemy marines – COI 3
- The system shall maintain communication links with USMC and USN high HQ – COI 2
- The system shall communicate with coalition forces – COI 2
- The system shall have the capability to detect and identify friend or foe (surface and air) up to a range of 120 nmi – COI 3
- The system shall be deployable to the targeted location in less than <72 hours from WARNO – COI 1
- The system shall support indefinitely the logistics requirements for men and equipment operating within the system in an A2AD environment – COI 2 and 4
- The system shall operate in an A2AD environment - COI 3 and 4

Requirements Analysis

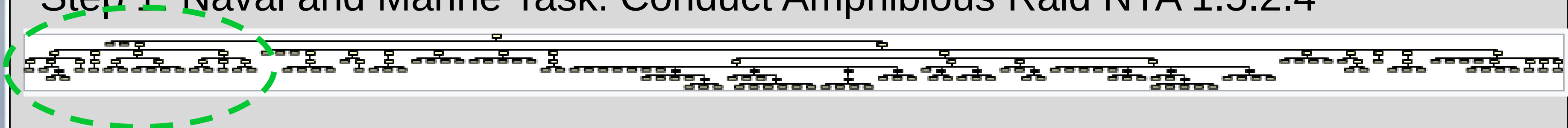


System Boundaries

- During Functional Analysis we find that you need large parts of the Navy and Marine Corps to conduct “Amphibious Raid” – 179 tasks
- System bounded by focusing on the assaulting force and supporting mechanism of the system by which a raid is conducted

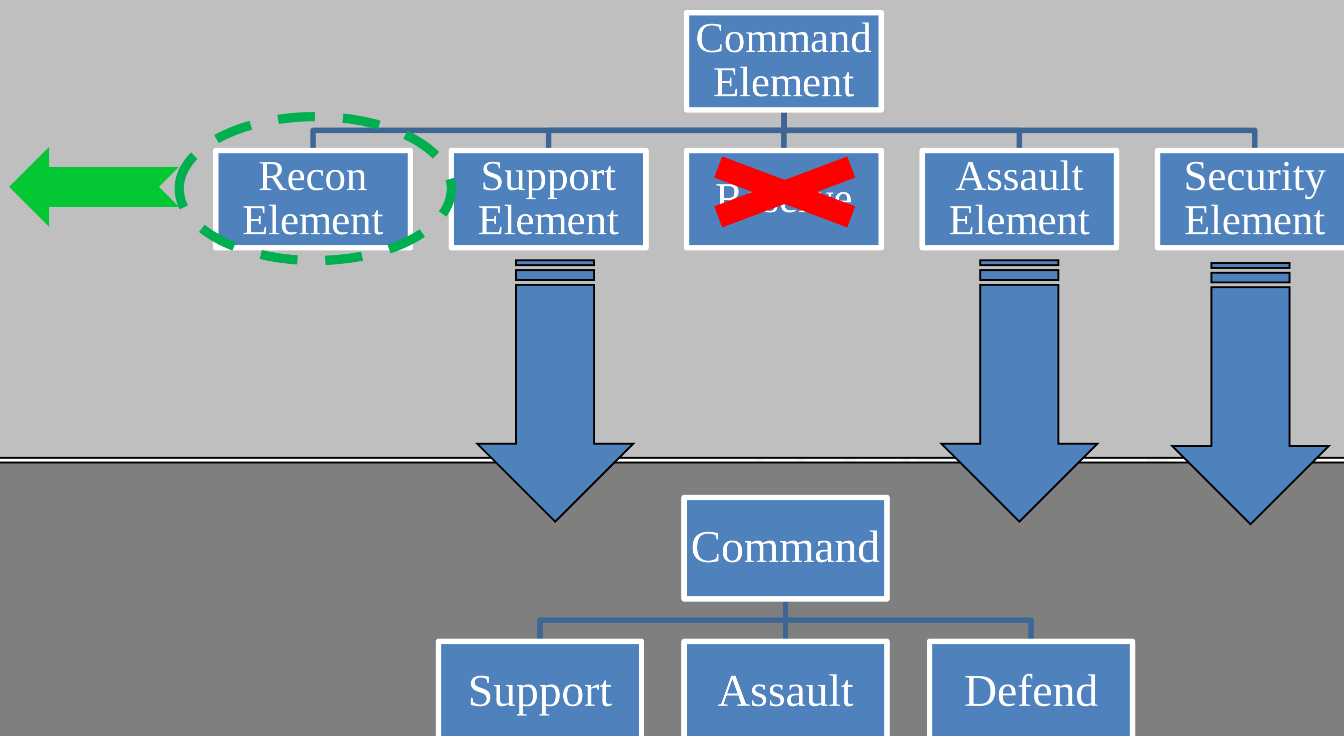
Functional Analysis

Step 1: Naval and Marine Task: Conduct Amphibious Raid NTA 1.5.2.4



- 179 Tasks
- Narrow focus on core raid tasks

Step 2: MCWP 3-43.1 Raid Operations Doctrinal Organization



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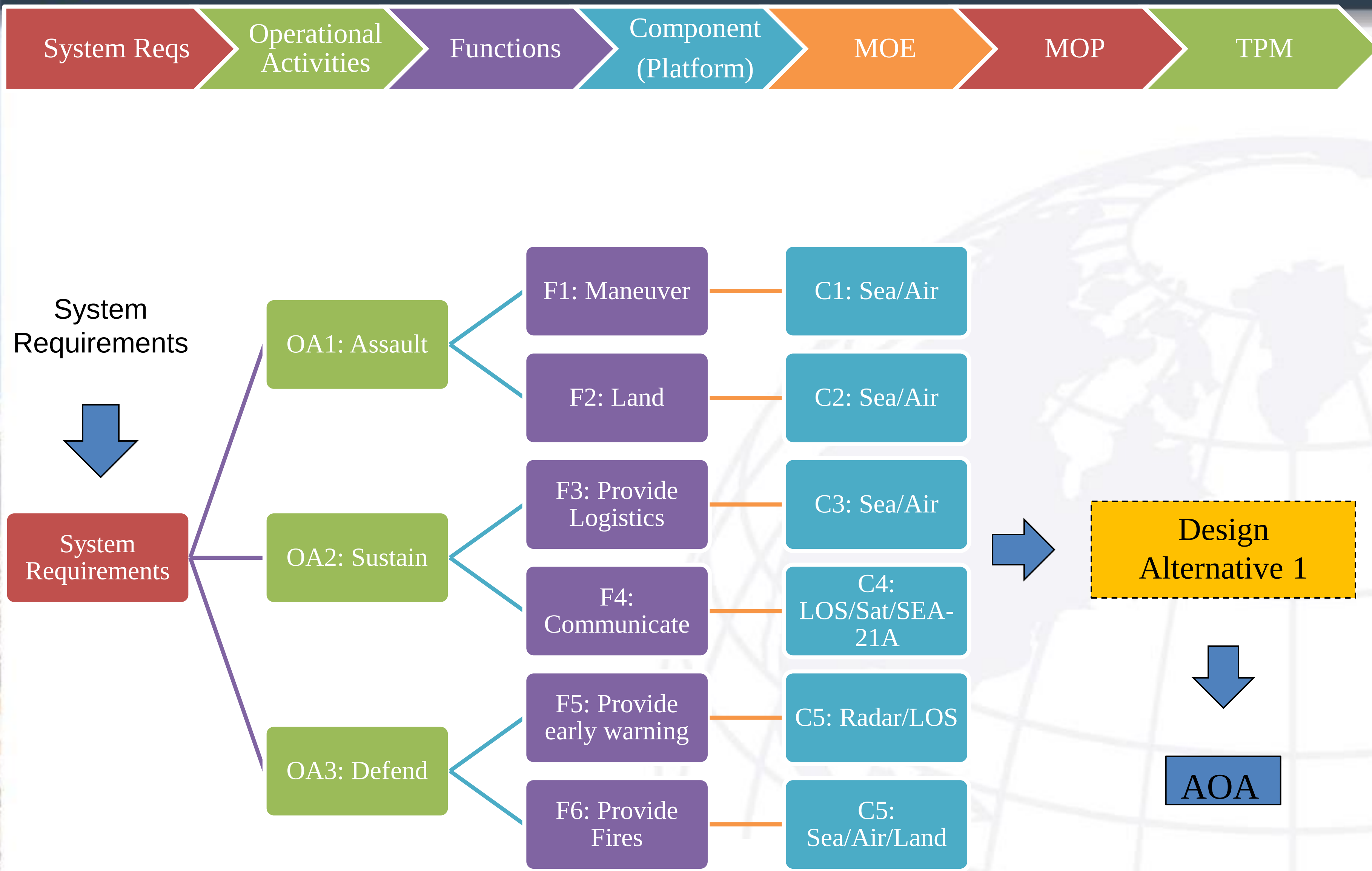
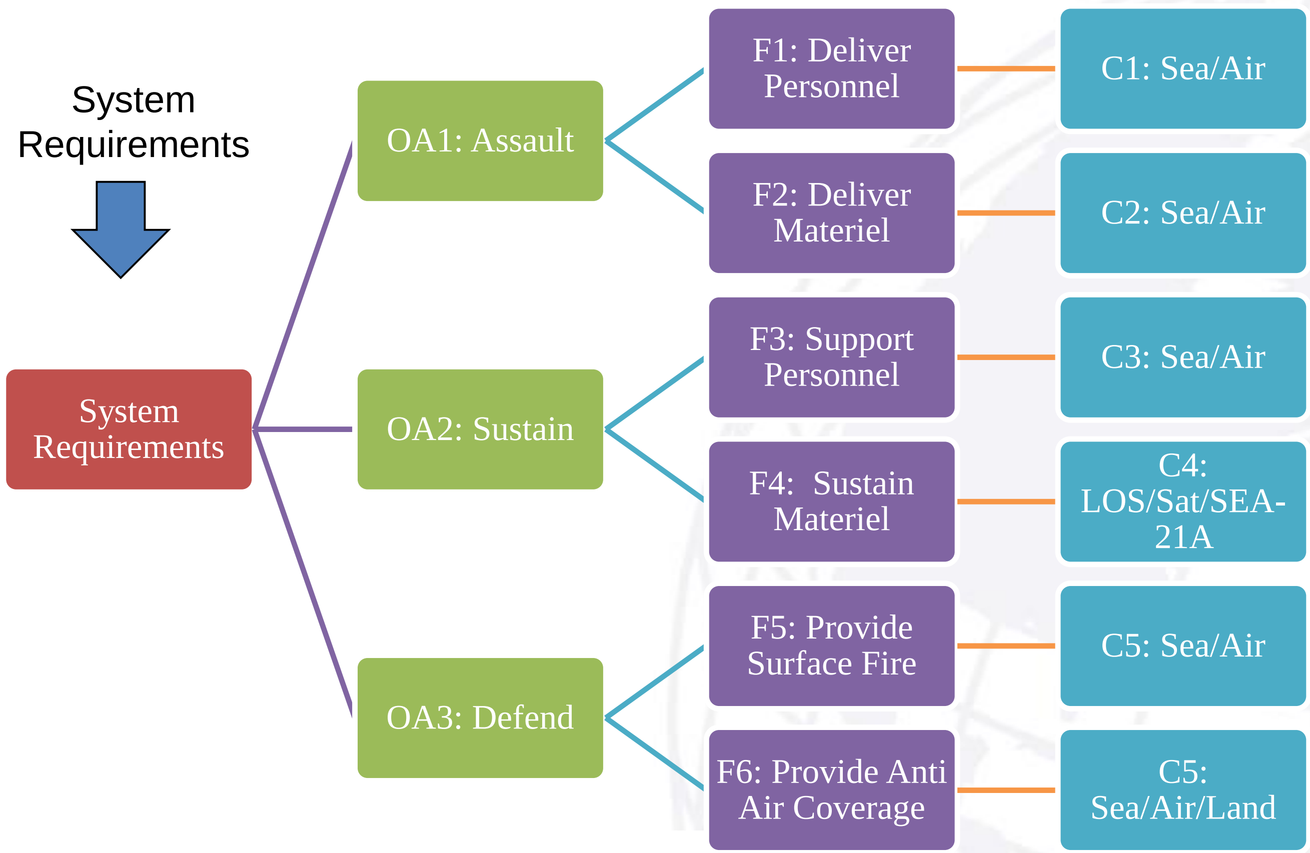
Requirements Analysis



Naval Function/Component Breakdown

System Reqs → Operational Activities → Functions → Component (Platform) → MOE → MOP → TPM



Naval Platform Options

LCS

SSGN

C-130

OTH LCU

MV-22

JHSV

Prospective COA's

	COA 1	COA 2	COA 3
Transport Personnel	LCS	OTH LCU	MV-22
Transport Material	JHSV	OTH LCU	JHSV
Deliver Personnel	11m RHIB	OTH LCU	MV-22
Deliver Material	Helicopter	OTH LCU	OCH LCU
Support/Sustain Personnel	LCS/Helicopter	LCS/Helicopter	Air Drop
Support/Sustain Material	LCS/Helicopter	LCS/Helicopter	Air Drop

	COA 4	COA 5
Transport Personnel	C-130	SSGN
Transport Material	C-130	C-130
Deliver Personnel	C-130	SSGN
Deliver Material	C-130	C-130
Support/Sustain Personnel	C-130	C-130
Support/Sustain Material	C-130	C-130

Platform Performance

Platform	Days Until Resupply	Operating Cost (Per 24 hours)	Platform Cost	Souls Onboard	Tons of Cargo	Personnel Per
LCS	14	$216,438	$480,000,000	100	231	75
JHSV	14	$65,753	$180,000,000	42	600	312
OTH LCU	10	$15,000	$750,000	8	80	30
C-130	0	$336,000	$30,000,000	4	22.5	64
MV-22	0	$228,480	$72,000,000	4	10	32
SSGN	45	$136,986	$2,700,000,000	155	0	66

Platform	Stealth	Speed	Visibility	Time on Station
LCS	1	3	6	5
JHSV	2	3	5	5
OTH LCU	3	4	4	3
C-130	5	6	3	1
MV-22	4	5	2	1
SSGN	6	1	1	6

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Platforms per COA

Number of Platforms Per COA					
Platform	**COA 1**	**COA 2**	**COA 3**	**COA 4**	**COA 5**
LCS	3	2	0	0	0
JHSV	1	0	1	0	0
LCU	0	7	2	0	0
C-130	0	0	1	10	7
MV-22	0	0	5	0	0
SSGN	0	0	0	0	2
Total Tonnage	1293	1022	832.5	225	157.5
Total Personnel	537	360	596	640	580

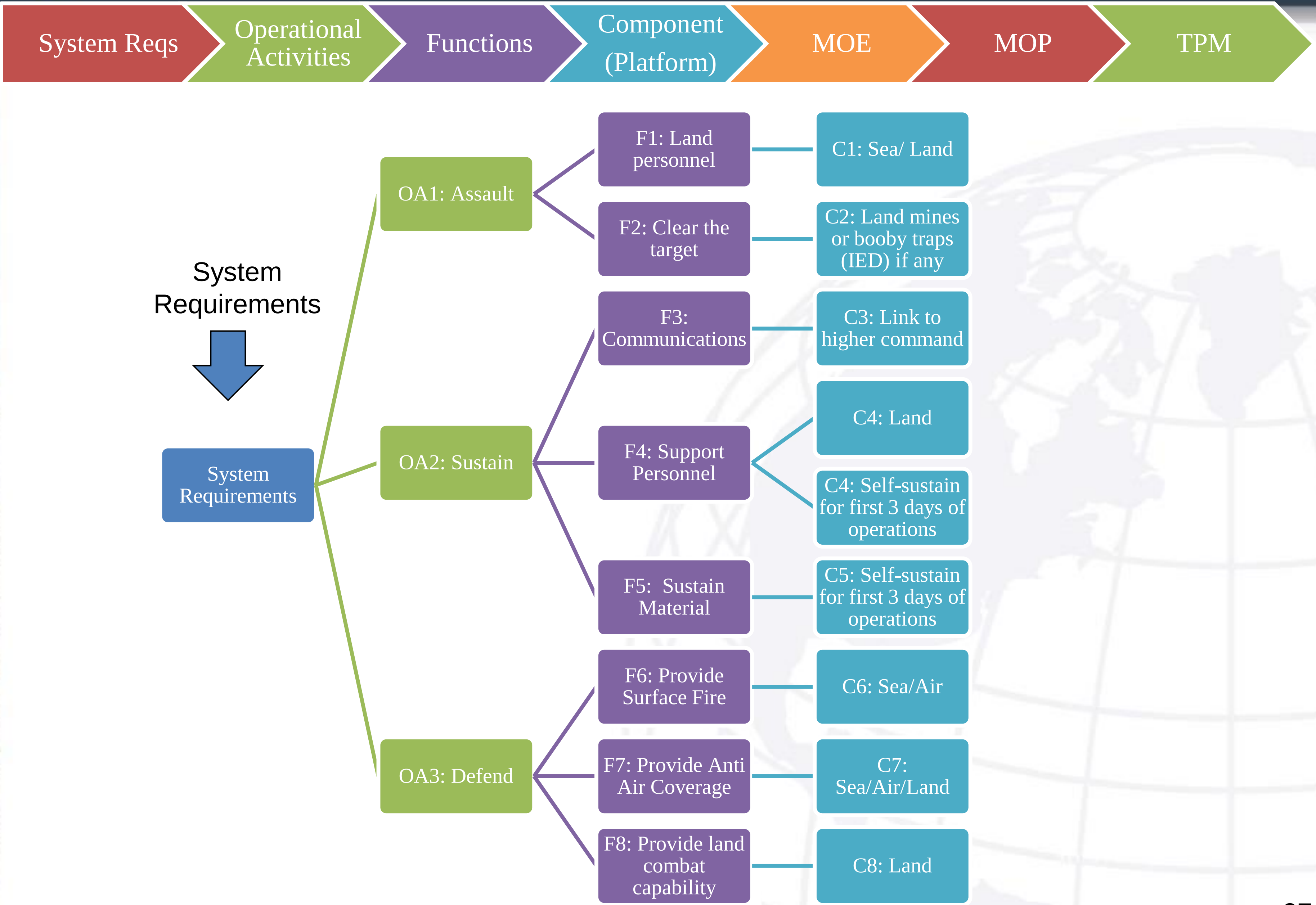
Based on personnel and weight requirements of tentative Marine Corps' Force Packages

COA Performance

COA vs MOP Results					
MOP	**COA 1**	**COA 2**	**COA 3**	**COA 4**	**COA 5**
Days Until Resupply	14	10	10	50	45
Operating Cost Per Day	$715,068	$537,877	$1,574,153	$3,360,000	$2,625,973
Platform Cost	$1,620,000,000	$965,250,000	$571,500,000	$300,000,000	$5,610,000,000
Souls Onboard	342	256	82	40	338
Stealth	1	3	2	4	5
Speed	2	3	4	5	1
Visibility	5	3	4	2	1
Time on Station	4	2	3	1	5

Force Packages Versus COA Capability										
COA	**Marine Corps Force Packages**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	X	X	X	X	X	X	X	X	*1 more LCS*	
2	X	X	X	X	X	X	*3 more LCU's*		*3 more LCU's*	
3	X	X	X	X	X	X	X	X	*3 more MV-22*	
4	X	X	X	X	X	X	*5 more C-130's*		*1 more C-130*	
5	X	X	X	X	X	X	*5 C-130, 1 SSGN*		*1 more SSGN*	
Personnel	118	118	136	136	136	136	168	168	254	254
Weight (Tons)	116.95	146.97	150.85	149.64	145.34	150.85	213.18	247.08	245.86	241.56

Marine Function/ Component Breakdown



Marine COAs

		Threats for Defend/Deter							Support	Supply	C4I
Scenario	Threat Level	DF-21 (cluster mini-bombs)	Cruise Missile	Land Mines	Aircrafts/ Air threats	Ships	UAV	SWARM	Landing Force		ISR
Spratly Island (Baseline)	Low	0	0	Engineering Group	0	- Trenches - Mobile Concrete Igloos	0	0	Rifle company (96) Support (22) Total (118)	Water Food Fuel Medical supplies Generators	ISR Balloon only
	Medium	0	0	Engineering Group	- Patriot - AMRAAM	- Naval Strike Missile (NSM) - Harpoon - Russian KH35 - P-800 Yakhont - French Exocet - Chinese C801	- Avenger/ Stinger - Laser - Jamming	Jamming	Rifle company (114) Support (22) Total (136)	Water Food Fuel Medical supplies Generators	- ISR Balloon - UAV or aircraft surveillance by USN?
	High	0	- Patriot	Engineering Group	- Patriot - AMRAAM	- Naval Strike Missile (NSM) - Harpoon - Russian KH35 - P-800 Yakhont - French Exocet - Chinese C801	- Avenger/ Stinger - Laser - Jamming	Jamming	Rifle company (114) Support (22) Total (136)	Water Food Fuel Medical supplies Generators	- ISR Balloon - UAV or aircraft surveillance by USN?
Netuna Besar (Higher Level)	Low	0	0	Engineering Group	0	- Trenches - Mobile Concrete Igloos	0	0	Rifle company (114) Support (54) Total (168)	Water (optional) Food Fuel Medical supplies Generators	ISR Balloon only
	Medium	0	0	Engineering Group	- Patriot - AMRAAM	- Naval Strike Missile (NSM) - Harpoon - Russian KH35 - P-800 Yakhont - French Exocet - Chinese C801	- Avenger/ Stinger - Laser - Jamming	Jamming	Rifle company (200) Support (54) Total (254)	Water (optional) Food Fuel Medical supplies Generators	- ISR Balloon - UAV or aircraft surveillance by USN?
	High	0	- Patriot	Engineering Group	- Patriot - AMRAAM	- Naval Strike Missile (NSM) - Harpoon - Russian KH35 - P-800 Yakhont - French Exocet - Chinese C801	- Avenger/ Stinger - Laser - Jamming	Jamming	Rifle company (200) Support (54) Total (254)	Water (optional) Food Fuel Medical supplies Generators	- ISR Balloon - UAV or aircraft surveillance by USN?

Marine Platform Options

AVENGER (Air)

ISR Balloon

NSM (Surface)

Patriot (Air)

AMRAAM

UAV (Surveillance)

Army

System Reqs → Operational Activities → Functions → Component (Platform)

- System Requirements
  - OA1: Assault
    - F1: Maneuver — C1: Sea/Air
    - F2: Land — C2: Sea/Air
  - OA2: Sustain
    - F3: Provide Logistics — C3: Sea/Air
    - F4: Communicate — C4: LOS/Sat/SEA-21A
  - OA3: Defend
    - F5: Provide early warning — C5: Radar/LOS
    - F6: Provide Fires — C5: Sea/Air/Land

JPADS- ENHANCED

Army – Air Force Morphological Box

OA1: Assault

Prepared Airfield	Austere Airfield	Unable to Support Landing Aircraft	Unable to Support Aircraft & Mined (*)
• C-17 • C-130 • Vertical Lift	• C-130 • Vertical Lift • High Speed AFSB	• Vertical Lift • High Speed AFSB • JPADS	• (3) High Speed AFSB • (2) JPADS - E • (1) Sacrificial Afloat Staging Barge

* Number indicate operation sequence. Entire process may be preceded by rapid mine clearing techniques

Army – Air Force Morphological Box

OA2: Sustain

Sustain by Sea		Sustain by Air	
Permissive	Denied*	Permissive	Denied+
• Large Cargo Ship • Medium Cargo Ship • JHSV • Go-Fast • Semi-Sub • Indigenous Entrepreneurs	• Go-Fast • Semi-Sub • Indigenous Entrepreneurs	• C-17 • C-130 • Vertical Lift • JPADS	• C-17 • C-130 • Vertical Lift • JPADS • Fulton Recovery System

* Aircraft unable to land on island

+ Blockade and/or possible mine threat

Army – Air Force Morphological Box

OA3: Defend

Traditional Threats

Surface Threats	Air Threats
• Automated Detection & Tracking Systems • ASM in a Box • Combat Air Patrol	• Automated Detection & Tracking Systems • Combat Air Patrol • SAM in a Box

C4ISR

Permissive	Denied
• Current Methods • Low Altitude Balloon • Anti-Jam Techniques • Network Optional Comms	• Low Altitude Balloon • Anti-Jam Techniques • Network Optional Comms

Measures of Effectiveness

1. Probability of Detection against enemy sensors in an A2AD environment → TBD% (COI 1 & 2)
2. Probability of Arriving first to the AOR → TBD% (COI 1)
3. 70% of your initial force delivered and 70% of supplies required by the force delivered on initial landing (COI 1 & 3)
4. Do not fall below 70% in supplies (COI 2)
5. TBD% of incoming threat detected prior to landing in time to allow system to initiate defense.(COI 3)
6. The System of Systems achieves a reliability of TBD% and availability of TBD% (COI 4)
7. TBD% of subsystem equipment used is TRL 8 or greater (COI 5)

MOE Modeling

MOE's

1. Probability of Detection against enemy sensors in an A2AD environment
   - Rank COAs against each other relatively. Entire COA's not platform v platform
2. Probability of Arriving first to the AOR
   - First arrival model. Rank COA's against each other based on performance
     - Requirements
       - Enemy starting location
       - Friendly starting location
       - Deployment delay
3. 70% of your initial force delivered and 70% of supplies required by the force delivered on initial landing
   - Based on capacity of the subsystem used to deliver initial force

MOE Modeling

MOE's

4. Do not fall below 70% in supplies
   - Logistics model
     - Based on consumption and resupply
     - Consumption approx. 15 metric tons per day
5. TBD% of incoming threat detected prior to landing in time to allow system to initiate defense
     - Based on detection capability of defense systems attached to various COAs
     - Distributed sensor system model is available if COA makes use of such a system

MOE Modeling

MOE's

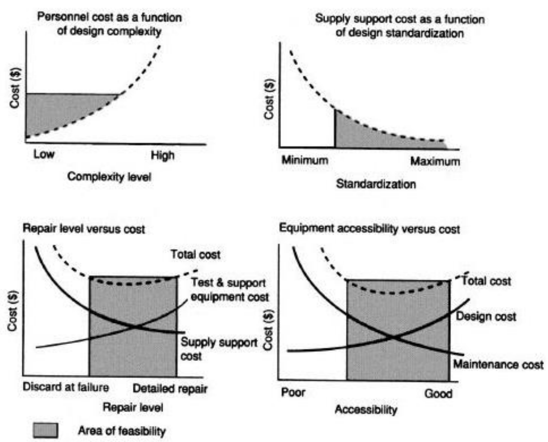
7. The System of Systems achieves a reliability of TBD% and availability of TBD% (COI 4)
   - Determine the reliability of each subsystem and perform appropriate calculations from Blanchard & Fabryky
   - Determine availability of each subsystem and perform appropriate calculations from Blanchard & Fabryky
8. TBD% of subsystem equipment used is TRL 8 or greater (COI 5)
   - Research subsystem TRL level
   - $\frac{number\ of\ subsystems\ less\ than\ TRL\ 8}{total\ number\ of\ subsystems}$

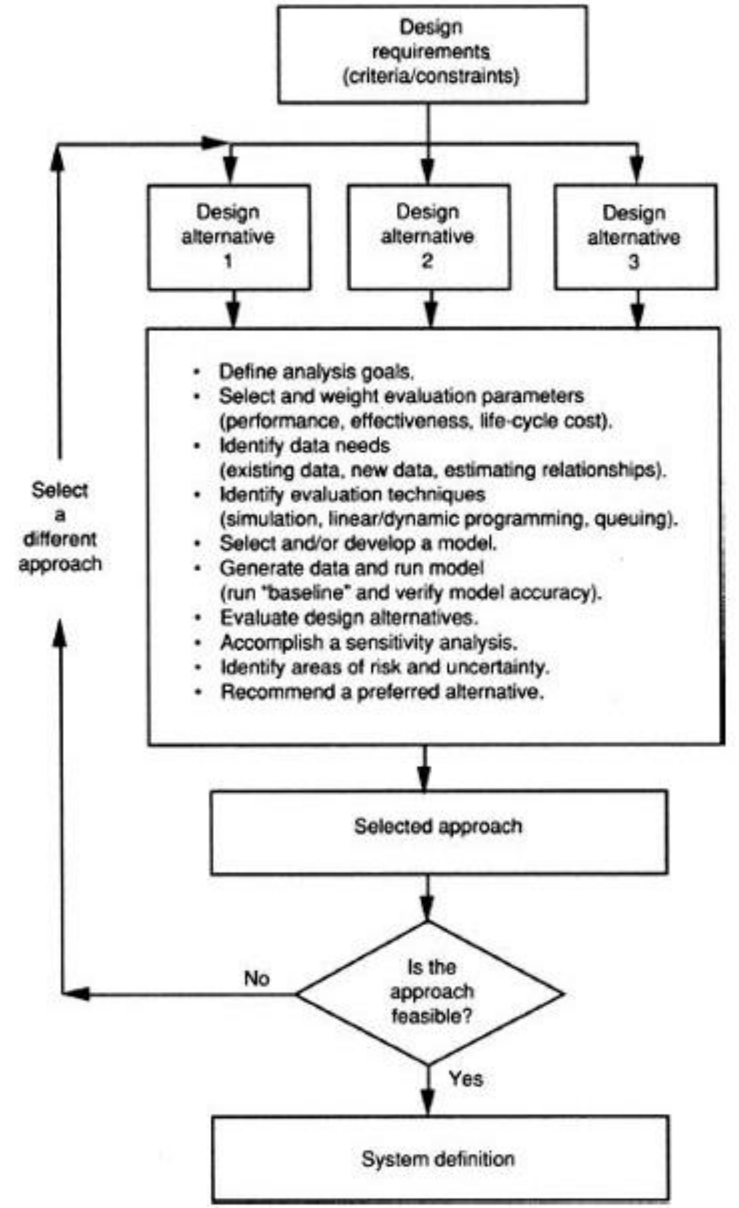
Measures of Performance

- Stealth/Visibility – MOE 1
- Speed – MOE 2
- Time on Station – MOE 3
- Days Until Resupply – MOE 3
- Daily Operating Cost –MOE 6
- Total Platform Cost – MOE 6
- Number of Souls Onboard Platforms – MOE 6
- Number of threats detected in time – MOE 4
- MTBF of 10,000hr? – MOE 5

Analysis of Alternatives

- Each Design Alternative measured against the same standard
  - MOE
  - MOP
  - TPM





System Modeling

Initial Feasibility Study

and

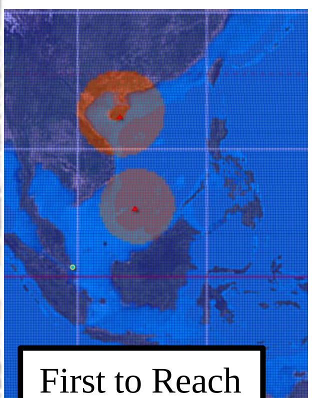
System Design

Areas for Analysis

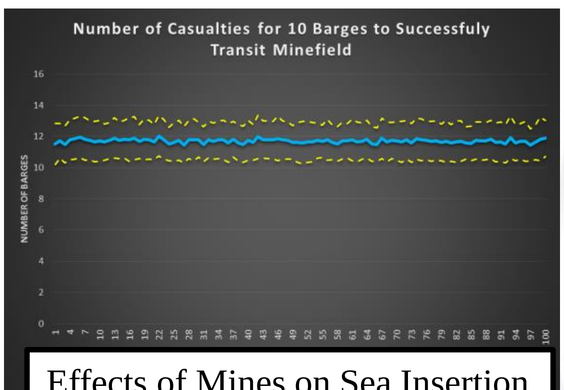
- **Critical Operational Issues**
  - Long distance deployment
    - Get to target first
  - Sea insertion in mined environment
  - Defeating enemy blockade
  - Consumption of supplies
    - Fuel / Electricity
    - Stores
  - Sea space intruder detection
  - Logistics and Supply
- **Modeling Tools**
  - Excel
  - SIMIO
  - MANA

Excel Brief Overview

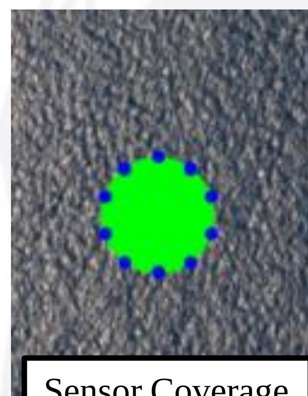
- Capable, flexible, and easy to use
- Many useful models already available
  - Washburn mine warfare simulations
  - Tallying logistics requirements
  - Search models



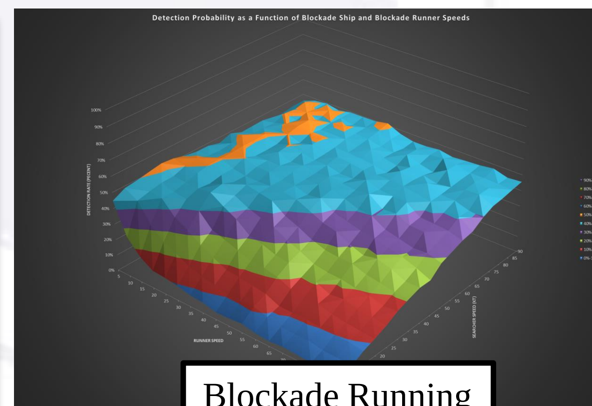
First to Reach



Effects of Mines on Sea Insertion



Sensor Coverage



Blockade Running

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Geographic Applicability

- Focused on South China Sea scenarios
  - Applicability
  - Provide proof of model concept
  - Applicable to other geographic areas

Ability to Achieve First Arrival

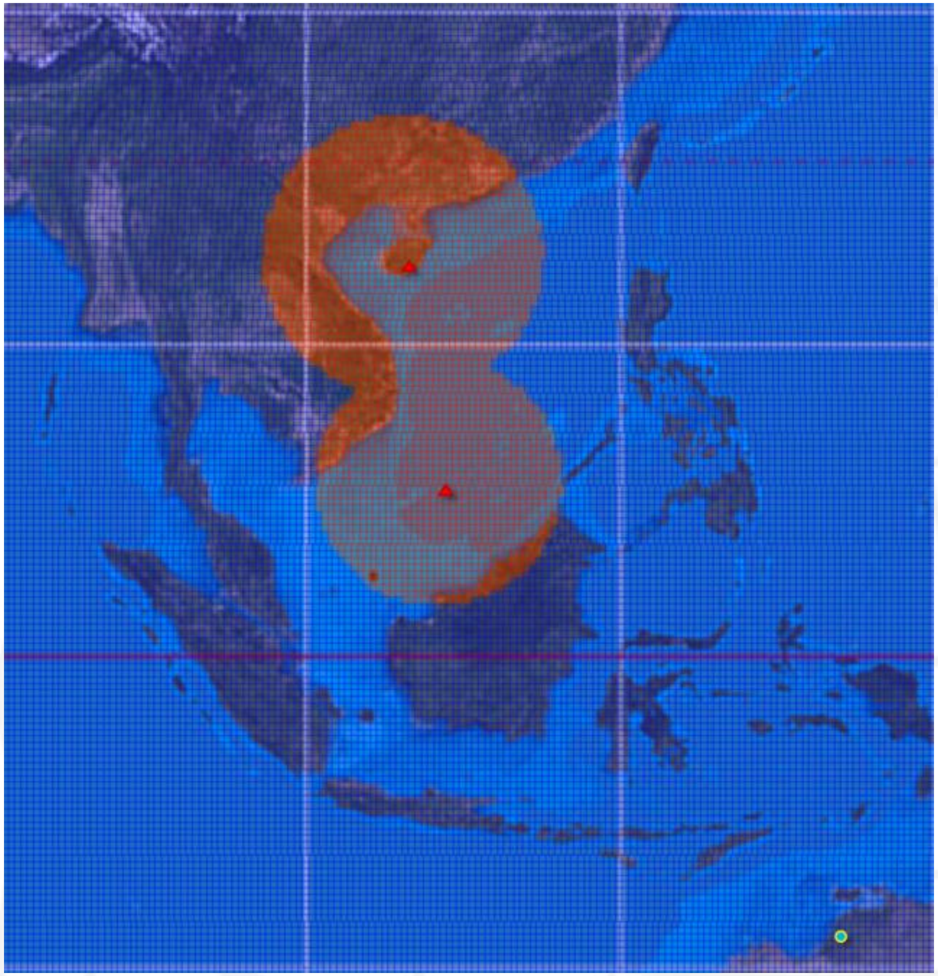
Purpose

- Show blue and red force area of influence

Preliminary Analysis

- Ability to beat adversary hinges on the following
  - Speed: ours and theirs
  - Destination location
  - Our deployment delay
  - Our travel range
- Being good at one aspect does not overcome being bad at others
- Every hour of delay (deployment, speed, or travel) expands the enemy circle of influence

Example Model Results



Red 30 knot ship
Red has 6 hour head start
Blue C-130 at cruise speed
Deploy from Darwin

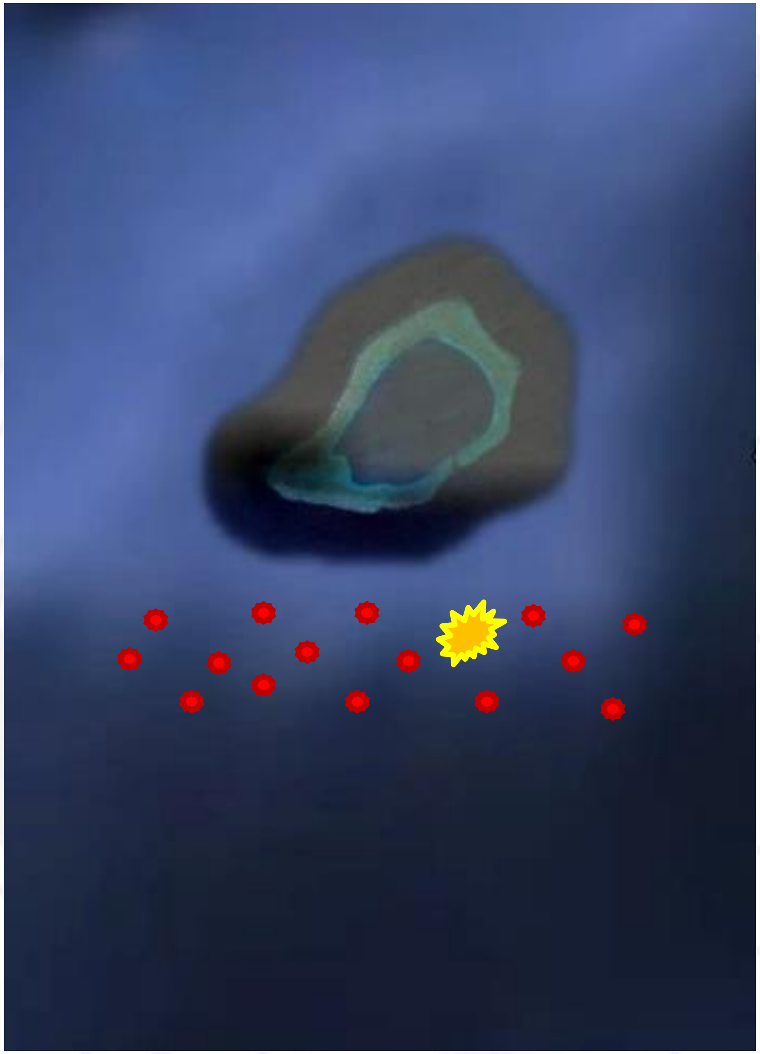
Delivery of Initial Troops and Material (Mine Scenario)

Purpose

- Determine platform attrition in creating staging platform near reef/atoll on other side of minefield

Preliminary Analysis

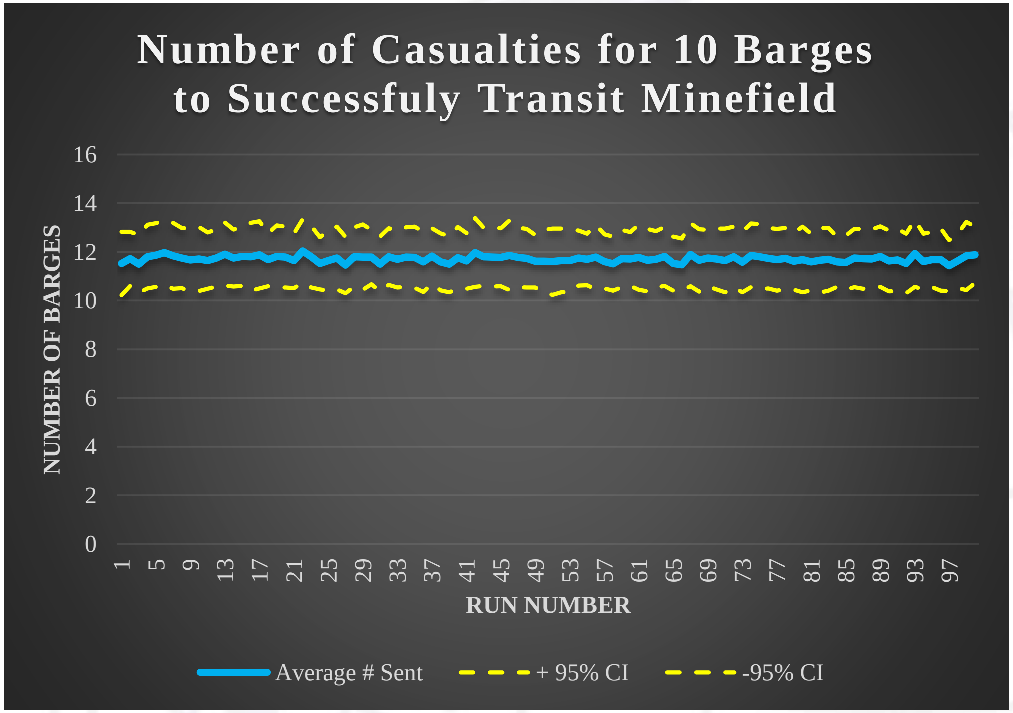
- Attrition of unmanned barges to clear channel through minefield
  - Towed
  - Remote piloted
  - Autonomous
- Connect surviving barges to form manned outpost
- Dependent on mine field density



Delivery of Initial Troops and Material (Mine Scenario)

Simulation parameters

- 10 barges required
- 12.5 mile wide minefield
- 20 mines
- Mines actuate upon detection
- .5 km kill radius per mine
- Mines randomly distributed across minefield
- 100 simulations with 100 replications each



Conclusion

- Attrition is dependent on mine field density, distribution, and type
- No more than 4 additional platforms required for this scenario

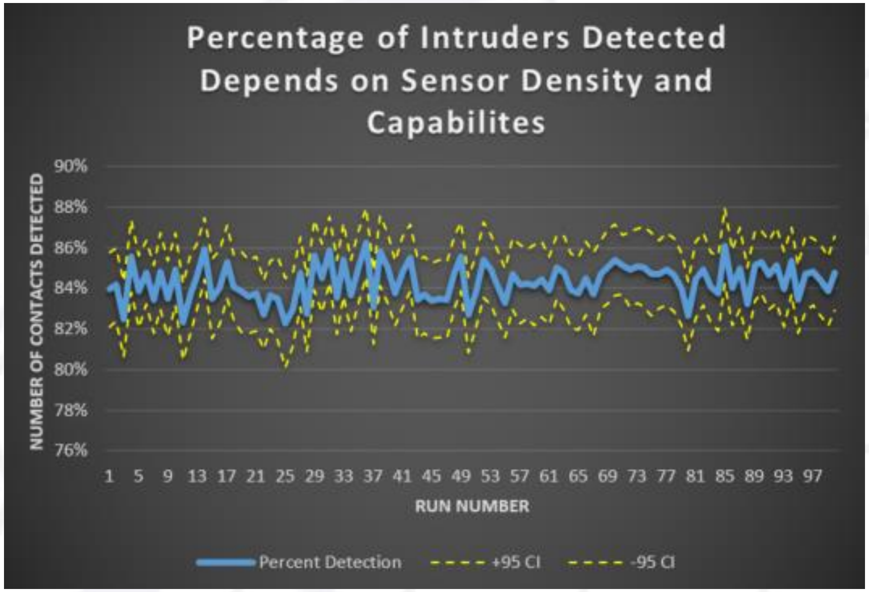
Defense: Smart Sensor Detection

Purpose

- Analyze ability to detect inbound intruders using networked sensor system composed of randomly disperese nodes

Simulation Parameters

- 50 sensors
- 250 meter detection radius
- 90% probability of detection
- 12.5 km wide sensor field
- 100 simulations with 100 replications each
- 20 intruders



Preliminary Analysis

- Approximately 85% probability of detection
- Sensor detection capabilities and density affected overall probability of detection

Sustainment: Blockade Running

Purpose

- Maintain supply lanes against surface blockade
- Model based on barrier search models

Preliminary Analysis

- Blockade runner success depends on:
  - Barrier length
  - Searcher speed
  - Runner speed
  - Searcher detection capabilities

Conclusion

- Faster and stealthy runner is most successful
- Faster searcher with longer detection range results in lower chance of success

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Sustainment: Blockade Running

Effects of Increased Blockade Runner Speed

Searcher Speed Increases ↓

Runner Speed Increases →

Probablility of detection as a function of searcher and blockade runner speed

Searcher Velocity \ Runner Velocity	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
5	45%	25%	16%	11%	11%	9%	7%	7%	5%	5%	6%	4%	3%	4%	4%	3%	3%	3%
10	49%	44%	33%	25%	21%	17%	15%	13%	11%	11%	11%	9%	7%	7%	7%	5%	5%	4%
15	50%	46%	45%	37%	32%	26%	22%	18%	17%	16%	15%	11%	11%	11%	10%	10%	10%	8%
20	51%	47%	45%	44%	40%	32%	29%	26%	23%	22%	21%	17%	16%	16%	14%	12%	11%	11%
25	52%	48%	47%	46%	47%	42%	38%	31%	29%	26%	25%	20%	21%	17%	18%	16%	15%	14%
30	52%	50%	49%	46%	49%	45%	41%	38%	35%	31%	28%	24%	22%	22%	20%	19%	17%	18%
35	50%	51%	50%	47%	46%	48%	46%	44%	38%	35%	31%	28%	27%	27%	24%	23%	21%	21%
40	48%	49%	50%	47%	46%	46%	46%	46%	45%	41%	37%	35%	31%	28%	29%	26%	23%	23%
45	48%	48%	50%	50%	48%	48%	46%	46%	43%	45%	39%	37%	35%	34%	31%	30%	27%	23%
50	46%	49%	51%	47%	48%	48%	47%	46%	46%	46%	44%	41%	40%	35%	33%	31%	31%	29%
55	49%	51%	50%	47%	49%	46%	47%	46%	47%	46%	45%	46%	40%	41%	37%	36%	34%	31%
60	46%	48%	51%	48%	50%	48%	47%	47%	45%	45%	47%	45%	44%	43%	38%	37%	36%	34%
65	46%	48%	49%	50%	48%	50%	47%	48%	47%	46%	47%	47%	46%	45%	43%	40%	41%	35%
70	47%	48%	50%	52%	50%	50%	48%	47%	47%	46%	44%	48%	46%	47%	44%	43%	40%	40%
75	44%	51%	49%	52%	49%	49%	49%	48%	49%	46%	45%	47%	45%	43%	44%	46%	46%	43%
80	45%	50%	51%	49%	50%	51%	49%	48%	47%	46%	48%	45%	43%	48%	45%	46%	46%	43%
85	46%	51%	50%	51%	49%	48%	49%	50%	48%	45%	47%	47%	48%	47%	45%	45%	45%	45%
90	46%	49%	50%	48%	50%	50%	50%	51%	48%	46%	46%	47%	45%	46%	46%	47%	45%	46%

Effects of Increased Searcher Detection Range

Searcher Speed Increases ↓

Searcher Detection Range Increases →

Probablility of detection as a function of searcher speed and Rdet

Searcher Velocity \ Rdet	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
5	5%	10%	16%	23%	29%	34%	41%	49%	54%	60%	64%	71%	75%	79%	85%	88%	92%	93%
10	8%	18%	28%	37%	47%	53%	60%	68%	74%	81%	86%	89%	92%	94%	98%	99%	100%	100%
15	8%	20%	29%	39%	51%	55%	61%	69%	76%	83%	89%	90%	94%	95%	98%	100%	100%	100%
20	9%	20%	29%	40%	47%	55%	60%	70%	75%	81%	85%	89%	92%	95%	98%	99%	100%	100%
25	10%	20%	31%	38%	48%	54%	63%	68%	71%	77%	82%	86%	89%	95%	98%	99%	100%	100%
30	9%	18%	30%	38%	46%	54%	61%	65%	71%	75%	81%	82%	88%	93%	97%	99%	100%	100%
35	8%	20%	30%	37%	48%	52%	60%	65%	66%	75%	79%	82%	88%	92%	96%	99%	100%	100%
40	8%	19%	30%	38%	48%	50%	56%	65%	68%	72%	78%	80%	87%	91%	96%	99%	100%	100%
45	9%	19%	30%	36%	47%	51%	56%	63%	66%	70%	77%	80%	86%	90%	95%	98%	100%	100%
50	9%	19%	29%	39%	45%	50%	56%	62%	67%	72%	75%	79%	83%	90%	93%	98%	100%	100%
55	10%	17%	28%	38%	44%	51%	54%	61%	65%	71%	75%	77%	84%	88%	93%	97%	100%	100%
60	9%	17%	28%	37%	45%	51%	53%	62%	66%	69%	75%	77%	83%	87%	93%	98%	100%	100%
65	8%	19%	28%	36%	46%	51%	53%	58%	65%	67%	72%	78%	83%	88%	92%	97%	99%	100%
70	9%	18%	27%	38%	44%	49%	53%	60%	65%	70%	73%	79%	82%	87%	92%	97%	100%	100%
75	9%	17%	26%	38%	45%	48%	54%	59%	63%	69%	74%	77%	82%	87%	92%	96%	99%	100%
80	7%	17%	28%	35%	44%	47%	54%	56%	63%	68%	74%	77%	81%	87%	91%	96%	100%	100%
85	9%	19%	27%	34%	44%	47%	54%	58%	63%	68%	72%	76%	82%	86%	92%	95%	99%	100%
90	9%	19%	27%	36%	42%	48%	53%	57%	63%	68%	71%	77%	82%	86%	91%	96%	100%	100%

2000 simulation iterations for each combination

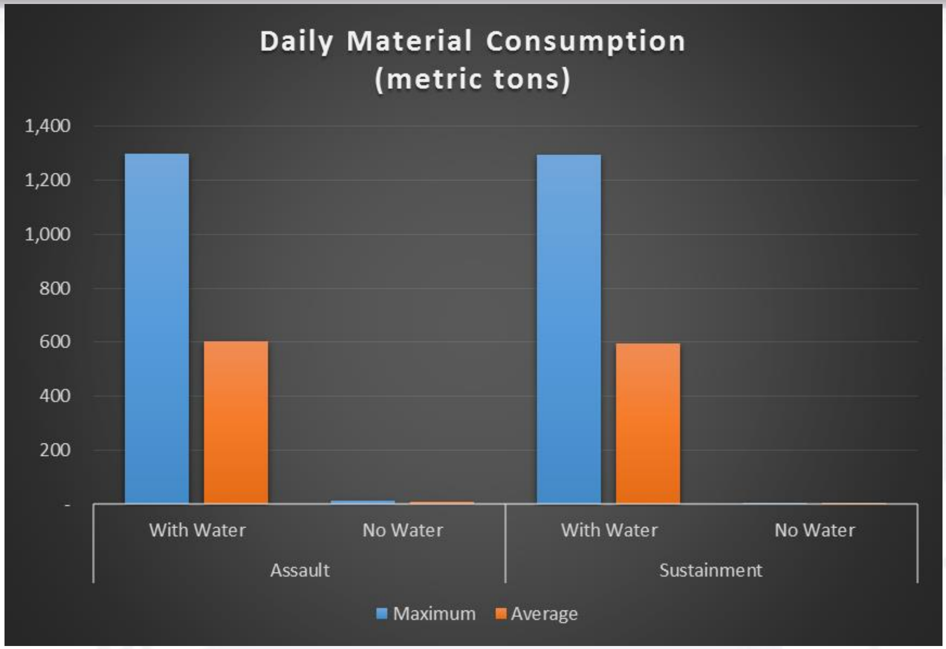
Sustainment: Water and Fuel Requirements

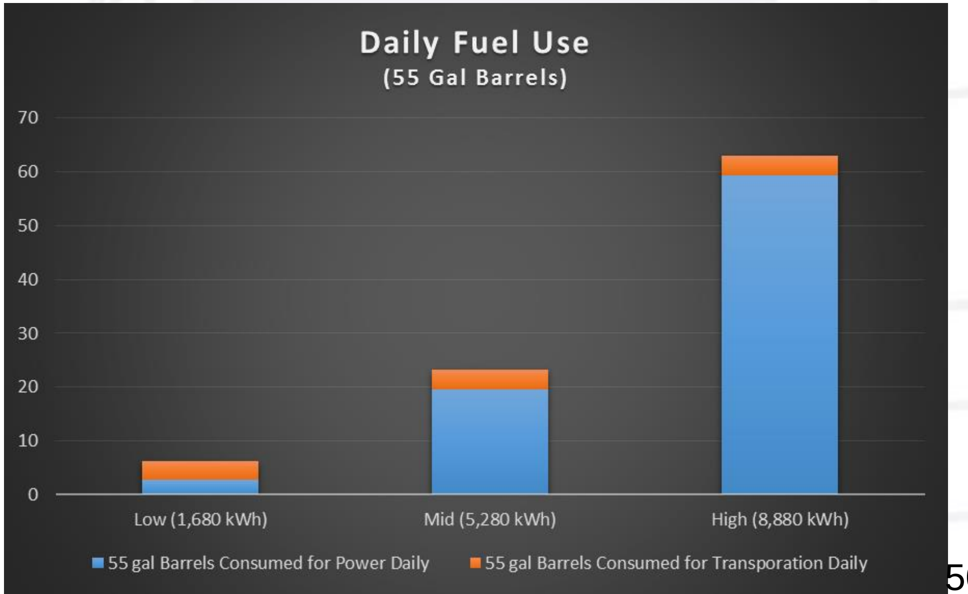
Purpose

- Determine impact of water and fuel requirements

Preliminary Analysis

- Water and fuel impacts will drive capabilities
- Require water purification on site
- Minimize energy requirements to conserve fuel



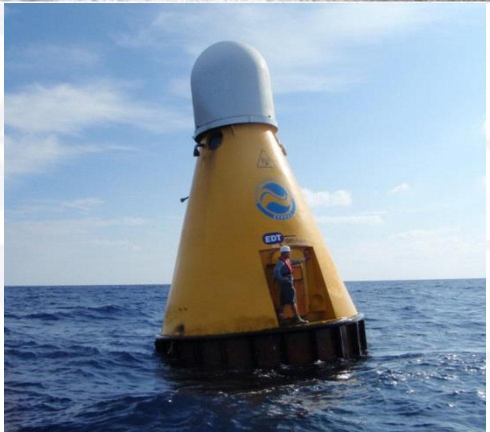


Defense: Detection & Engagement

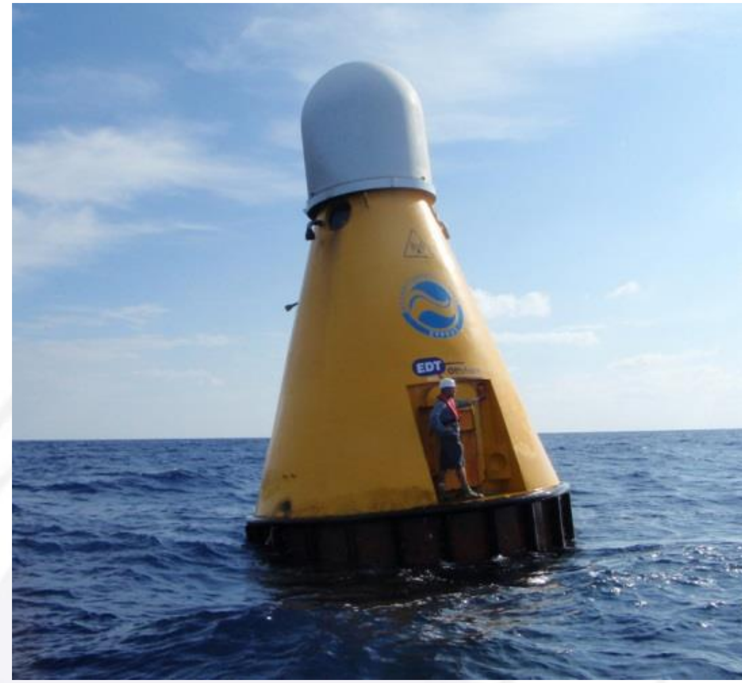
Purpose

- Sea-space Intruder Detection by Fixed Systems

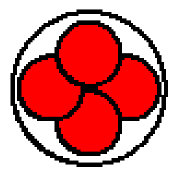
- Detect traffic in 12NM area around island
- Fixed/Aerostat System
    - 105 feet 12 NM
    - 200 feet 16 NM
    - 400 feet 23 NM
    - 1000 feet 37 NM
  - Day/Night
  - "Most" Weather
  - Self-Contained
  - Power Requirements
    - 24/7 Operations
  - Communication
  - Co-operative Targeting



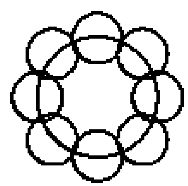
Defense: Intruder Detection & Engagement



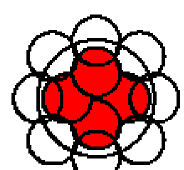
- Fixed Barrier System
  - Air/Surface/Subsurface
- Baseline assumptions
  - 20ft height
  - 5+ NM radar horizon
  - 5 NM visual horizon
- Min coverage (70%)
  - 4 units



- Perimeter coverage
  - 8 units

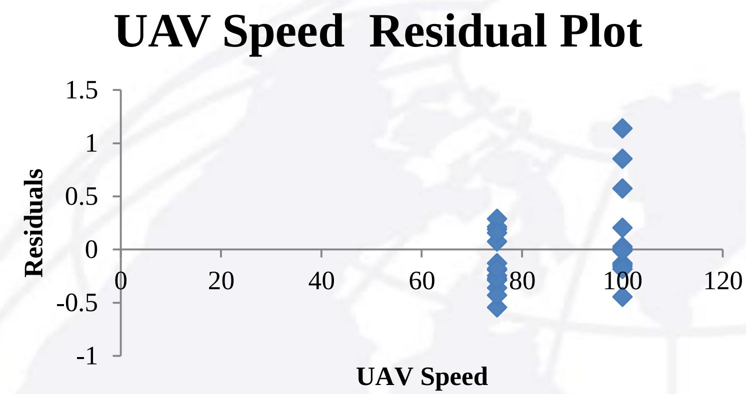


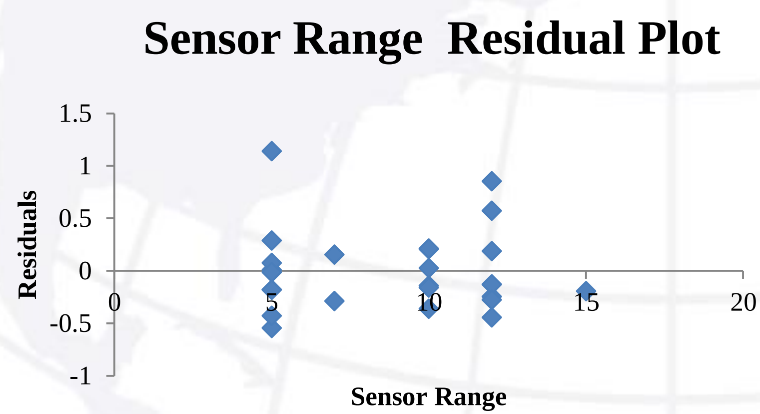
- Full coverage
  - 12 units



Sea-space Intruder Detection Mobile System

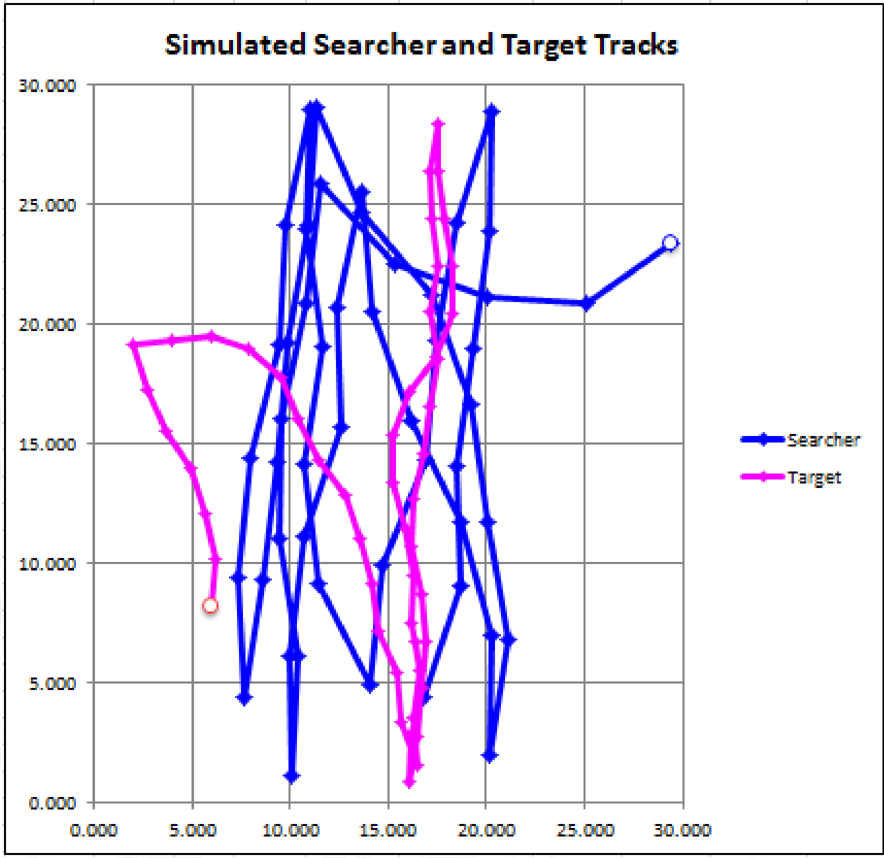
- Area search model
  - Random UAV Search
  - Random TGT location
  - 90% and 95% probability of detection
- – UAV speed
  - Little effect on probability of detection
  - For a long range sensor slower speeds are more robust against variety of tgt speeds
- – Sensor range
  - Greatest effect on probability of detection
  - “Sweet Spot” around 10 NM
- – Target speed
  - Unknown to us
  - Faster targets less likely to intercept





Defense: Intruder Detection & Engagement

- UAV Requirements
  - 452 sq/NM search area
    - Every 72 min for 10 kt tgt
    - Every 36 min for 20 kt tgt
    - Every 18 min for 40 kt tgt
- UAV Simulation results
- 1,000 replications
  - 90% Prob of detection
    - Search < 1 hour
    - Sensor range 10-15 NM
  - 95% Prob of detection
    - Search < 1 hour
    - Sensor range 12-15 NM



UAV vs. TGT Random Search
Graph of Single Run

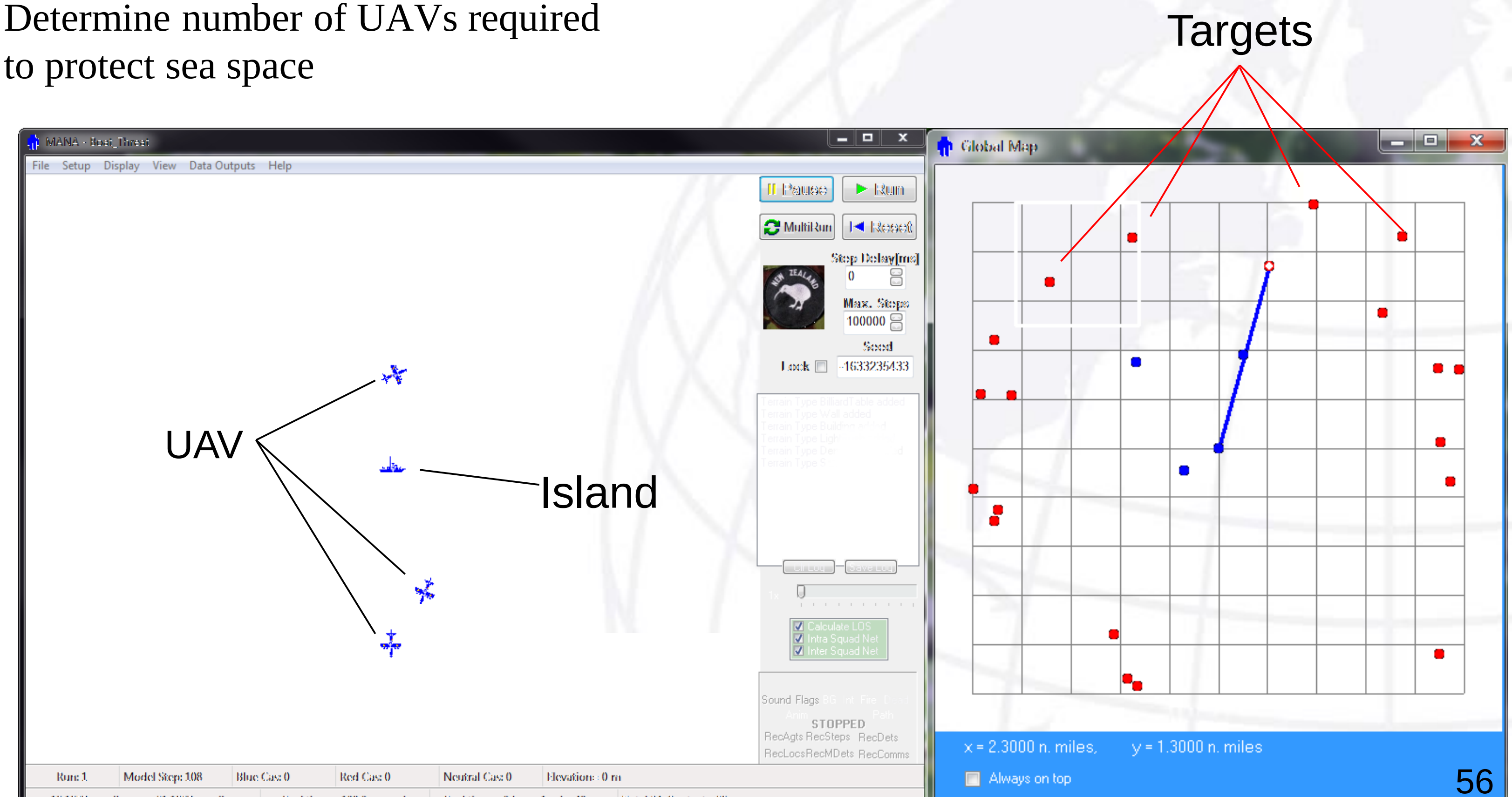
MANA Brief Overview

- Agent Based Model
- Stochastic Results
- **Aimed Fire Capability**
- Significant expertise around campus
- Ideal for short duration engagement analysis

Defense: Intruder Detection & Engagement

- MANA Agent Modeling of UAVs
  - Random location of enemies
  - Sensor range of 10 NM
  - Determine ability to detect when enemy encroaches 12NM ring
  - Determine number of UAVs required to protect sea space

MANA V



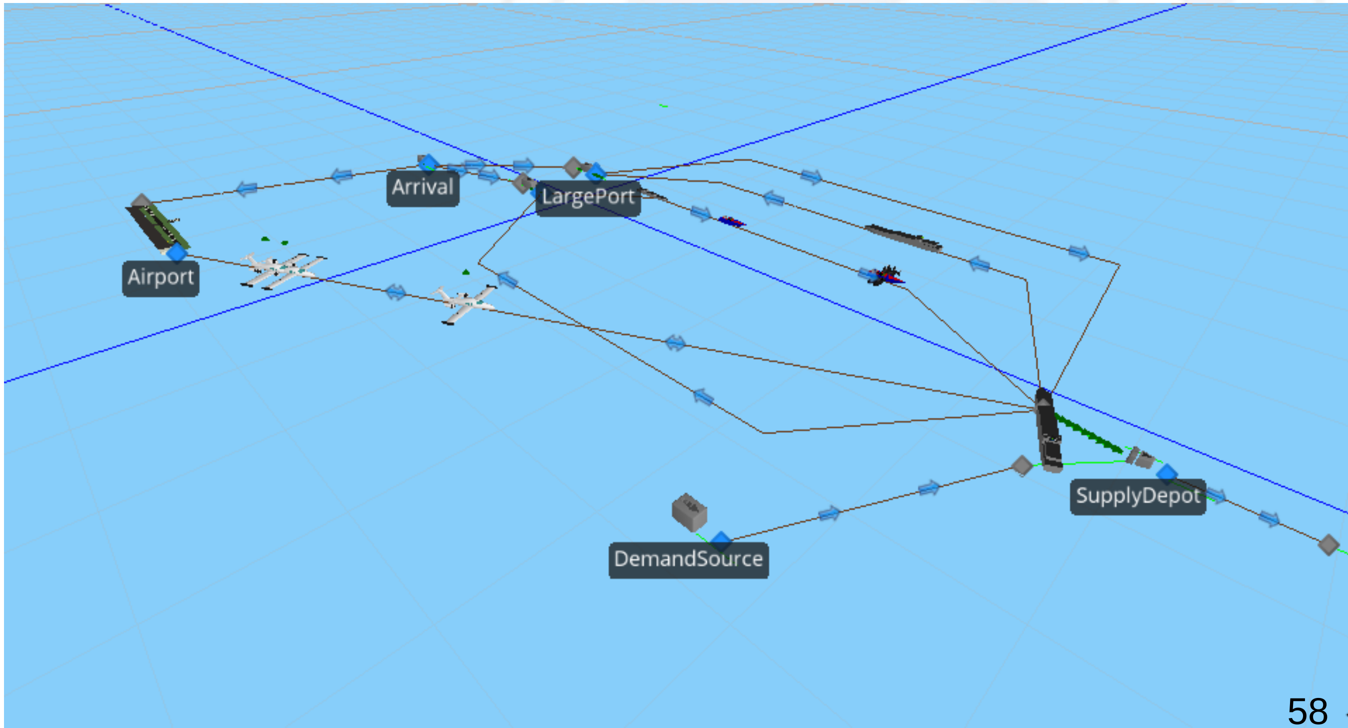
SIMIO Brief Overview

- Object oriented model
- Discrete event simulator
- Typical applications
  - Fleet sizing/design for resupply
  - Design/evaluation of refurbishment operations
  - Process improvement

Defense: Intruder Detection & Engagement

- SIMIO Model of Logistics
  - Mixture of supply delivery methods
    - Large cargo ship (AOE)
    - Med sized faster cargo (LCS)
    - Smaller very fast vessel (drug boat)
    - Small semi-submersible sub
    - Aircraft (C-130)

- Results
  - Two aircraft deliveries per day is sufficient
  - Minimum of two small cargo boats
    - Turn around time becomes an issue
  - Large cargo vessel is too slow and quantities are excessive
  - One small boat and one aircraft can also fulfill the requirements



Island Defense: Hughes-Salvo Equations

Purpose

- Determining the probability of the system to defend the island
- A missiles scenario more than land battle
  - Land Surface to Air
  - Land Surface to Sea Surface
  - More..

$$\Delta B = \frac{(\sigma_A \alpha A - \tau_b b_3 B) b_4}{b_1}$$

$$\Delta A = \frac{(\sigma_B \beta B - \tau_a a_3 A) a_4}{a_1}$$

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Risk Mitigation

Excel

Risks:

- Avoiding "garbage in garbage out" situation
- Obtaining accurate data input data

MANA

Risks:

- Steep learning curve

SIMIO

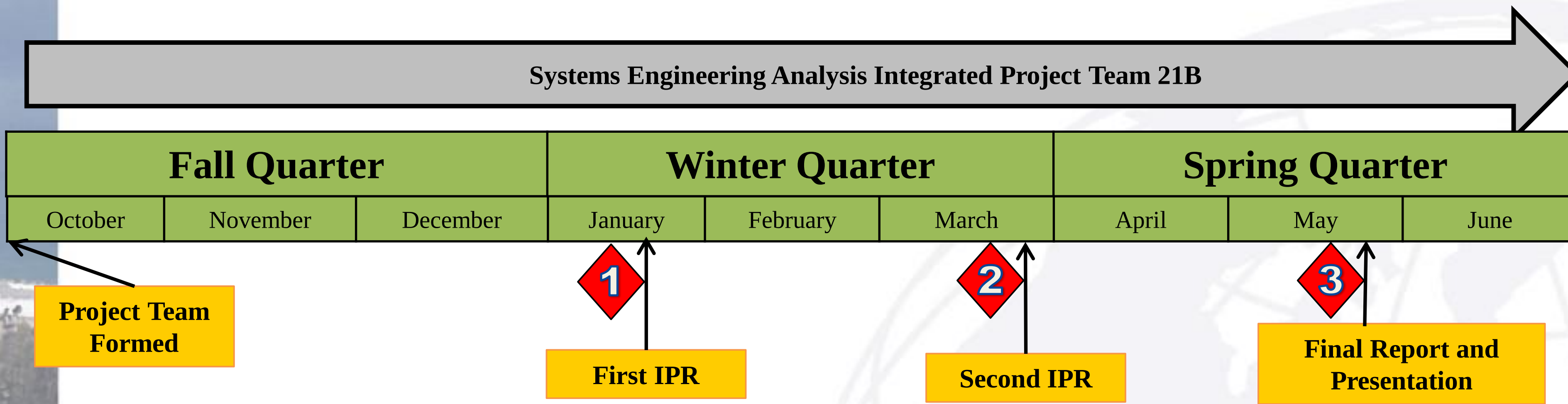
Risks:

- Steep learning curve

Risk Mitigation:

- Faculty Involvement
- Specification of Analysis Requirements

Project Timeline & Milestones



1 Milestone 1: Form problem statement. Select analysis methods.

2 Milestone 2: Develop concept of operations. Modeling force on force engagements. Initial observations gained from logistics model.

3 Milestone 3: Gain major insights from combat and logistics models and identify key performance parameters.

Project Status

- Quarter 3 processes
  - Requirements Allocation: Req→ Function→ Form
  - System Synthesis
  - Trade off analysis
- Work through the SE process again through the feedback loop to refine system requirements

Way Ahead…

- Liaison with SEA-21A to ensure future concept integration capability
- Allocate Requirements
- System Synthesis
- Trade off analysis
- Solicit feedback from key stakeholders on critical system development
- List recommendations for future systems

Desired End State

At IPR 3, we will present a system of systems that:

- Provides decision makers with a myriad of options for moving troops and materiel to a remote island on short notice
- Provides recommendations for a company-sized ground force that is tailorable to specific threats
- Evaluates the potential integration of the ISR platform developed by SEA 21A
- All options are supported by sufficient analytical rigor

Questions?

"As the PACOM commander, I need you to be thinking in the offensive: How are you going to show up? How are you going to be dominant? How are you going to be lethal?"

Admiral Locklear,

Commander, U.S. Pacific Command

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Backup Slides

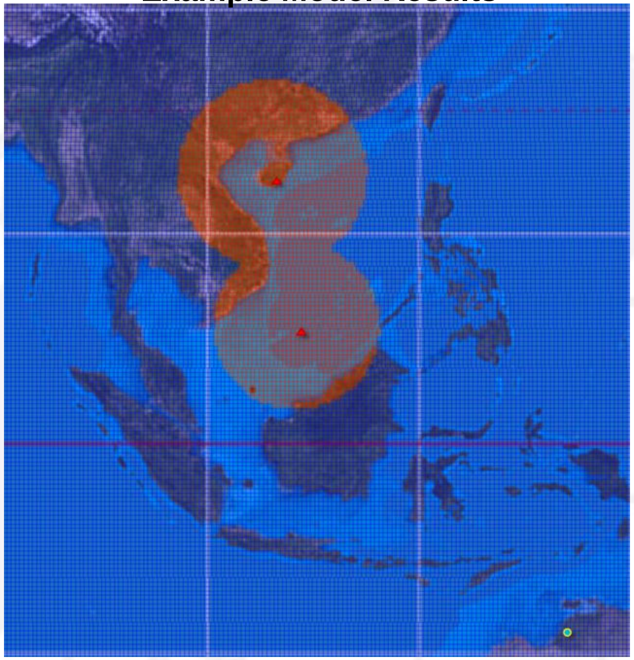
Purpose

- To describe the models used in this project
  - COI analyzed
  - Modeling Tools/Techniques
  - Results
- COIs
  - Can we beat the adversary to the destination
  - Can we deliver initial troops and material
  - Can we defend the outpost
  - Can we sustain the outpost

Ability to Achieve First Arrival

- Purpose
  - Answer COI
- Tools/Techniques
  - Excel model with VBA backend
- Analysis
  - Ability to beat adversary hinges on the following
    - Speed: ours and there's
    - Destination location
    - Our deployment delay
    - Our travel range

Example Model Results

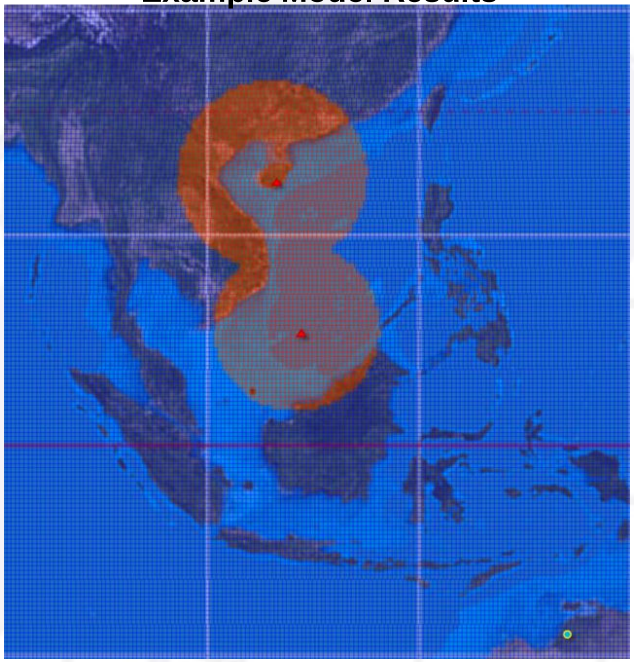


Red 30 knot ship
Red has 6 hour head start
Blue C-130 at cruise speed
Deploy from Darwin

Ability to Achieve First Arrival (con't)

- Conclusion
  - Ability to satisfy this COI is extremely sensitive to all the listed factors
  - Being good at one aspect does not overcome being bad at other
  - Every hour of delay (deployment, speed, or travel) expands the enemy circle of influence in a way that can't be compensated for
- Want to have the advantage in all three areas
  - Close, fast, flexible

Example Model Results

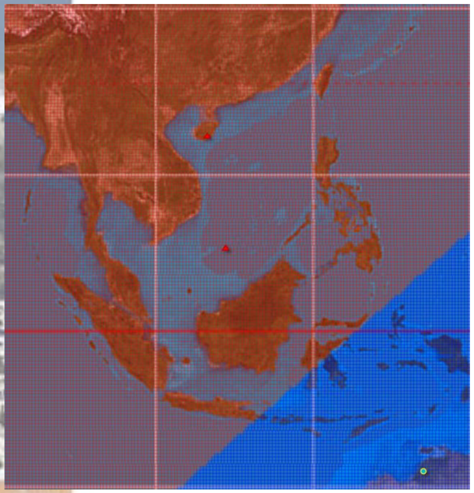


Red 30 knot ship
Red has 6 hour head start
Blue C-130 at cruise speed
Deploy from Darwin

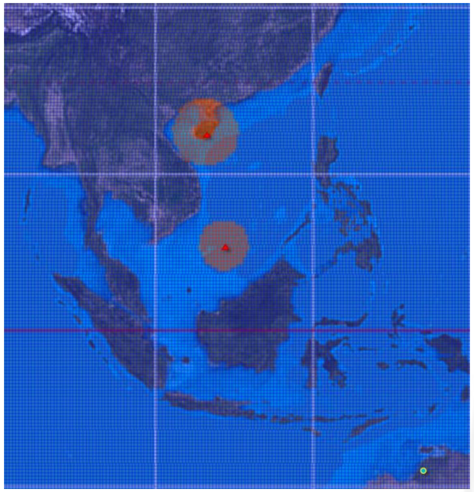
Effects of Speed

High transit speed provides the following:

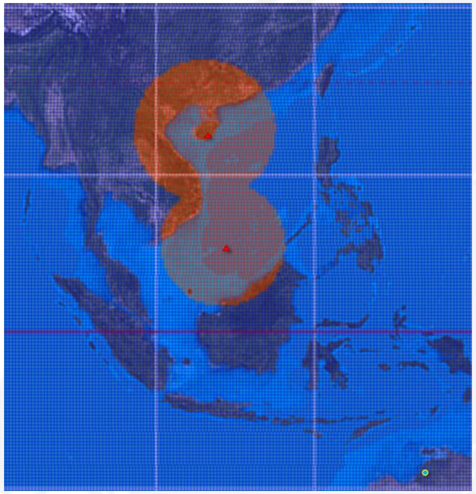
- Alleviates requirement for nearby basing
- Still need rapid reaction to avoid shutout



Blue and Red Equal Speed



Red 30 knot ship
Red has no head start
Blue C-130 at cruise speed



Red 30 knot ship
Red has 6 hour head start
Blue C-130 at cruise speed
Deploy from Darwin

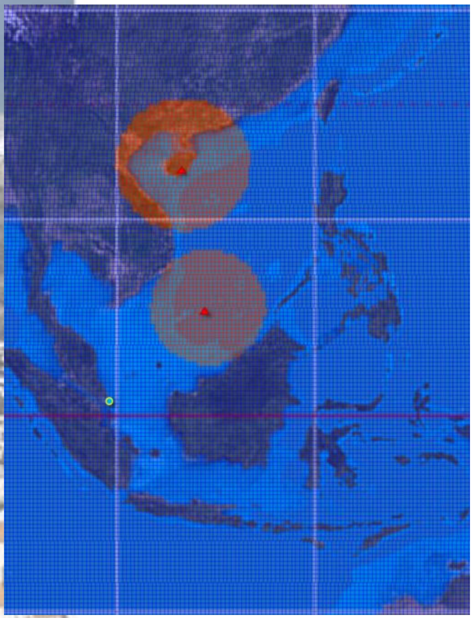
Deployment delay still results in significant shut out even with high speed transit

Effects of Location

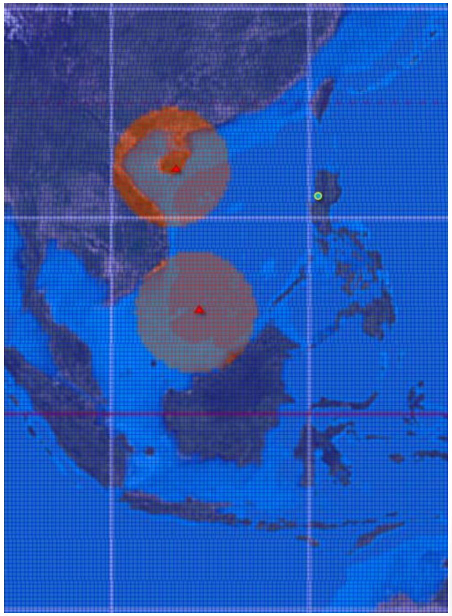
Deployment location closer to islands of interest

- Can mitigate enemy head start

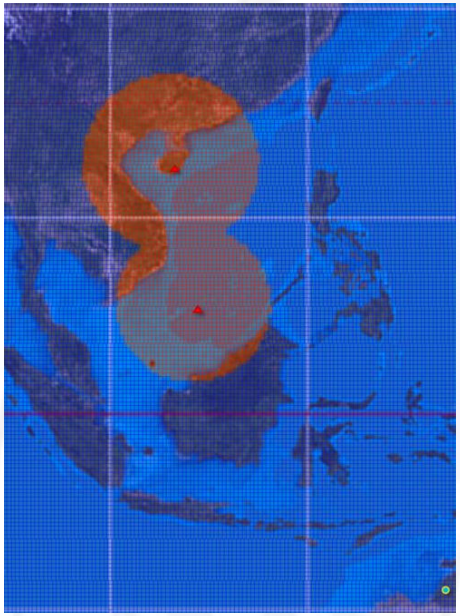
Red 30 knot ship
Red has 6 hour head start
Blue C-130 at cruise speed



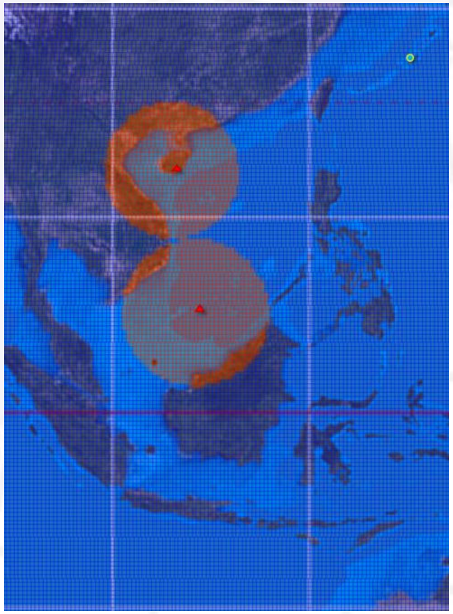
Deploy from Singapore



Deploy from Clark



Deploy from Darwin

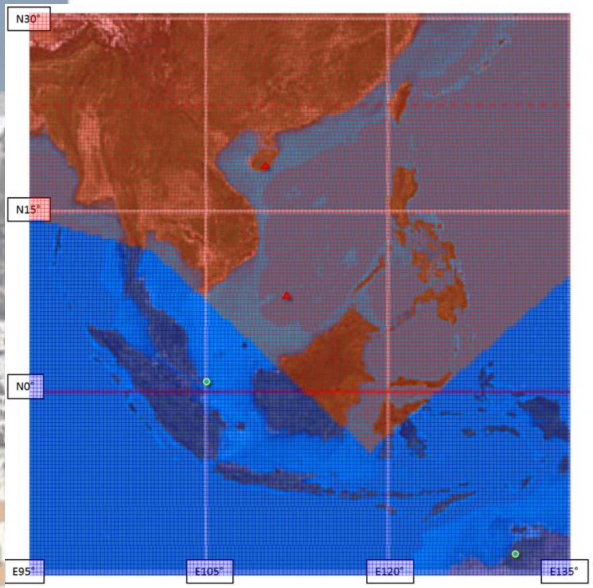


Deploy from Okinawa

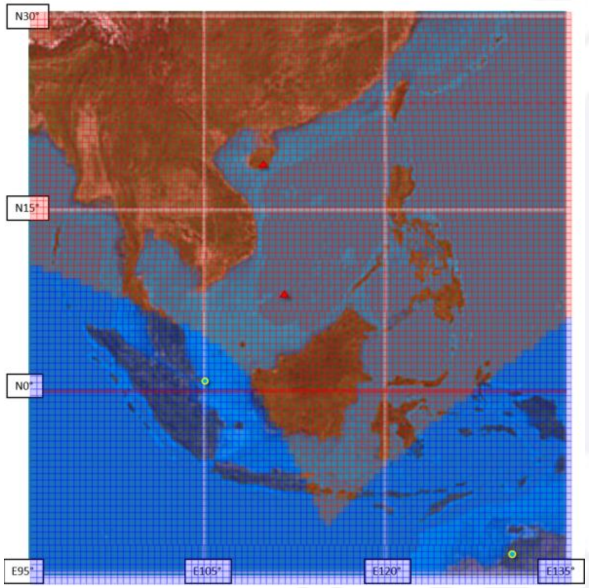
Effects of Rapid Deployment

Blue forces deploy from Darwin and Singapore at 30 kts

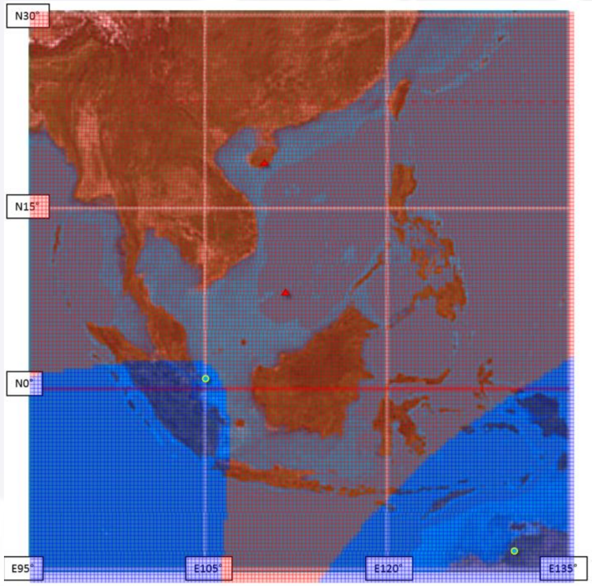
- Every hour of delay is an hour's worth of travel distance lost
- 6 hour delay at 30 knots = enemy owns everything 340 km around their starting point



Blue and Red Equal Speed
Same Start time



Blue and Red Equal Speed
Red has 12 hour head start



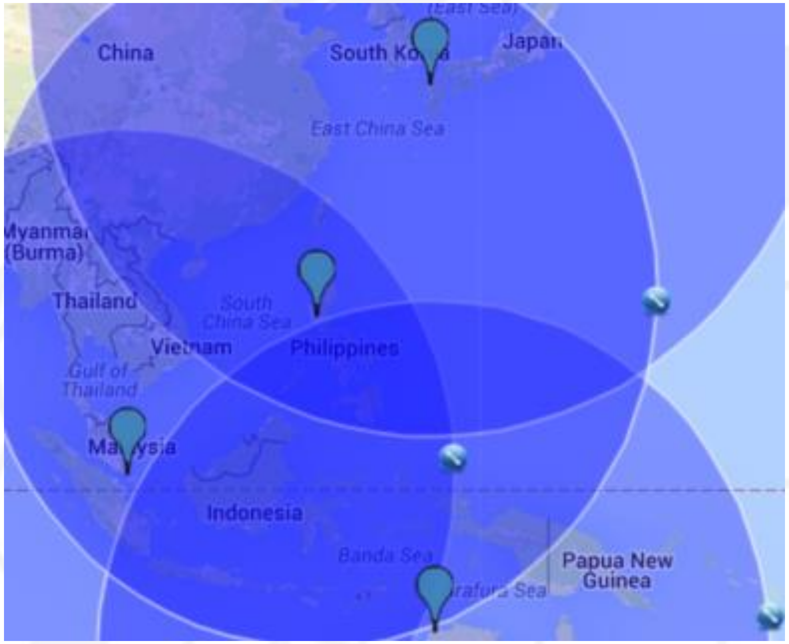
Blue and Red Equal Speed
Red has 24 hour head start

Range Requirements

- Tools/Techniques
  - Map and compass
- Analysis
  - Operational range is measurable attribute of the platform used for transport
  - Using refueling (in-flight or unrep) results in large

Range Requirements (con't)

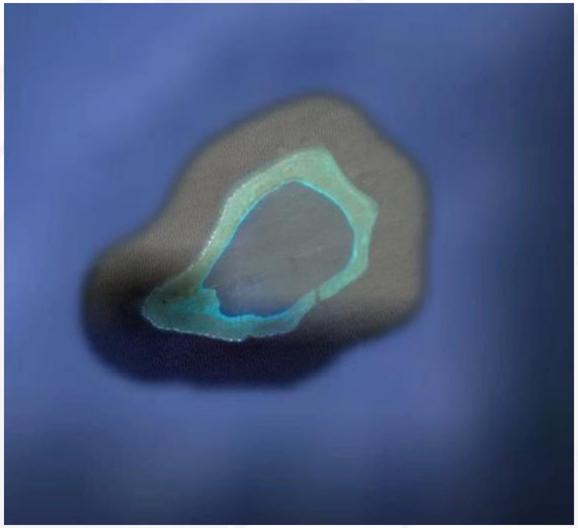
South China Sea 4 hour C-130J Coverage



South China Sea 4 hour C-17 Coverage

Delivery of Initial Troops and Material

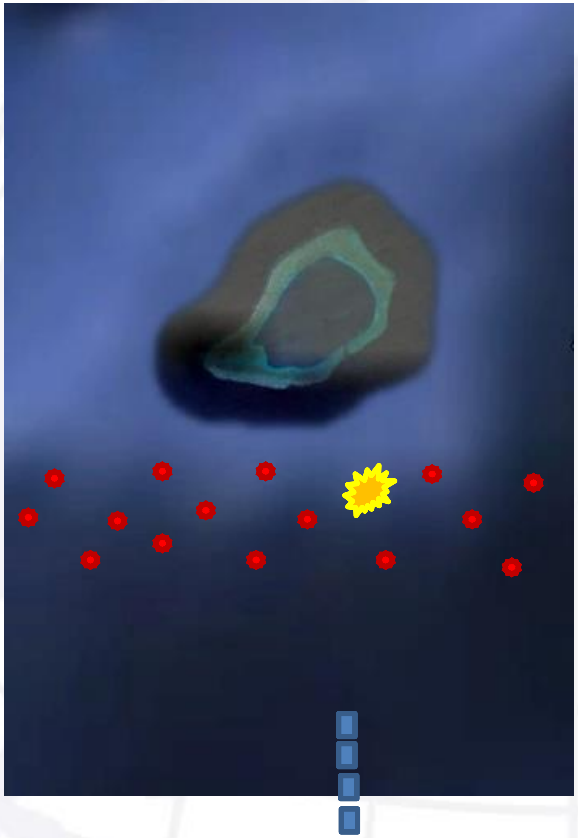
- Purpose
  - What-if scenario to analyze losses in trying to set up an outpost on an island too small to perform an airdrop
- Tools/Techniques
  - Excel Monte Carlo simulation to determine loss of platforms in sea insertion in a mined environment.
    - Based on Prof. Alan Washburn's "Mine Warfare Models"
  - Inputs:
    - Number Mines
    - Mine field size



Subi Reef
4 km wide
No permanent dry land

Delivery of Initial Troops and Material (Mine Scenario)

- Proposal
  - Use inexpensive barges to clear a channel through the mine
    - Towed
    - Remote piloted
    - Autonomous
  - Connect surviving barges to form manned outpost
  - Determine
    - Number of barges required
    - Barge attrition
    - Effects of using rapid mine counter-measure techniques



Delivery of Initial Troops and Material (Mine Scenario) (con't)

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Simulation parameters

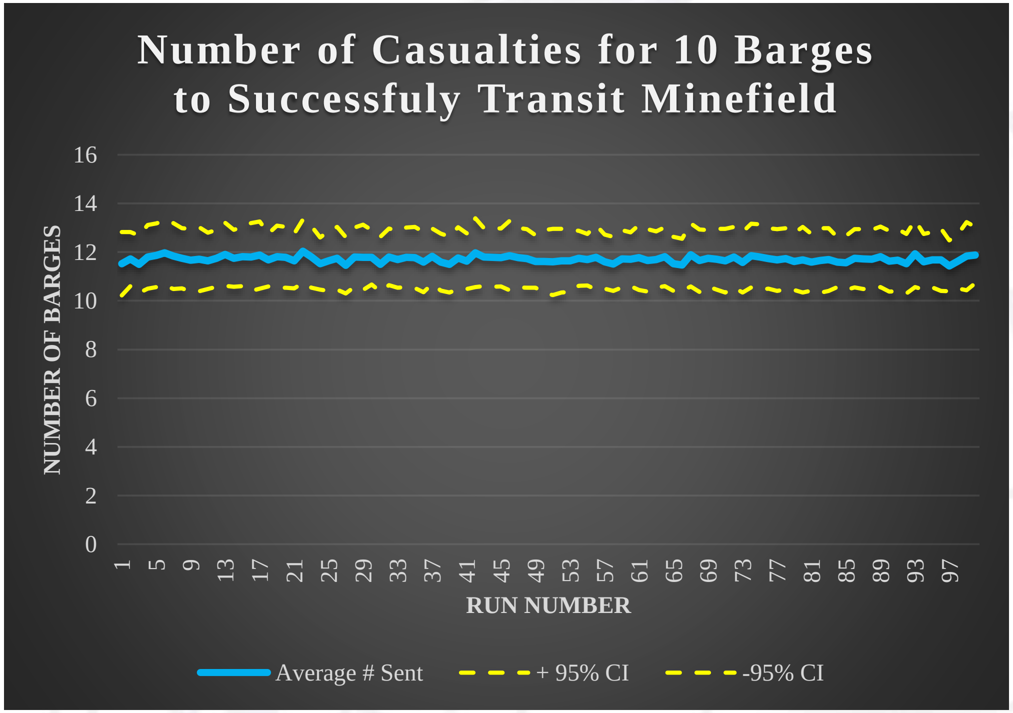
- 10 barges required
- 12.5 mile wide minefield
- 20 mines
- Mines actuate upon detection
- .5 km kill radius per mine
- Mines randomly distributed across minefield
- 100 simulations with 100 replications each

Conclusion

- Attrition is dependent on mine field density, distribution, and type

Additional Results

- 23 to make 20
- 63 to make 60



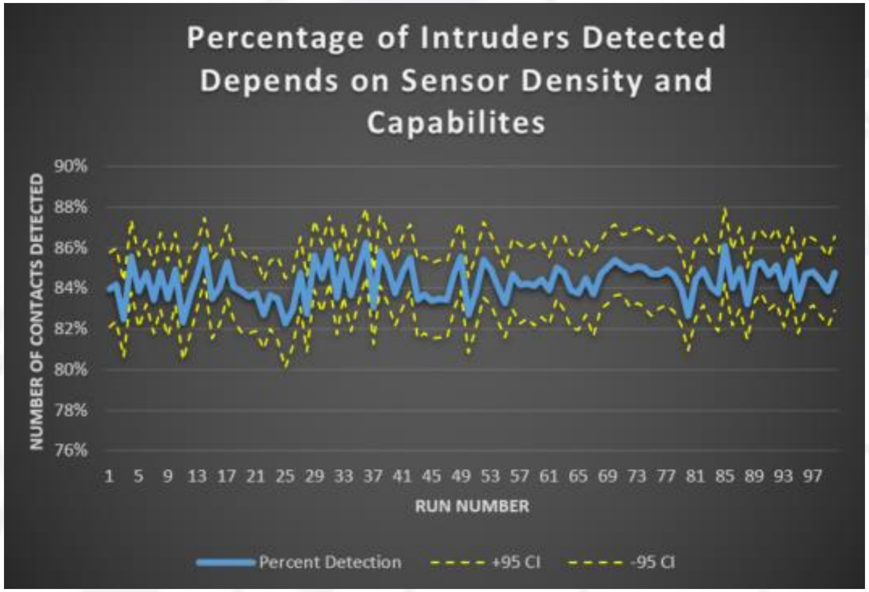
Defense: Smart Sensor Detection

- Purpose
  - Determine capability and requirements of network of smart sensors to detect
  - Applicable to land and sea snesors

- Tools/Techniques
  - Excel Monte Carlo simulation
    - Based on Prof. Alan Washburn's "Mine Warfare Models"
  - Inputs:
    - Number of intruders
    - Sensor field width
    - Sensor detection radius
    - Sensor probability of detection
    - Number of Sensors

Defense: Smart Sensor Detection

- Simulation Parameters
  - 50 sensors
  - 250 meter detection radius
  - 90% probability of detection
  - 12.5 km wide sensor field
  - 100 simulations with 100 replications each
  - 20 intruders
- Conclusion
  - Approximately 85% probability of detection
  - Sensor detection capabilities and density affected overall probability of detection



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Defense: Intruder Detection & Engagement

- Purpose
  - Determine capability and requirements to detect and engage inbound threats as they approach land
  - Analyze maintenance man hours and fuel requirements for automated systems
- Assumption
  - Sentry can engage what it sees

- Tools/Techniques
  – Excel graphic and tabular models to display perimeter system coverage
  – Inputs:
    - Island modeled as circle with user defined radius
    - Number of sentries
    - Individual sentry detection / engagement radius
    - Maintenance hours per sentry
    - Fuel requirements per sentry
    - Even spacing
    - No space between sentries
    - Double up sentries

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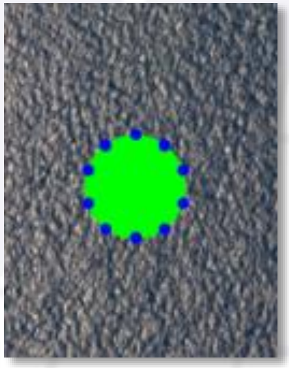
Defense: Intruder Detection & Engagement

Defense: Intruder Detection &

- Analysis
  - Sentry capabilities affect number required
    - Detection and engagement range
    - D&E probability
    - Sentry mobility
    - Tactics
  - Defended perimeter affects number
    - Geography affect
  - Maintenance and fuel requirements vary between systems

Model Inputs		
Number of Sentries	10	
Sentry Search Radius	0.5	kilometers
Island Radius	5	kilometers
Maint Hours per day per system	2	hours per day
Fuel consumption per day per system	5	gals per day

Results	
Percent of perimeter covered	32%
Fuel Used	50
Maint Hours Req	20
Number of Sentries required for 100%	31
Daily Maint Hours	63
Daily Fuel Req (gals)	157



10 sentries with 500m range = 32% coverage on island with 5 km radius

Sustainment: Blockade Running

- Purpose
  - Determine capability and requirements to supply outpost via sea in a blockade scenario
- Assumption
  - Blockade forces act as a quarantine of the island
  - Model covers Cold War style blockade
    - Adversary forces must interdict with surface vessel to stop blockade runner
    - Shooting blockade is beyond the scope of this model

- Tools/Techniques
  - Excel Barrier Search Model
  - Inputs:
    - Searcher speed
    - Runner speed
    - Barrier length
    - Searcher detection range

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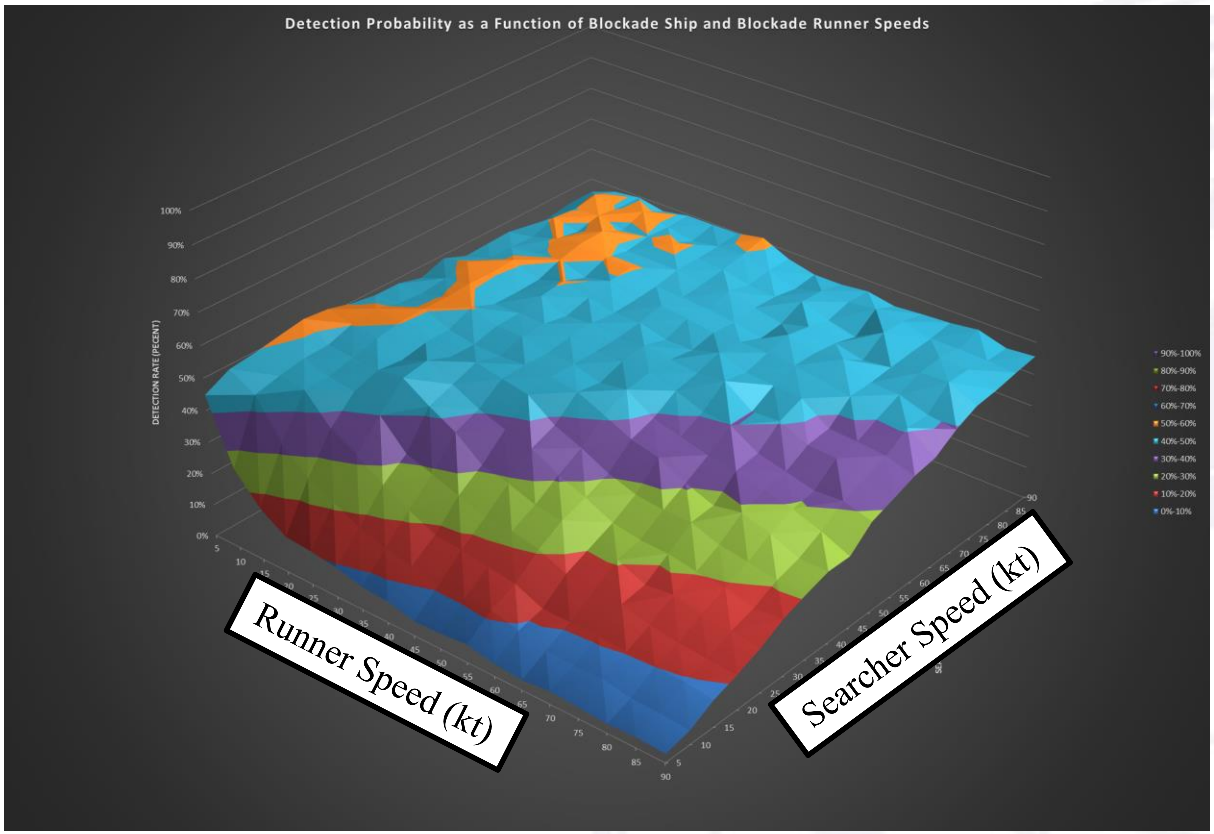
Sustainment: Blockade Running

- Analysis
  - Blockade runner success depends on:
    - Barrier length
    - Searcher speed
    - Runner speed
    - Searcher detection capabilities

- Parameters
  - 60 nm barrier
  - 10 nm detection range
- Conclusion
  - Faster and stealthy runner is most successful
  - Faster searcher with longer detection range results in lower chance of success

Probablility of detection as a function of searcher and blockade runner speed

Searcher Velocity \ Runner Velocity	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
5	45%	25%	16%	11%	11%	9%	7%	7%	5%	5%	6%	4%	3%	4%	4%	3%	3%	3%
10	49%	44%	33%	25%	21%	17%	15%	13%	11%	11%	11%	9%	7%	7%	7%	5%	5%	4%
15	50%	46%	45%	37%	32%	26%	22%	18%	17%	16%	15%	11%	11%	11%	10%	10%	10%	8%
20	51%	47%	45%	44%	40%	32%	29%	26%	23%	22%	21%	17%	16%	16%	14%	12%	11%	11%
25	52%	48%	47%	46%	47%	42%	38%	31%	29%	26%	25%	20%	21%	17%	18%	16%	15%	14%
30	52%	50%	49%	46%	49%	45%	41%	38%	35%	31%	28%	24%	22%	22%	20%	19%	17%	18%
35	50%	51%	50%	47%	46%	48%	46%	44%	38%	35%	31%	28%	27%	27%	24%	23%	21%	21%
40	48%	49%	50%	47%	46%	46%	46%	46%	45%	41%	37%	35%	31%	28%	29%	26%	23%	23%
45	48%	48%	50%	50%	48%	48%	46%	46%	43%	45%	39%	37%	35%	34%	31%	30%	27%	23%
50	46%	49%	51%	47%	48%	48%	47%	46%	46%	46%	44%	41%	40%	35%	33%	31%	31%	29%
55	49%	51%	50%	47%	49%	46%	47%	46%	47%	46%	45%	46%	40%	41%	37%	36%	34%	31%
60	46%	48%	51%	48%	50%	48%	47%	47%	45%	45%	47%	45%	44%	43%	38%	37%	36%	34%
65	46%	48%	49%	50%	48%	50%	47%	48%	47%	46%	47%	47%	46%	45%	43%	40%	41%	35%
70	47%	48%	50%	52%	50%	50%	48%	47%	47%	46%	44%	48%	46%	47%	44%	43%	40%	40%
75	44%	51%	49%	52%	49%	49%	49%	48%	49%	46%	45%	47%	45%	43%	44%	46%	46%	43%
80	45%	50%	51%	49%	50%	51%	49%	48%	47%	46%	48%	45%	43%	48%	45%	46%	46%	43%
85	46%	51%	50%	51%	49%	48%	49%	50%	48%	45%	47%	47%	48%	47%	45%	45%	45%	45%
90	46%	49%	50%	48%	50%	50%	50%	51%	48%	46%	46%	47%	45%	46%	46%	47%	45%	46%


Detection Probability as a Function of Blockade Ship and Blockade Runner Speeds
DETECTION RATE (PECENT)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Runner Speed (kt)
Searcher Speed (kt)
90%-100%
80%-90%
70%-80%
60%-70%
50%-60%
40%-50%
30%-40%
20%-30%
10%-20%
0%-10%

Sustainment: Consumption

- Purpose
  - Calculate force material consumption to determine rate of supply requirements
- Assumption
  - Consumption follows data from following sources:
    - Logistics Planning Factors
    - CENTCOM Sand Book, 2008
    - 249th ENGR BN Interviews
      - Mr. John Varin P.E., "Power and Energy Considerations at Forward Operating Bases (FOBs)“
  - Studied similar sized units
    - Maximum and Average Consumption
    - Sustainment and Assault Operation

- Tools/Techniques
  – Excel worksheet
  – Analogy based analysis

Sustainment: Water and Fuel Requirments

1. Choose units with roughly similar functions, and size. Pick units with vehicles to simulate our vehicles

UNIT	T/O #	Personnel #s	Class I (Food) STONS	Class I (Water) Gal	Class II STONS	Class III (POL) Gal	Class III (POL) Gal	Class IV STONS	Class V STONS	Class V STONS	Class VI STONS	Class VII STONS	Class VIII STONS	Class IX STONS	TOTAL
			lbs / person / day	gal / person / day	lbs / person / day	Daily Fuel Req (gal) Assault	Daily Fuel Req (gal) Sustained	lbs / person / day			lbs / person / day		lbs / person / day		
Maximums		272	0.759	1,227	0.284	3,701	1,725	1	0.000	0.000	0.462	0.000	0.320	0.000	**2.93**
Averages		185	0.515	833	0.193	2,686	976	1			0.314		0.217		**1.99**

2. Convert everything to pounds, and multiply by the number of people if needed

Totals			lb/day	lb/day	lbs/day	lbs/day	lbs/day	lbs/day			lbs/day		lbs/day	
Maximums			206.41536	2,836,176.64	77.31328	27,758	12,938	299.2653	0	0	125.7728	0	86.9312	0
Averages			95.193035	1,307,965.95	35.65474	20,148	7,323	138.0128	0	0	58.00292	0	40.09026	0

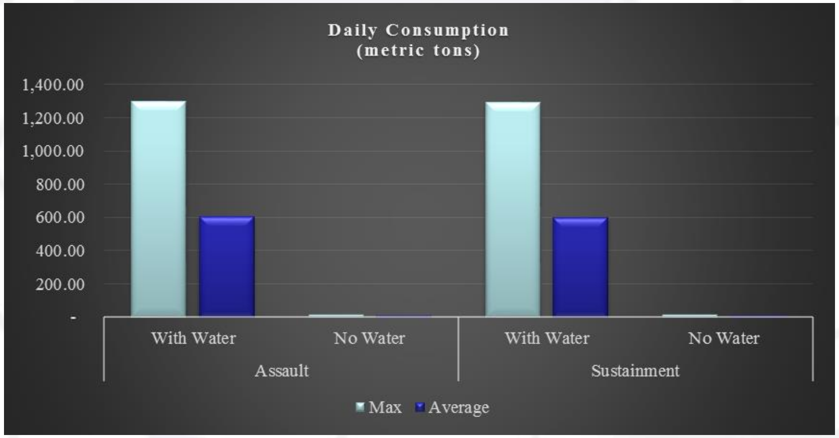
Daily pounds		Daily Metric Tons		
Assault	Sustainment	Assault	Sustainment	
2,864,729.84	2,849,909.84	1,299.41	1,292.69	
1,328,480.40	1,315,655.40	602.59	596.77	with Water

3. Remove water from the equation to simulate organic water purfication capabilities. This will increase the amount of fuel required to run generators to purify the water ----->

Daily pounds		Daily Metric Tons		
Assault	Sustainment	Assault	Sustainment	
28,553.20	28,553.20	12.95	12.95	
20,514.45	20,514.45	9.31	9.31	no Water

Conclusion

– Water requirements will have a large impact



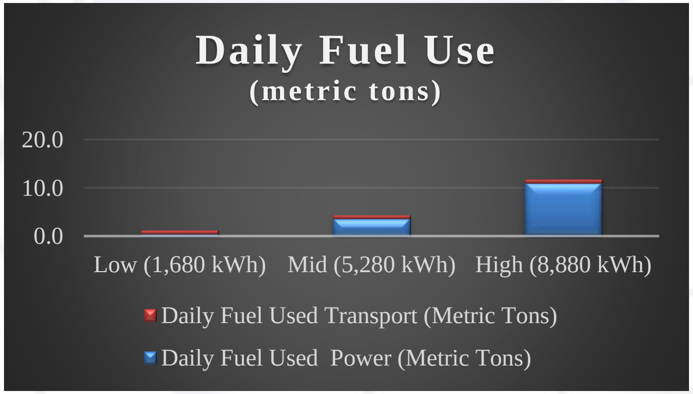
Sustainment: Fuel Consumption

- Analysis
  - Calculate power required
    - Range of requirements
  - Determine number of generators
    - Based on requirement
  - Calculate fuel requirements
    - Vehicles chosen for utility and size

	Source	kW per person	Company (150)	Scenario (200)	kWh Used (12 hours)	Scenario monthly (kWh)
Low	CENTCOM Sand Book, 2008	0.7	105	140	1,680	50,400
Mid	Averaged	2.2	330	440	5,280	158,400
High	249th ENGR BN Interviews	3.7	555	740	8,880	266,400

Daily Power Draw and fuel consumption (assumes power draw equivalent to 12 hours of full power, and generators run for 22 hours a day)

Generators	Low (1,680 kWh)	Mid (5,280 kWh)	High (8,880 kWh)
MEP 012A 750kW	0	0	0
MEP 806A/B 60kW, 60/400Hz	1	3	5
MEP 805A/B 30kW, 60Hz	1	2	4
Daily Fuel Used Power (metric tons)	0.5	3.7	11.1
Daily Fuel Used Transport (metric tons)	0.677	0.677	0.677
Totals Fuel Used (metric tons)	1.2	4.3	11.8



Vehicles

	Number	Amount Consumed (km /liter)	Daily Travel Distance (km)	Daily Fuel Use (liters)	Total Weight (kg)
HMMV	4	6	100	66.7	56.7
Dirt Bike	4	41	100	9.8	8.3
11m RIB	4	0.85	150	705.9	600.0
Forklifts	2	0.85	10	23.5	11.8
			totals -->	805.8	676.7

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Sustainment: Fuel and Water Summary

- Daily Consumption varies based on actual force structure and activity level

With fuel for power and no water					
Power	Daily pounds		Daily Metric Tons		Sustainment Type
Max	Assault	Sustainment	Assault	Sustainment	
	58,553	43,733	26.56	19.84	Max
	50,514	37,689	22.91	17.10	Avg
Mid	Assault	Sustainment	Assault	Sustainment	
	42,436	27,616	19.25	12.53	Max
	34,397	21,572	15.60	9.78	Avg
Min	Assault	Sustainment	Assault	Sustainment	
	33,713	18,893	15.29	8.57	Max
	25,674	12,849	11.65	5.83	Avg

Consumption (metric tons)	
Max	26.56
Min	5.83

Sustainment: Vehicle Capacity

- Purpose
  - Determine amount of daily requirement carried by various platforms
- Sources
  - Capacities based off open source fact sheets

Maximum Consumption (metric tons)	Minimum Consumption (metric tons)
26.5	5.8

Days of Capacity Per Delivery System					
Ships					
544	2	9	5		20
JHSV	Go Fast	Semi Sub	UUV	Full Sized Sub	Transport
20.48	0.08	0.34	0.19	-	0.75
93.34	0.34	1.54	0.86	-	3.43

Air					
5.4	19.1	19.1	72.6	9.1	4.5
	C-130H	C-130J	C-17	MV-22	CV-22 (SOF)
0.20	0.72	0.72	2.73	0.34	0.17
0.93	3.28	3.28	12.46	1.56	0.77