The Expeditionary Warfare Integrated Project

Wayne Meyer Institute of Systems Engineering

Naval Postgraduate School

Introduction

CDR Bill Erhardt, USN

The Intent Of This Morning's Briefing

- To share our most important results with you
- To show you the methodology we used to obtain our results
- To interest you in the details of how we performed the study

A copy of our Final Report will be available in January at www.nps.navy.mil/sea/exwar/

What Will I See That Is Transformational?

- The Navy Marine Corps Team has already transformed its thinking with the Sea Basing and Ship to Objective Maneuver Operational Concepts
- We tried to tie this transformational thinking to a future system of systems capable of fully implementing these doctrines

What Were We Trying To Do?

- Take a big picture, overarching look at how future operational concepts might work
- Examine the system implications of these operational concepts
- Create conceptual designs to fill some of the possible capabilities gaps discovered during the analysis
- Lay a foundation of tools and methodologies for a more detailed system study of specific emerging operational concepts

What Did We Find Out?

- STOM is a viable operational concept, given a suitable force architecture
- The Sea Base concept is capable of achieving the throughput required to sustain a brigade size force ashore, given a suitable force architecture
- While the programs of record provide a level of STOM capability, it could be further enhanced by the addition of specifically designed air and surface craft
- These results were attained through application of system engineering methodology and the use of large scale, high resolution dynamic modeling and simulation

Conceptual Architecture Generation

CDR Erhardt, USN

Lt Steeno, USN

How Did We Try To Do It?

Top Down Analysis
(Integral of Capabilities Required)

Functional Flow Analysis
Integrated Future CONOPS
Joint Campaign Analysis

Integration
(Identification of "gaps" and opportunities)

Conceptual Architecture
Dynamic System Model
Analytical Studies

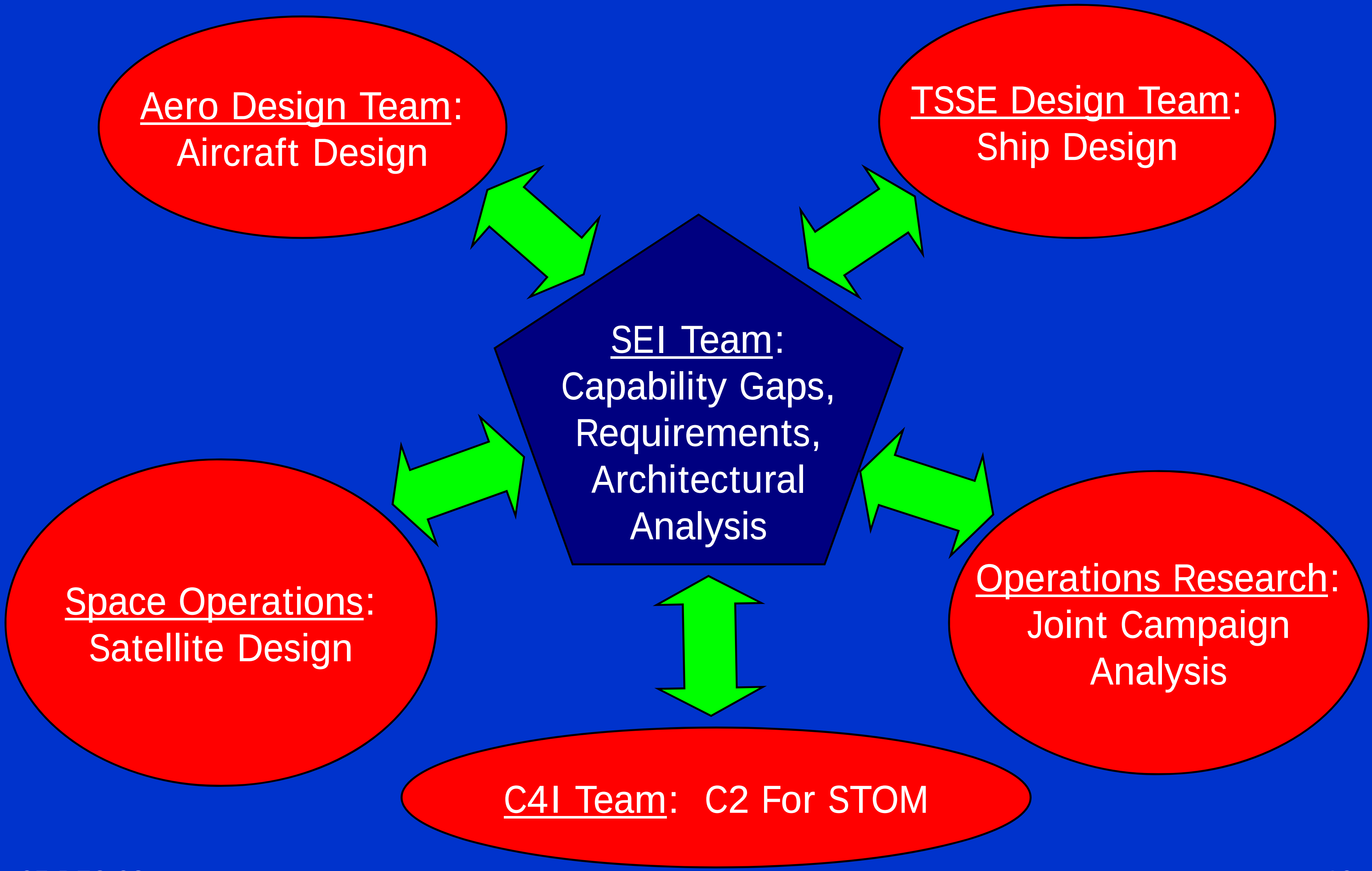
Bottom Up Analysis
(Integral of Capabilities Available)

Current and Planned Architectures
Current and Planned CONOPS

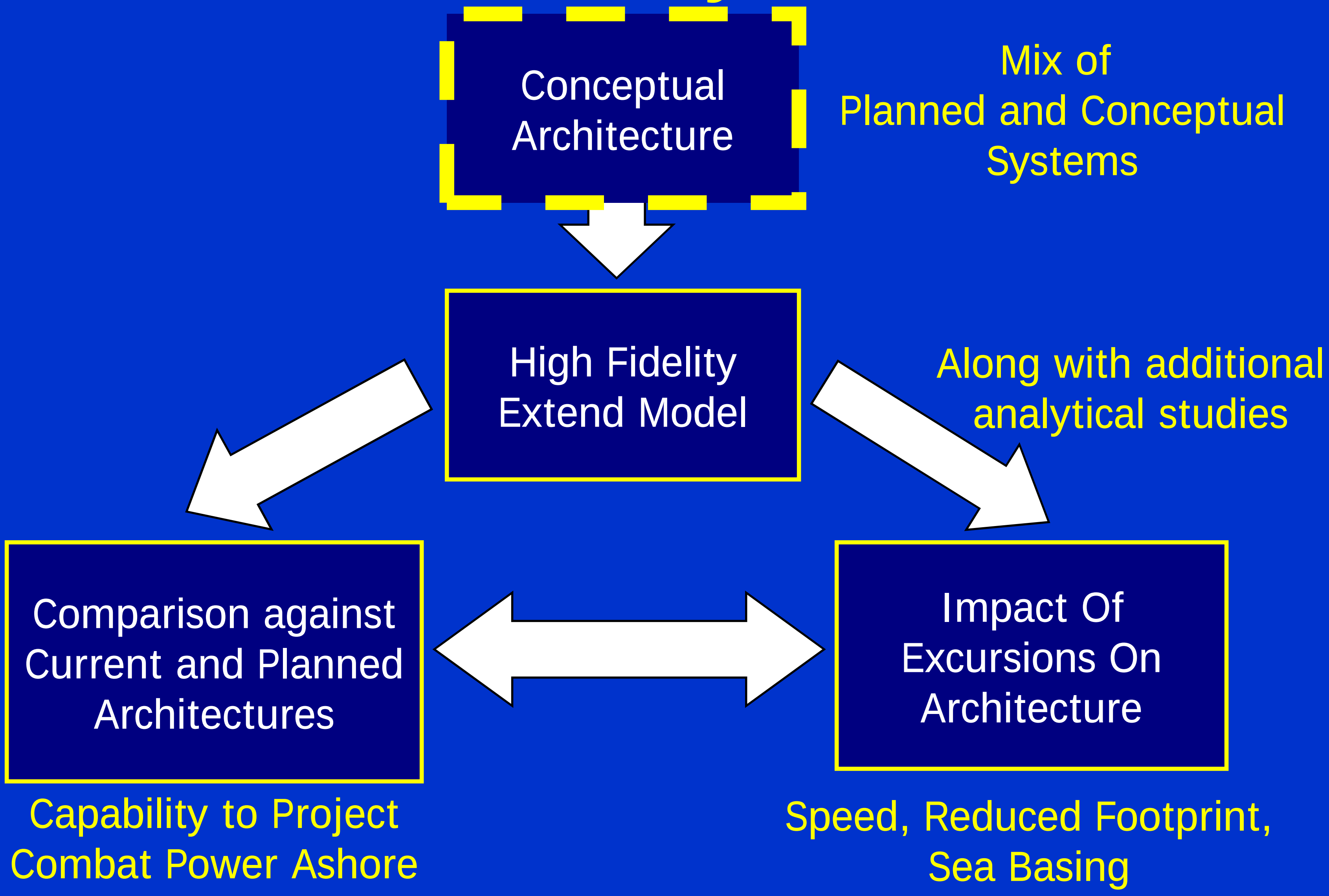
Significant Capability Gaps Identified For Resolution In The Conceptual Architecture

Capability Gap	Addressed in Conceptual Architecture
Surface Platforms Capable of Forming and Sustaining a Sea Base	YES
Shipboard Aircraft Capable of Transporting Large Loads Over Long Distances	YES
Ability to Rapidly Deliver Combat Force to Theater	YES
Highly Survivable Air Transport Platforms To Sustain STOM Operations	YES
Organic Capability to Collect ISR Data Throughout Area of Operations	YES
The Ability to Support Marines Ashore with Both Precision and Volume Fires From The Sea Base	
The Ability To Provide Sufficient C4 Support To Fully Implement STOM	
Providing Force Protection For Surface Craft Transiting to Shore	
Robust Organic Mine Countermeasures Capability	

Who Else Was Involved?



How Did We Try To Do It?



What We Were Not Trying To Do:

- We were *not* trying to generate operational requirements
  - all requirements documents for in-house design use only
- We were *not* trying to write doctrine
  - Our CONOPS combines existing USN/USMC doctrine concepts and is intended for in-house use only
- We were *not* trying to generate specifications for building actual systems

What We Didn’t Have Time To Do:

- Analysis of the costs and benefits as well as the design of systems to provide precision and volume fire support from the Sea Base
- A detailed examination of C4ISR systems and requirements to support OMFTS
- Analysis of more detailed operational concepts such as “Sense and Respond Logistics” and “Enhanced Networked Sea Basing”

So What Did We End Up With?

- A system of systems, some Planned and some Conceptual, to place the Ground Combat Element of a Marine Expeditionary Brigade and its pre-positioned equipment ashore in a forcible entry environment, provide them with the ISR information they need to fight and win, while sustaining the operation through the Sea Base
- Based on certain assumptions

ExWar Project Key Assumptions

- System to execute a MEB size forcible entry operation in the *2015-2020 timeframe.*
- MEB and Sea Base operations are *conducted up to 200 nm inland from a Sea Base 25-250 nm offshore. Assaults are launched from up to 75 nm offshore.*
- Projected legacy force structure does not change
- MEB Ground Combat Element (GCE) composition and sustainment requirements remain the same

ExWar Project Key Assumptions

- A MEB sized expeditionary forcible entry operation will not take place without the *support of at least one Carrier Strike Group (CSG).*
- The Sea Base will form by merging *a minimum of two Marine Expeditionary Unit (MEU) sized Naval Expeditionary Strike Groups (NESG)*, their logistics and prepositioned equipment support ships, and the associated CSG.

Joint Campaign Analysis

- Does a MEB provide the capability to conduct tactically significant forcible entry operations through a Sea Base?
- JCA results were used to quantify the viability of a MEB in realistic combat operations in order to validate our conceptual Sea Base sized to project and sustain a MEB in combat operations

Burma Scenario

Allied Forces:

2 MEU

Prepositioned Equipment

6,840 rebel troops

Burmese Forces:

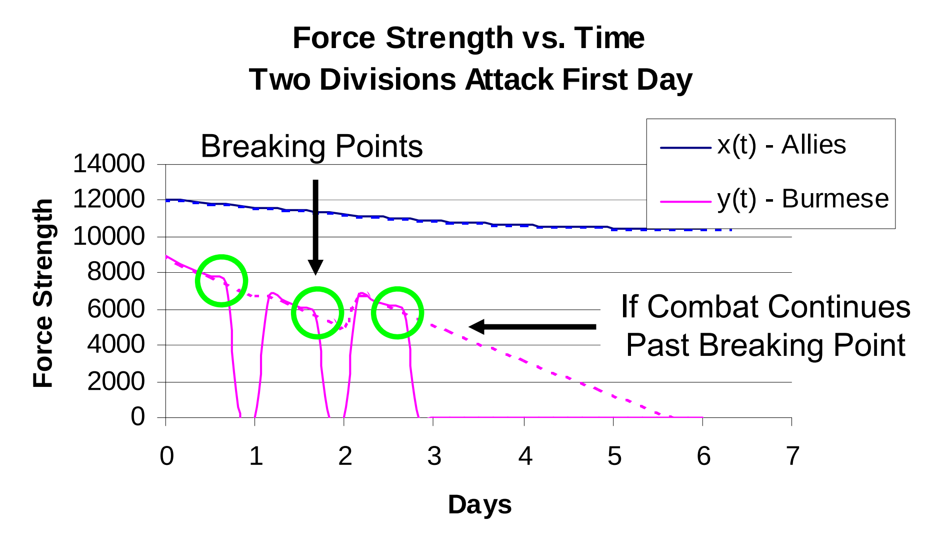
3.5 Infantry Div

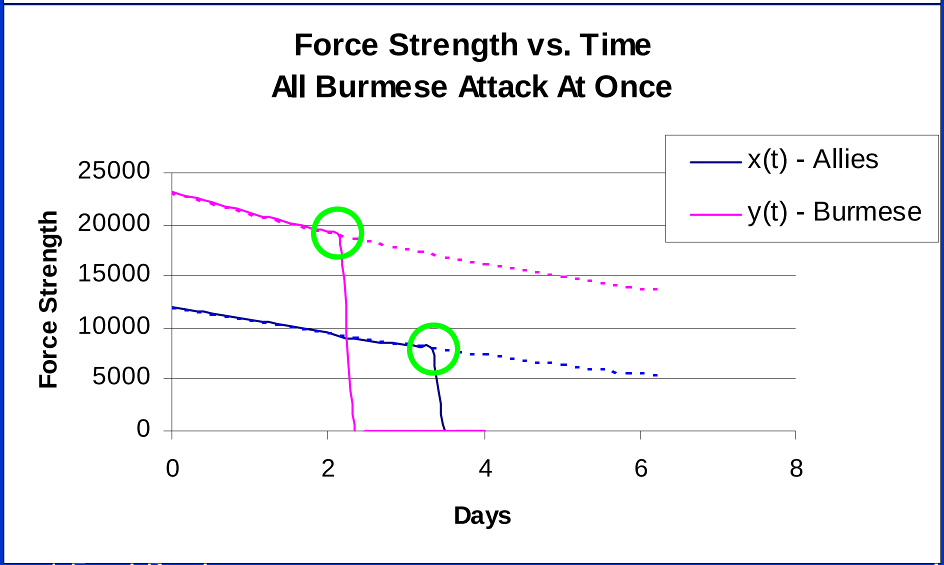
1 Armored Div

(42,000 troops + 80 Tanks)

Burma Scenario Results

- From a Lanchester Exchange Model built in Excel
- Parameters were derived from differing combat capabilities with “will to fight” considered
- Combat capability represents the entire capability of the NESG and rebel forces





Whether Burmese forces trickle down or attack en mass, *2 MEUs are the minimum force required* for a reasonable chance for victory

Robust sustainment would enhance combat capability in this scenario

Joint Campaign Analysis Conclusions

- *Need* capability to quickly deliver combat power to theater
  - Must have at least 2 MEU and equipment in place 8 eight days after the start of enemy movement
- *Need* capability for highly survivable transport aircraft
- *Need* capability for wide area surveillance and targeting
- *Need* capability for enhanced self defense for expeditionary ships
- *Need* capability robust organic MCM capability
  - Manned and unmanned

Results of the Process to This Point

After the Top Down and Bottom Up analysis identified capability gaps and JCA validated the size of the GCE and Sea Base,

We generated conceptual platform requirements to fill the highest priority gaps

The Conceptual Architecture then evolved based on design team inputs, our analysis, and other recent NPS conceptual designs

Capability Gaps With Platform Solutions

- Ships capable of forming a Sea Base and supporting STOM
- Long Range, Heavy Lift Aircraft
- High speed transport escort aircraft
- ISR family of systems

Ship Requirements

- System must deliver and sustain a MEB-sized force to the objective via the Sea Base
- Operate 25 to 250 NM offshore
- Solve throughput bottlenecks to achieve indefinite sustainment of operations
- Possess enough self-defense capability to defeat air “leakers,” destroy small boat threats, and conduct USW.

TSSE System Design

- Sea Base carries 17,000 troop-MEB, associated vehicles, and 30 days of supply
- 1,260,000 Sq ft of flight deck space to support STOM-enhanced ACE with a range of 250 NM
- Can operate as a six-ship Sea Base, an LHA(R) in a NESG, or as a prepositioned support ship
- Achieves indefinite sustainment by interfacing with CLF, MSC, and Commercial Shipping
- Self-defense provided by JSF, helicopters, RAM, FEL, UUVs, and robust C4ISR architecture

The ExWar Ship

DWL = 990 ft

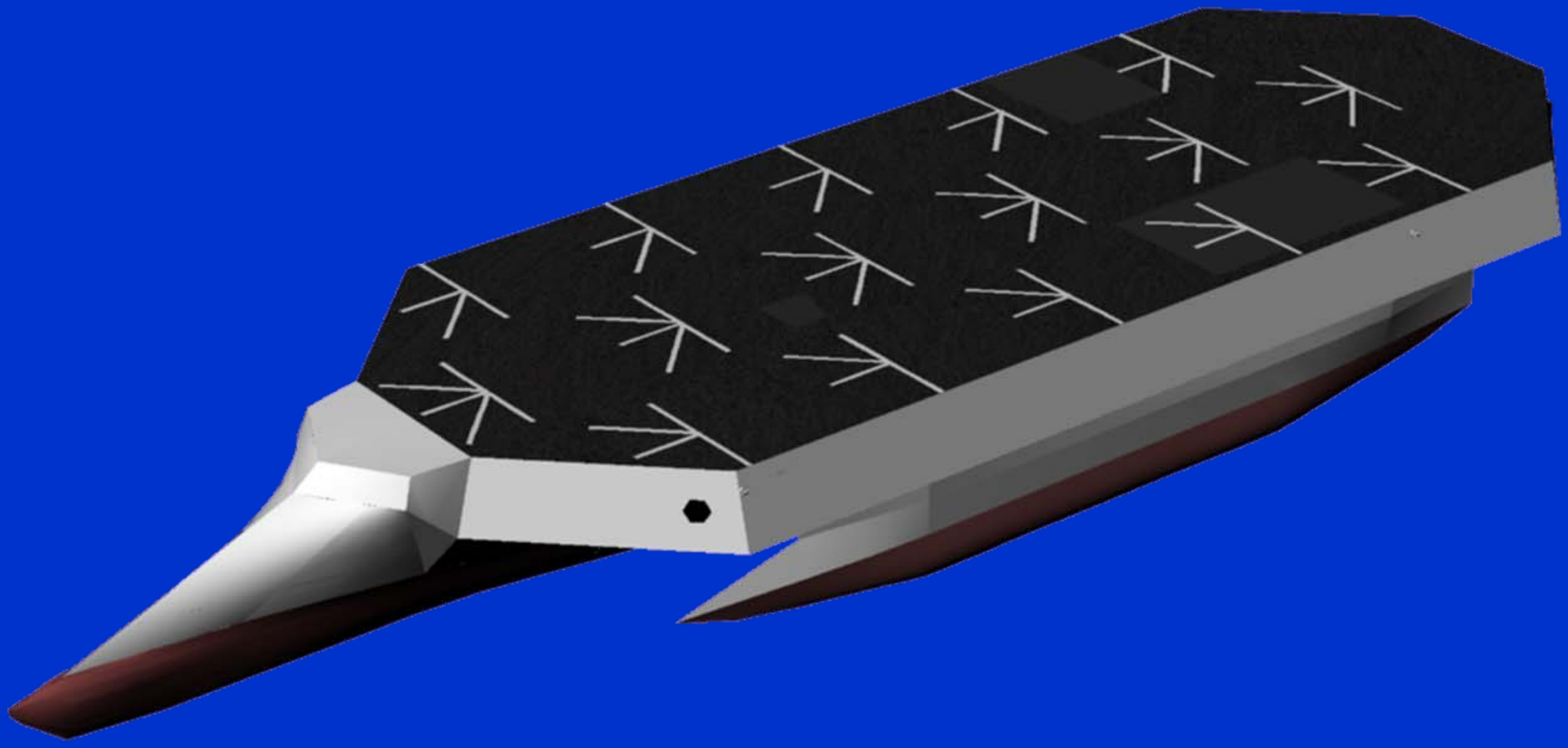
Flight deck = 770' x 300'

Displacement = 86,000 LT

Well deck for 3 HLCACs

Max speed approx. 30 Kts

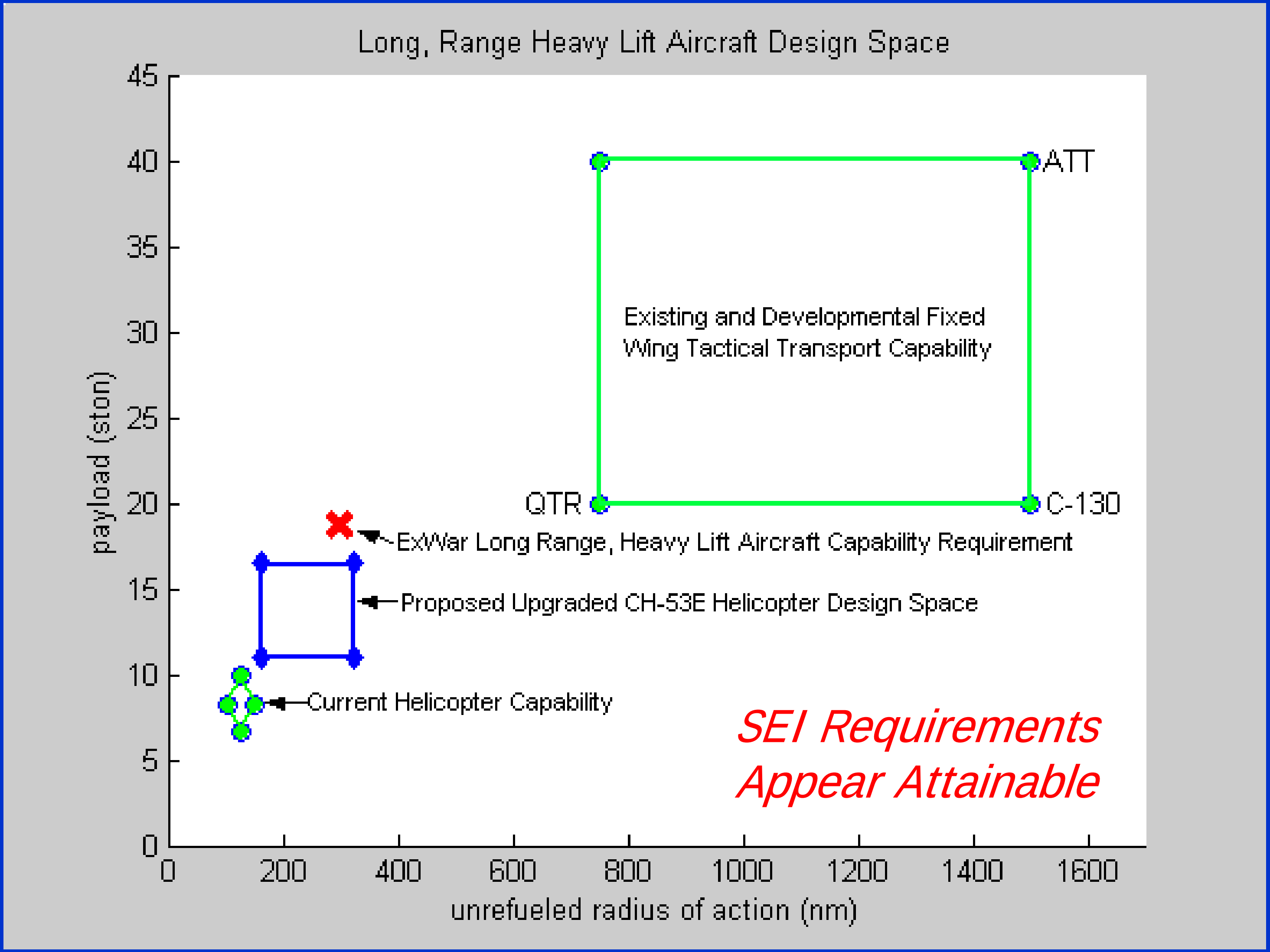
Draft = 42'



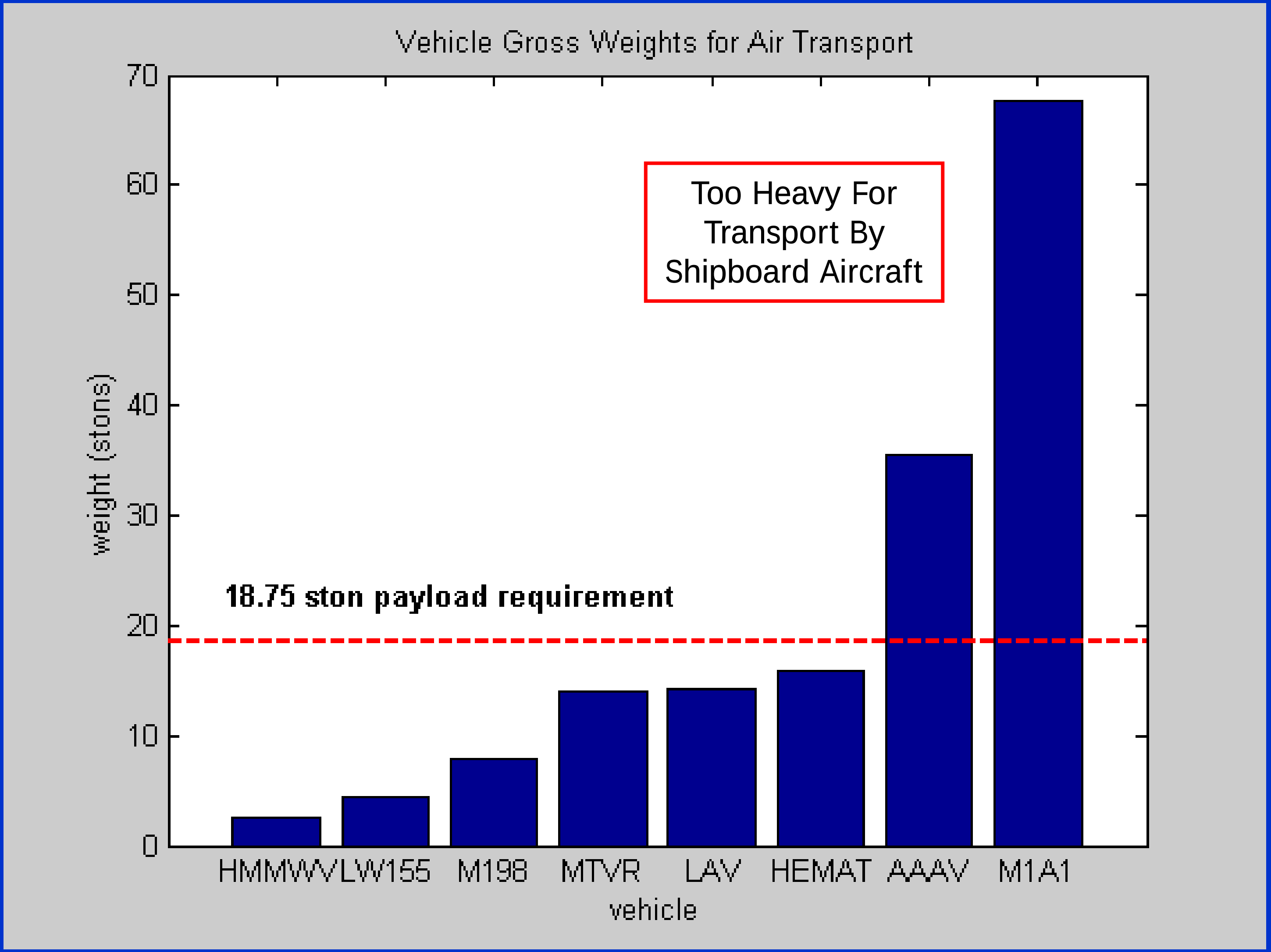
Long Range, Heavy Lift Aircraft

- Key requirements:
  - 300 nm radius of action
  - Payload: 37,500 lb (18.75 ston)
  - Desired speed in 200 – 250 kt range
  - Capability to carry vehicles like LAV, MTVR, or HEMAT (internal or external)
  - Capable of 15 minute cargo on load or off load using only aircrew
  - Shipboard compatible

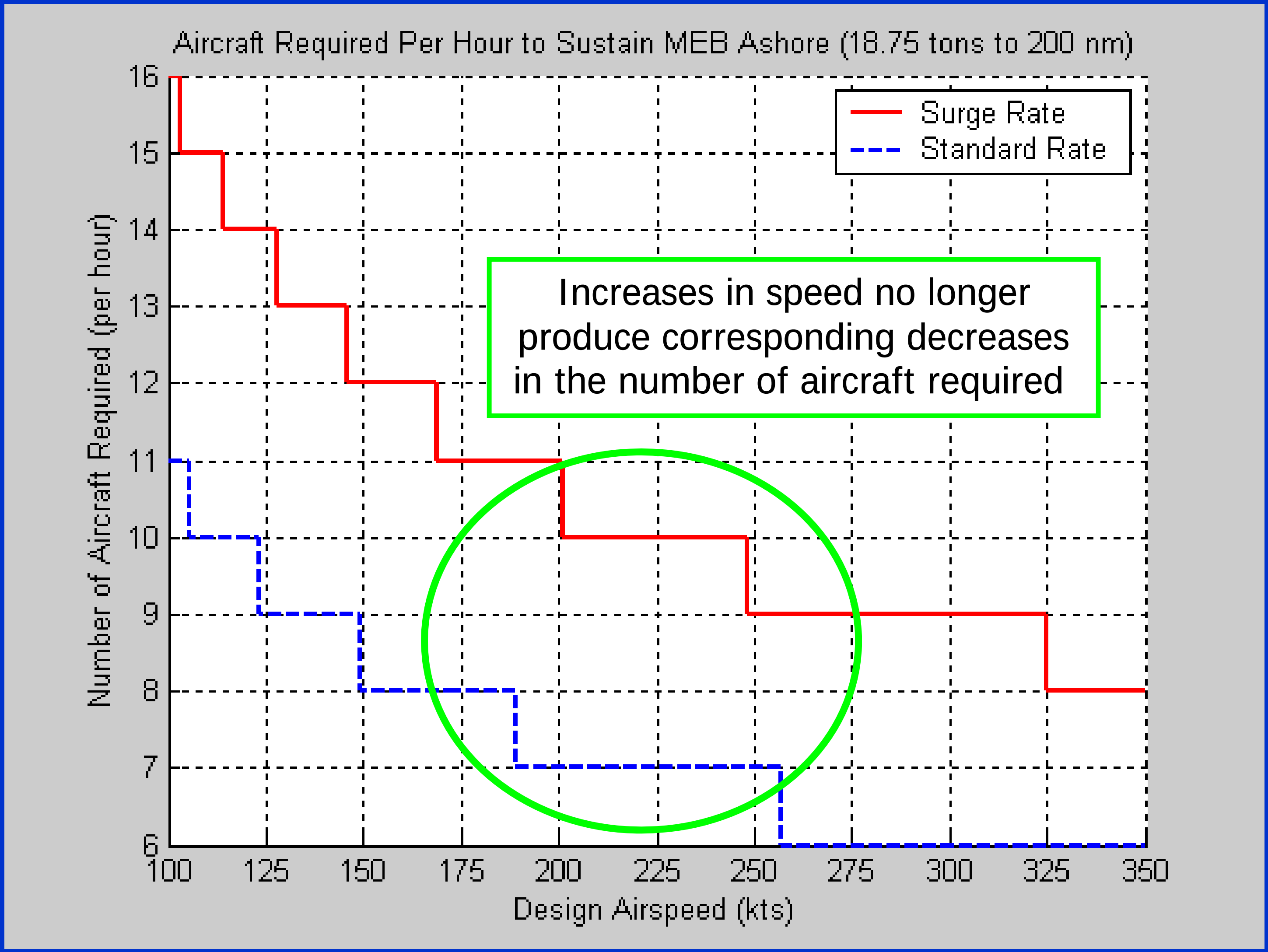
Conceptual Aircraft Design Space



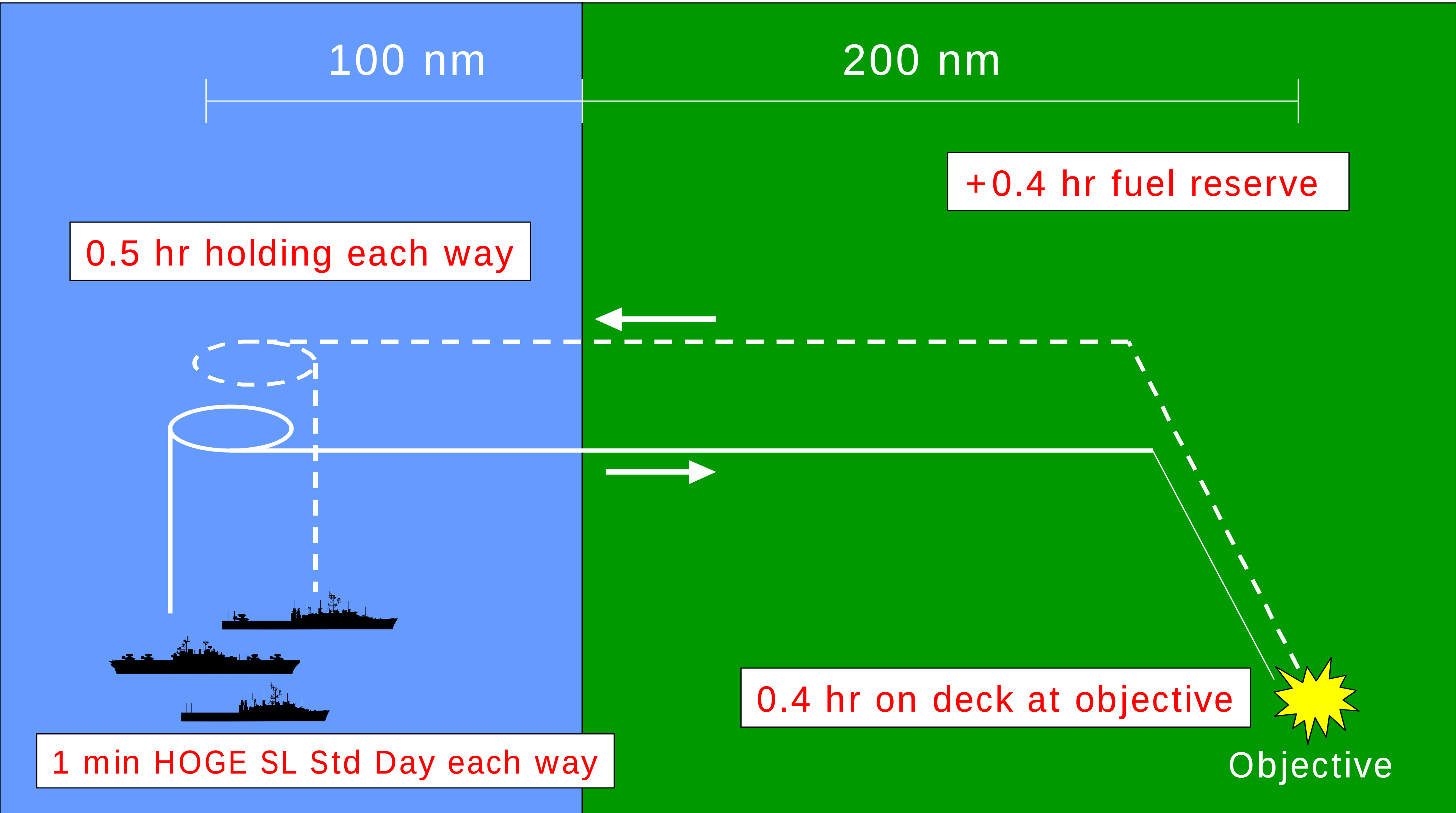
Payload Determination



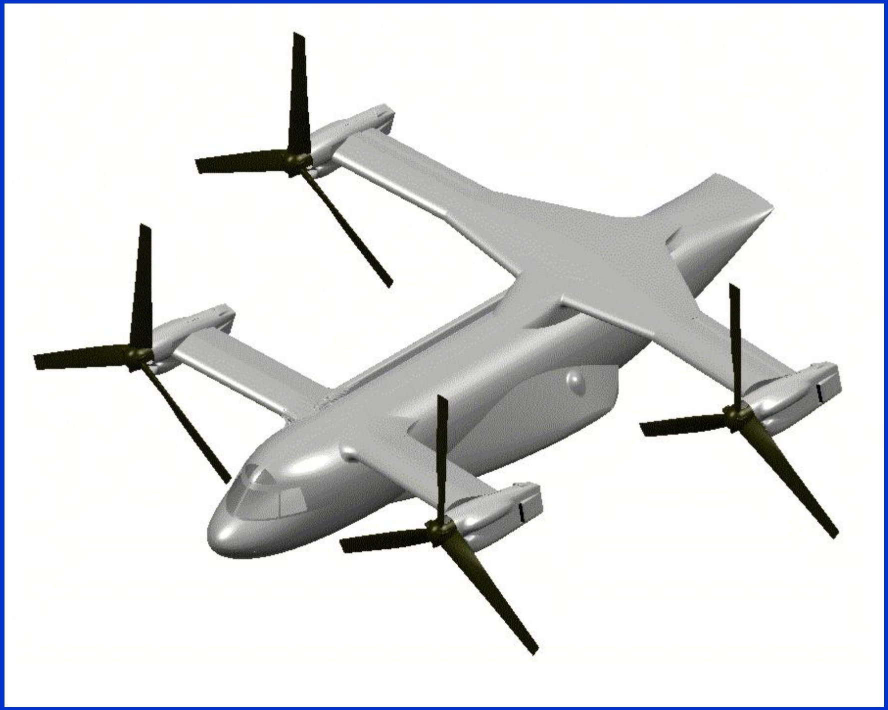
Desired Speed Determination



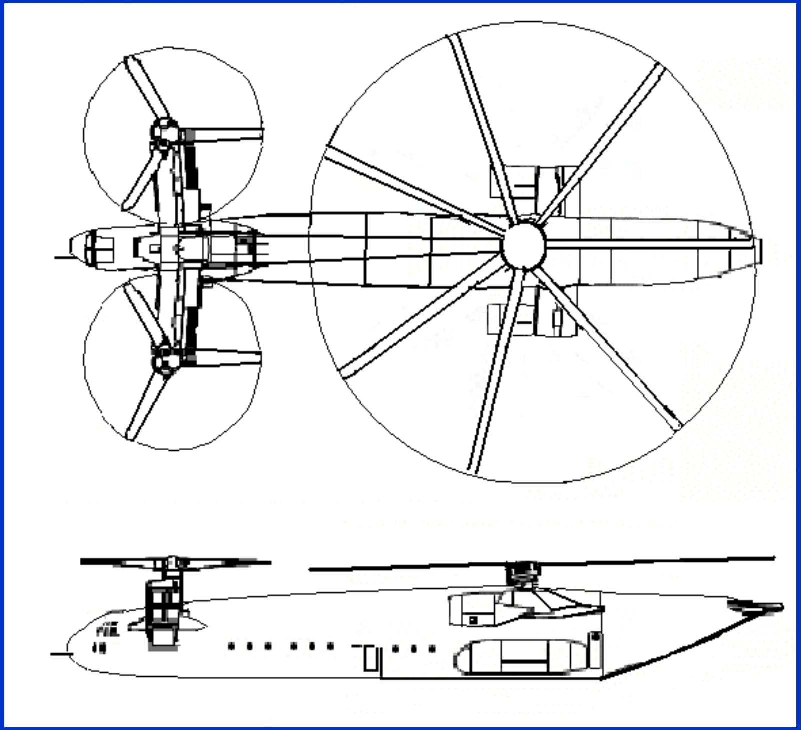
Long Range Heavy Lift Aircraft Mission Profile



Design Concepts Under Evaluation



The Quad Tilt Rotor



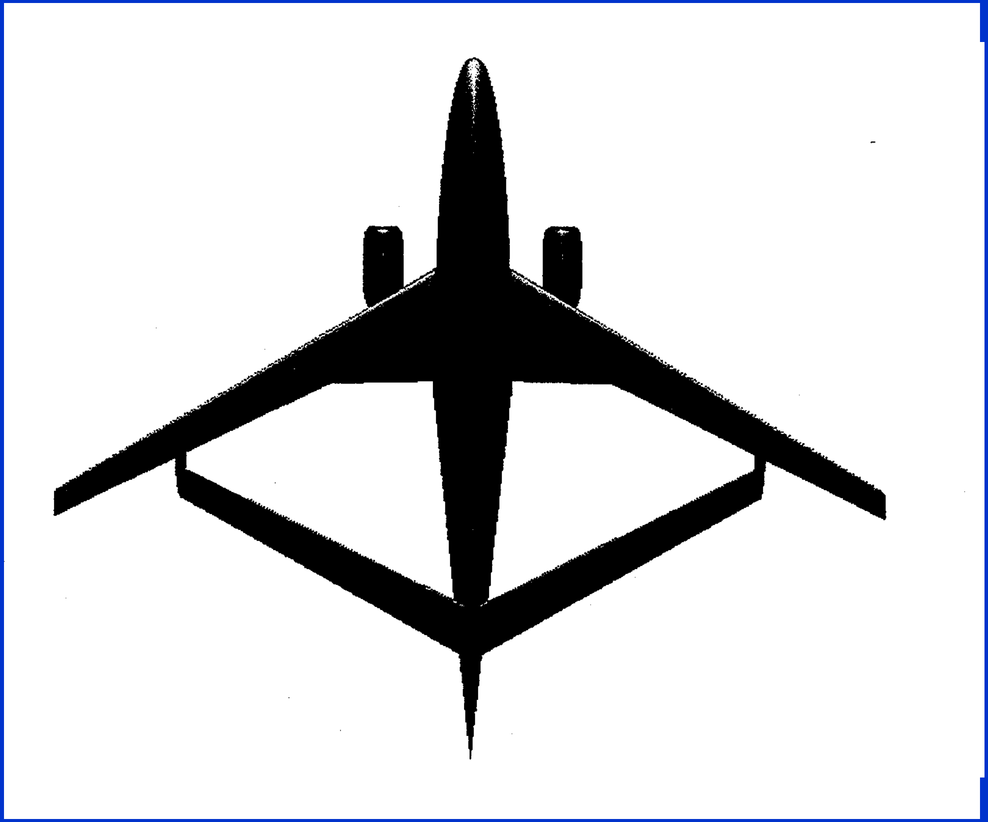
The Compound Helicopter

ISR Family of Systems

- STOM operations place a premium on the timely acquisition and dissemination of ISR data
- The ISR family of systems is an organic means by which the force commander can collect ISR data tailored to their specific needs
- The first tier consists of short range tactical UAVs operating from ships or units ashore

Sea Spectrum UAV

- Second of three tiered ISR system
- Shipboard compatible (LHA)
- Global Hawk class payload
- 12 hr endurance at 60K ft 300 nm from launch platform
- Limited weapon delivery capability

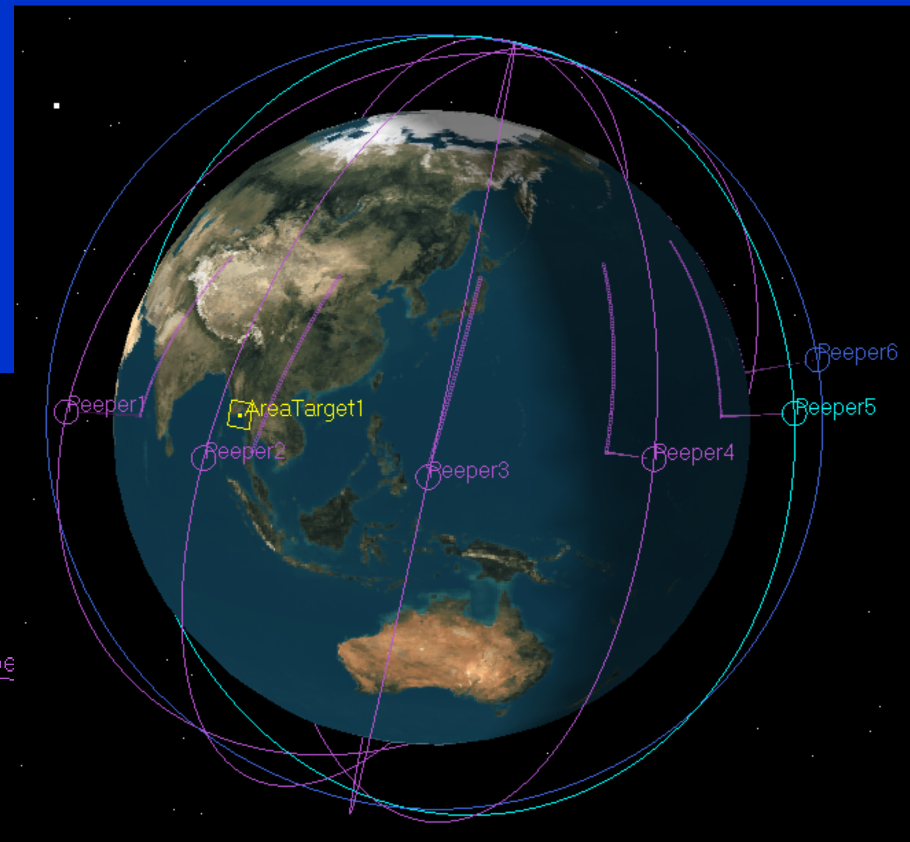


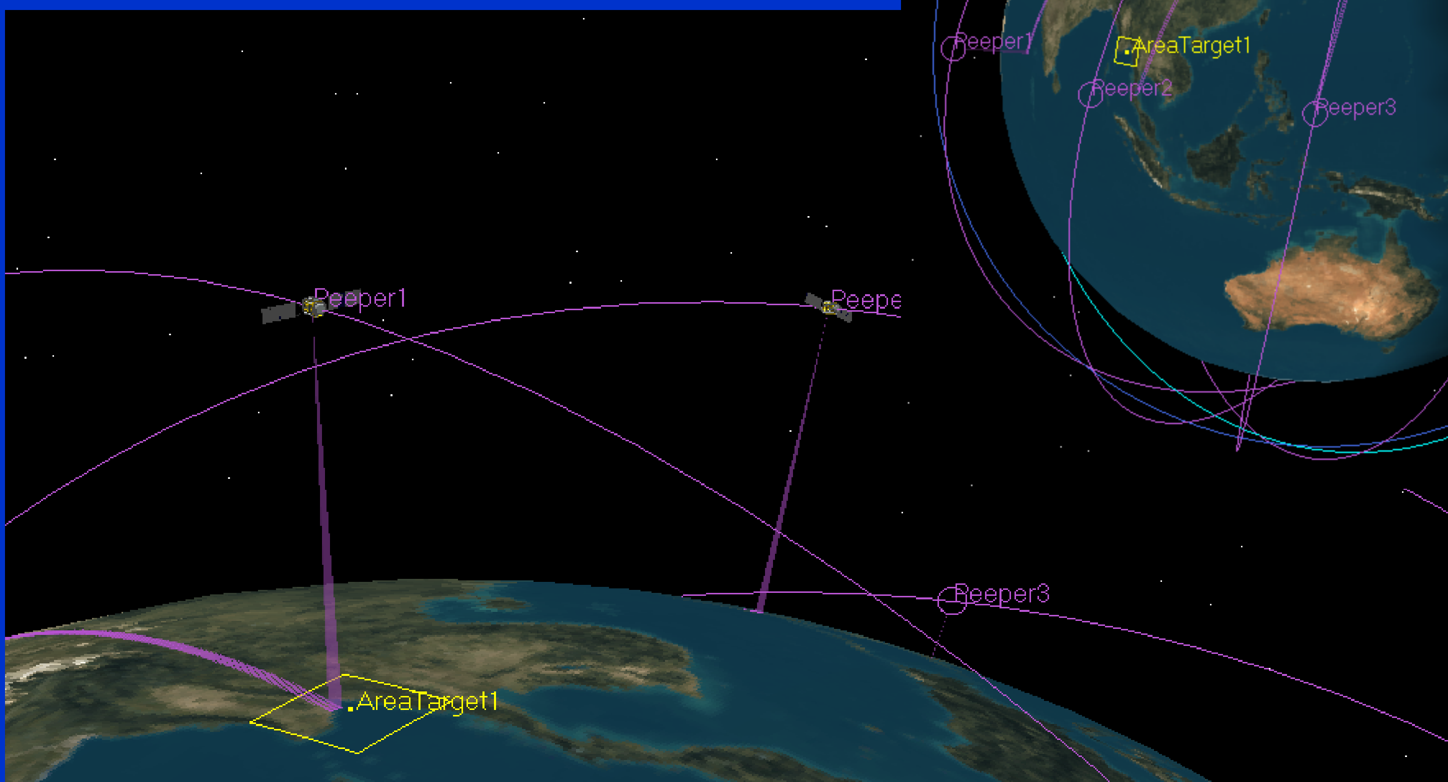
LEO Multi-spectral Imager

- “Persistent Peepers” system
  - High component of three tiered ISR family of systems
  - Capable of conducting mapping, wide area surveillance, and specific target imaging missions
  - 6 satellite constellation
  - Multi-spectral pan-chromatic/RGB/Near IR images to 2.0 m resolution over 250x250 nm area with 48 hour revisit time
  - Near real time crosslink/downlink to expeditionary force commander

Persistent Peepers Constellation

Sun synchronous, circular,
polar orbit with 101.8º inclination





Viper Tilt Rotor Escort

- Increase survivability of MV-22 and other high speed transports
- Conserve JSF strike assets
- Limited CAS capability further offloads JSF tasking
- 400 kt dash speed
- 6 internal AGM-114 Hellfire and 4 external AIM-9 Sidewinder

Conceptual Design Conclusions

- Once capability gaps had platform solutions assigned, the conceptual architecture was initially defined
- The conceptual architecture was then ready for comparison against the Current and Planned architectures using the high fidelity Extend model
- Prior to discussing the comparison methodology and results, all three architectures will be briefly described

Architecture Description

MAJ Ong, SAF

ExWar MEB Architectures

Year 2002 ~ 2014

Current Architecture

Year 2015 ~ 2020

Planned Architecture

Conceptual Architecture

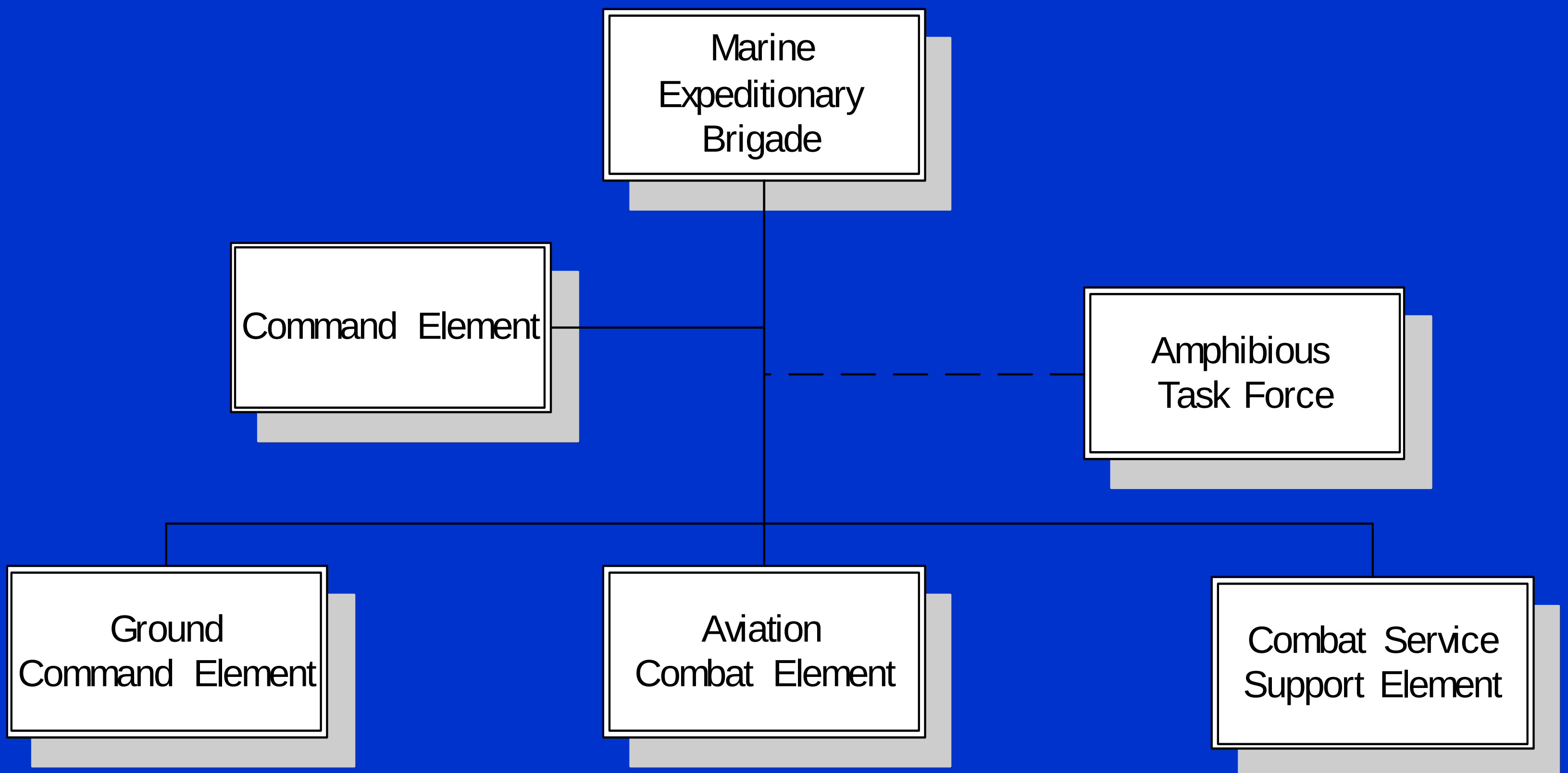
ExWar MEB Architectures

- Current Architecture (Baseline)
  - “Notional” Force Structure
- Planned Architecture
  - Marine Corps Vision
- Conceptual Architecture
  - ExWar study group’s Visualization

ExWar MEB Architectures

- Structure and ORBAT
- Capabilities
- Concept of Operations
- Limitations
- Advantages

Structure and ORBAT



Command Element (Current, Planned & Conceptual)

- C2
- Reconnaissance/ Surveillance assets
- Dep MEF Commander as MEB Commander

Ground Combat Element

Current

- Infantry Regiment as Main maneuver forces
- Wide range of Ground Combat Support elements
- Estimated 5,500 Marines

Planned

- Infantry Regiment remains
- AAV battalion converted to AAAV battalion
- Improved Firepower

Conceptual

- Leaner Maneuver and support forces with Higher Mobility
- Incorporate Long Range Precision Weapons
- Leverage on Hi-Tech

Aviation Combat Element

Current

- Composite of Marine Aircraft Groups
- Fixed and Rotor wings
- Anti-air and Support Squadrons

Planned

- Structure remains functionally identical
- Replacements
  - CH46E >> MV-22A
  - AV-8B >>JSF
- Upgrades
  - UH-1H>>UH1T
  - AH1W>>AH-1Z

Conceptual

- More Air Lift Assets
- New Heavy Lift aircraft to replace CH-53E

Combat Service Support Element
(Current, Planned & Conceptual)

- Brigade Service Support Group
- Support MEB from ashore in Current architecture and from sea for both Planned and Conceptual architectures in all missions

Amphibious Task Force

Current

- Formed from 3 NESG
- Each NESG comprises:
  - LHA or LHD
  - LPD-4 class
  - LSD – 41 or 49
  - Escort Ships
- Additionally:
  - 6 MPF ships

Planned

- Same
- Each NESG comprises:
  - LHA (R)
  - LPD-17 class
  - LSD – 41 or 49
  - Escort Ships
- Additionally:
  - 6 MPF (F)ships
  - Form Sea Base
  - LCU (R) and HLCAC

Conceptual

- Leaner but with more capabilities
- Each NESG comprises:
  - 2 ExWar Combat ships
  - Escort ships
- Additionally:
  - 3 ExWar Logistics ships
  - Form Sea Base

Capabilities (Current, Planned & Conceptual)

- Deploy Forces/ Conduct Maneuver
- Develop Intelligence
- Exercise C2
- Employ Firepower
- Perform Logistics and CSS
- Protect the Force

Capabilities (Current Architecture)

- Conduct offensive and defensive operations against an enemy, both at sea and in support of forces ashore.
- MPF is capable of building up Iron Mountain to re-supply forces in AO.
- Provide logistics and maintenance at sea and ashore via amphibious ships and Iron Mountain.

Capabilities
(Current Architecture)

- Reconstitute the forces ashore and re-deploy in support of other operations, in or out of theater.
- Self-protection measures to operate independently in a threat environment
- Passive defense against Chemical, Biological and Radiological (CBR) attack.

Additional Capabilities (Planned & Conceptual Architecture)

- Able to conduct STOM operations.
- MPF (F) capable of at-sea arrival and assembly of forces and equipment.
- Coordinate fire support functions from a Sea Base or ashore.
- Provide logistics and maintenance at sea via Sea Base.
- Reconstitute forces at sea and re-deploy in support of other operations, in or out of theater

CONCEPT OF OPERATIONS
Current Architecture

- 3 MEUs organized into 3 NESG
  - 2 NESG forward deployed in Yokosuka, Japan and Southern Arabian (Persian) Gulf
  - Another NESG deployed from San Diego
  - 3 NESG sail to launching area and prepare for operations ashore upon activation
- 6 MPF ships in MPSRON located at Diego Garcia
  - Carries equipment and supplies to sustain 17,000 MAGTF personnel for up to 30 days

CONCEPT OF OPERATIONS

Current Architecture

- ‘Iron mountain’ with port facilities is established near landing area as base for combat force and logistics build-up
  - Combat forces proceed for operations at objective area
  - MPF pull in to unload equipment and supplies
  - Subsequent re-supplies from CONUS to iron mountain by commercial ships at regular intervals

CONCEPT OF OPERATIONS
Planned Architecture

- 6 MPF (F) ships at Diego Garcia proceed to form Sea Base
- STOM principles and concepts will be applied
  - No 'iron mountain' and no operational pause at landing beach
  - Landing forces proceed directly to objective area from landing beach.
  - MPF (F) ships form Sea Base at a secure location at sea and supply the forces ashore directly from Sea Base
- Subsequent re-supplies from CONUS to Sea Base by commercial ships or high-speed vessels (HSV) at regular intervals

CONCEPT OF OPERATIONS
Conceptual Architecture

- Capable of launching from 75 NM from the sea to 200 NM inland upon arriving at the launching area
- Re-supplied by 3 dedicated shuttle ships, as well as commercial and other logistic ships
- Requirement to conduct beach landings because AAAV and M1A1 are too heavy to be transported to objective by shipboard compatible aircraft
- LCU(R) and HLCAC provides Expeditionary Force of the future an over-the-horizon strike capability

Current Architecture Limitations

- Inability to conduct Sea Base Operations
- Limitations
  - Unable to execute STOM with large forces.
  - Unable to provide logistic support in STOM environment.
  - Unable to indefinitely sustain large forces ashore without a large footprint.
  - Unable to rapidly reconstitute and redeploy forces

Planned Architecture Advantages

- Planned systems being designed to allow forces to execute Sea Basing and STOM
- Planned systems:
  - LHA(R), MPF(F), LPD-17
  - LCU(R), HLCAC , AAAV
  - MV-22, F-35B (JSF)

Conceptual Architecture Enhancements

- Fully integrated Sea Base based on TSSE and AERO conceptual designs given considerations to the Planned capabilities
- The conceptual architecture allows
  - Deployment of MEB directly to objective up to 200 NM inland
  - Rapid and accurate re-supply of forces
  - Reduced footprint ashore
  - Indefinite sustainment at sea
  - Sea Base logistic and maintenance support
  - Rapid reconstitution and redeployment of forces at sea

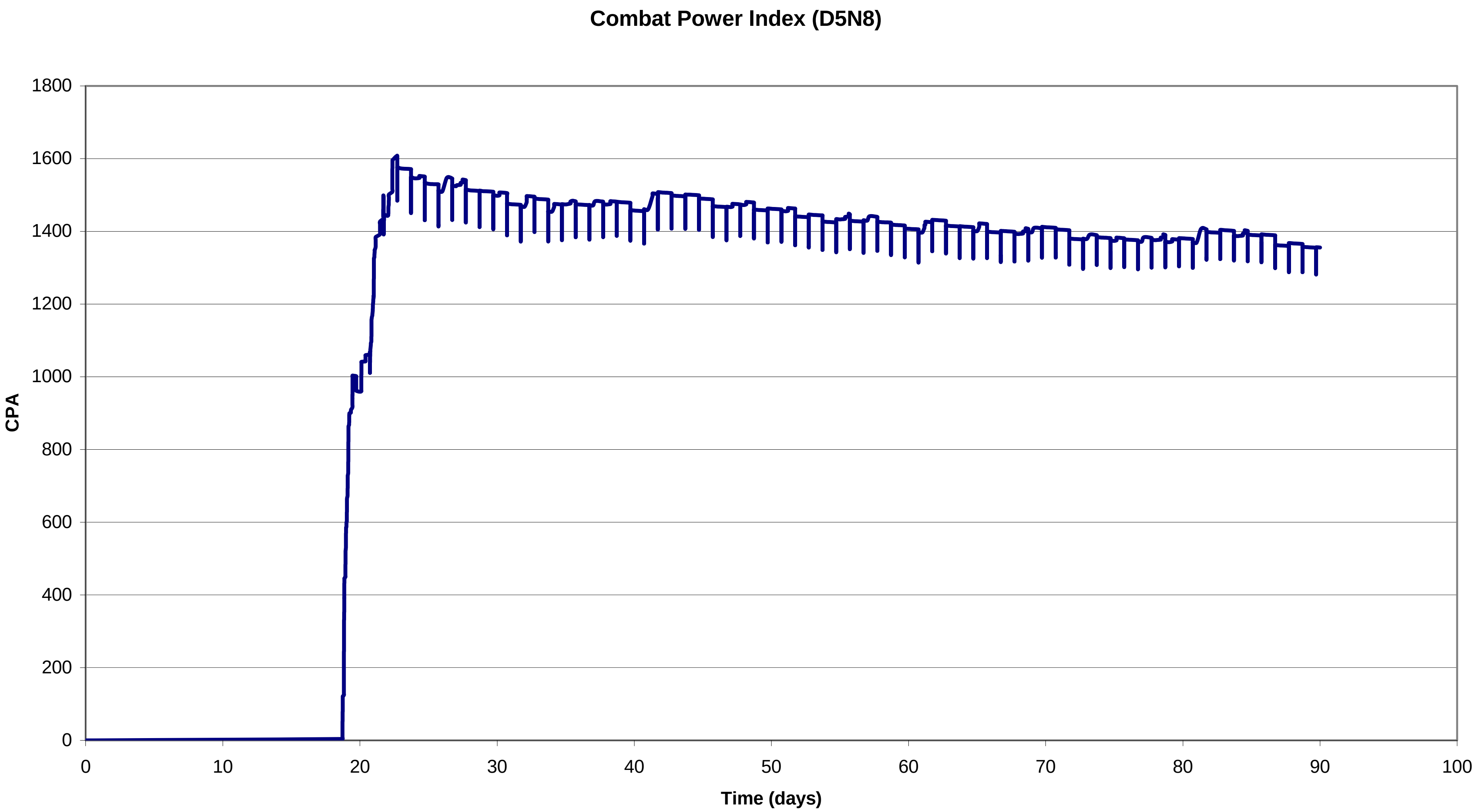
Architectural Modeling With EXTEND

MAJ Poh, RSN

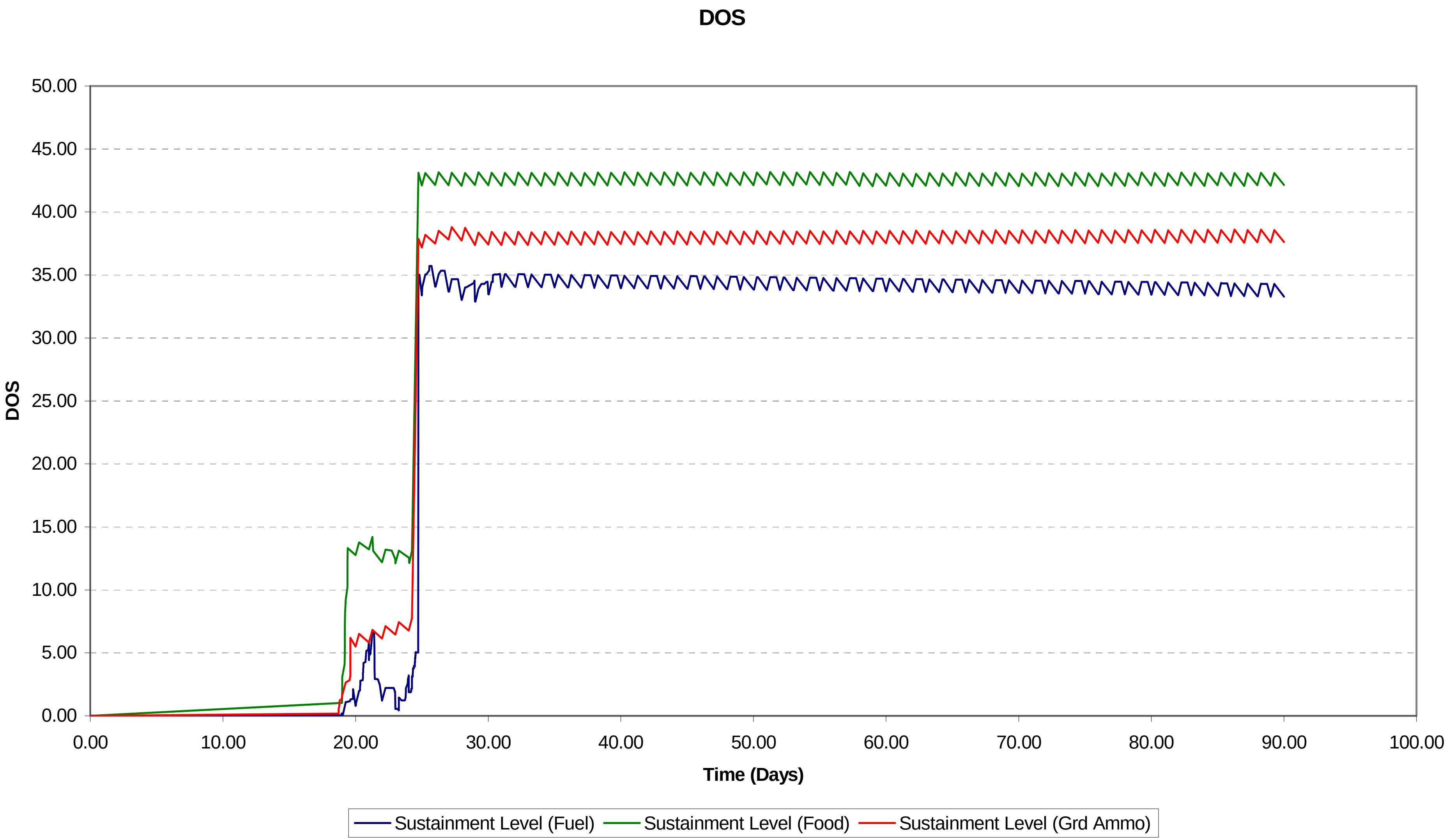
Why Model ?

- The need to be able to quantitatively analyze system of systems and to identify critical factors within that system
  - End-to-end emulation of the processes involved in accumulating, assembling, deploying, and sustaining expeditionary forces ashore
  - Allows a systematic approach to study and verify the end-to-end system processes involved in the expeditionary warfare (ExWar) system
  - Provides a full accounting of all the moving parts and interactions within the ExWar system

Sample Model Output
- At the Objective

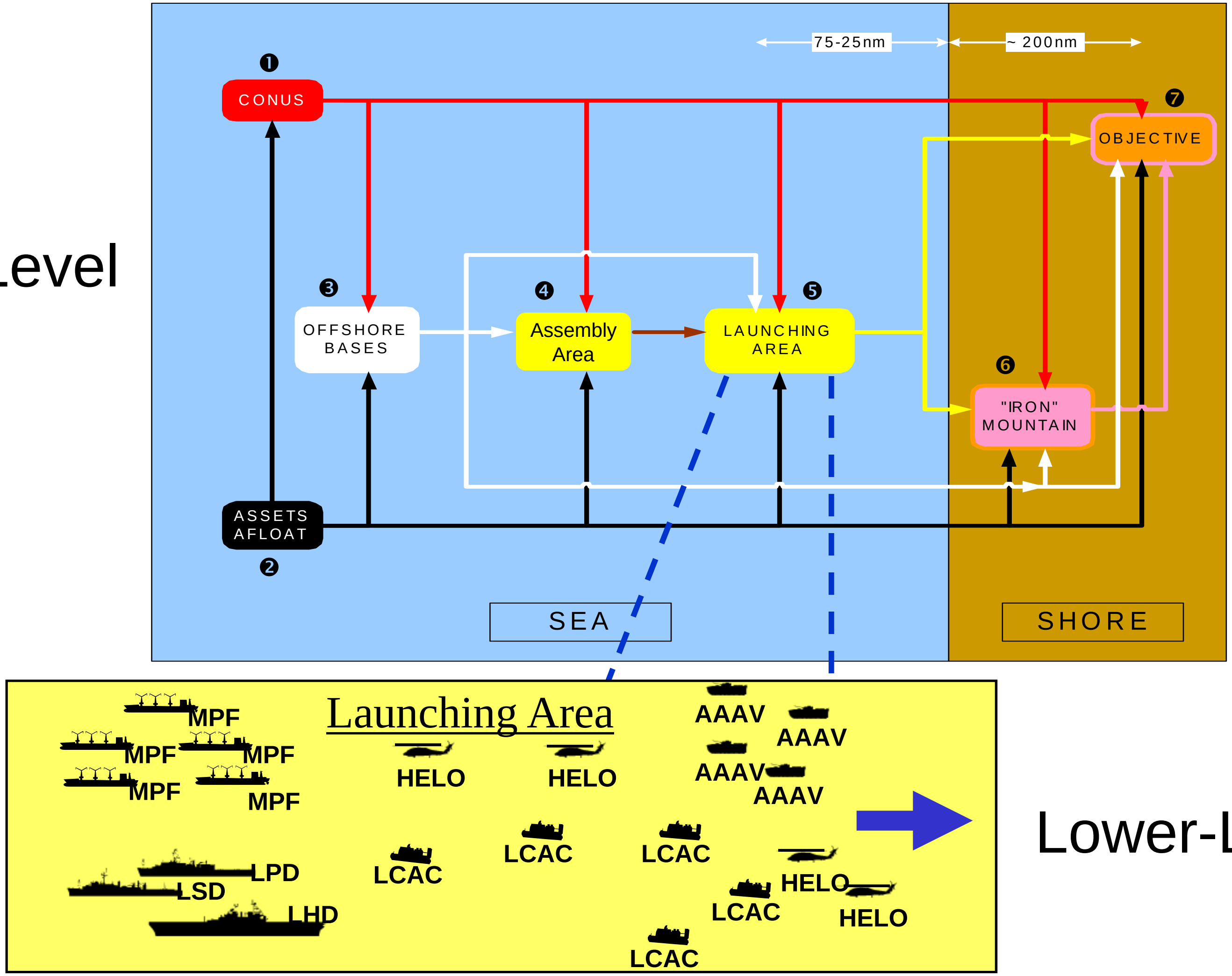


Sample Model Output
- At the Iron Mountain



Overview of ExWar Model

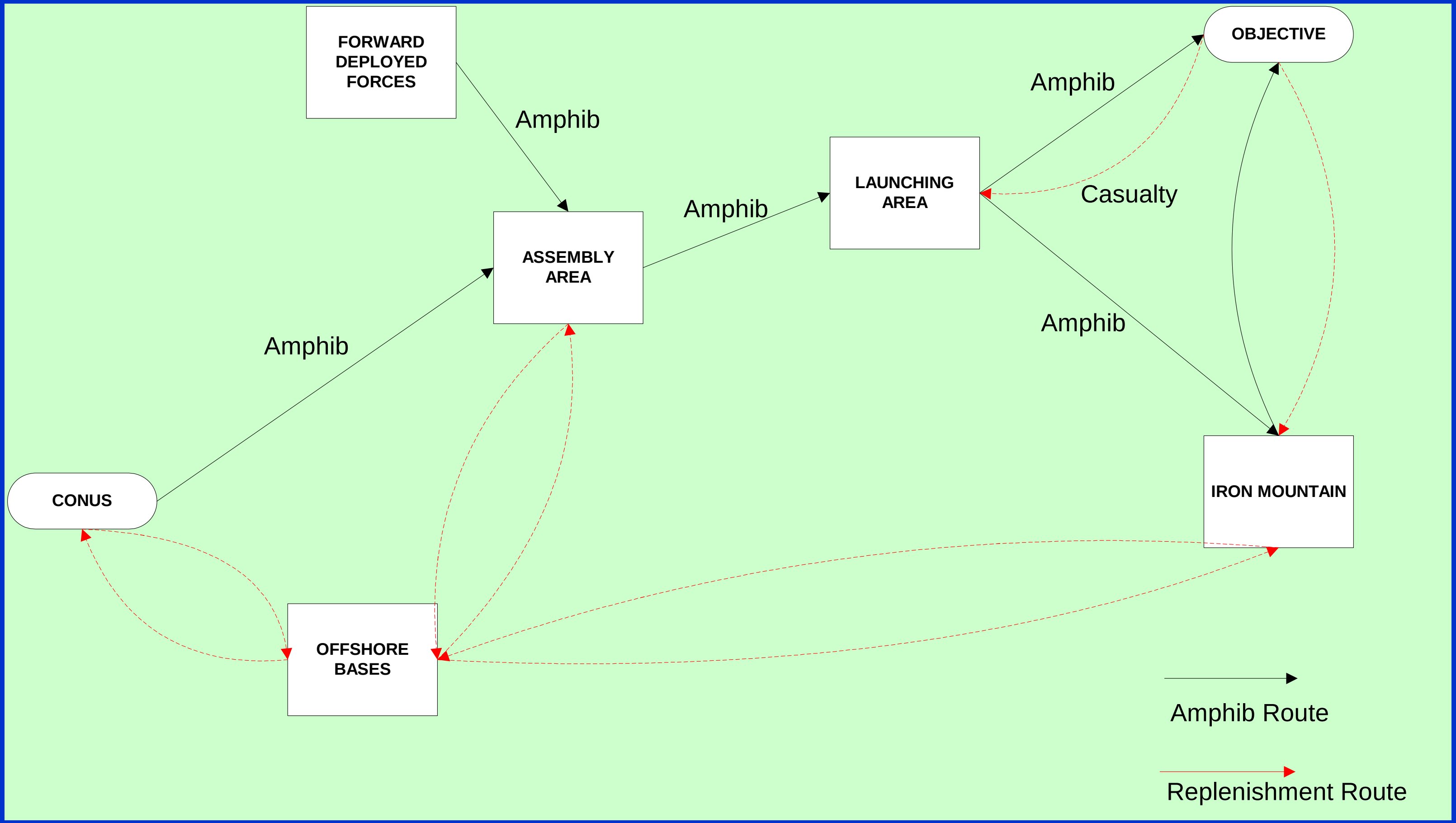
High-Level



Lower-Level

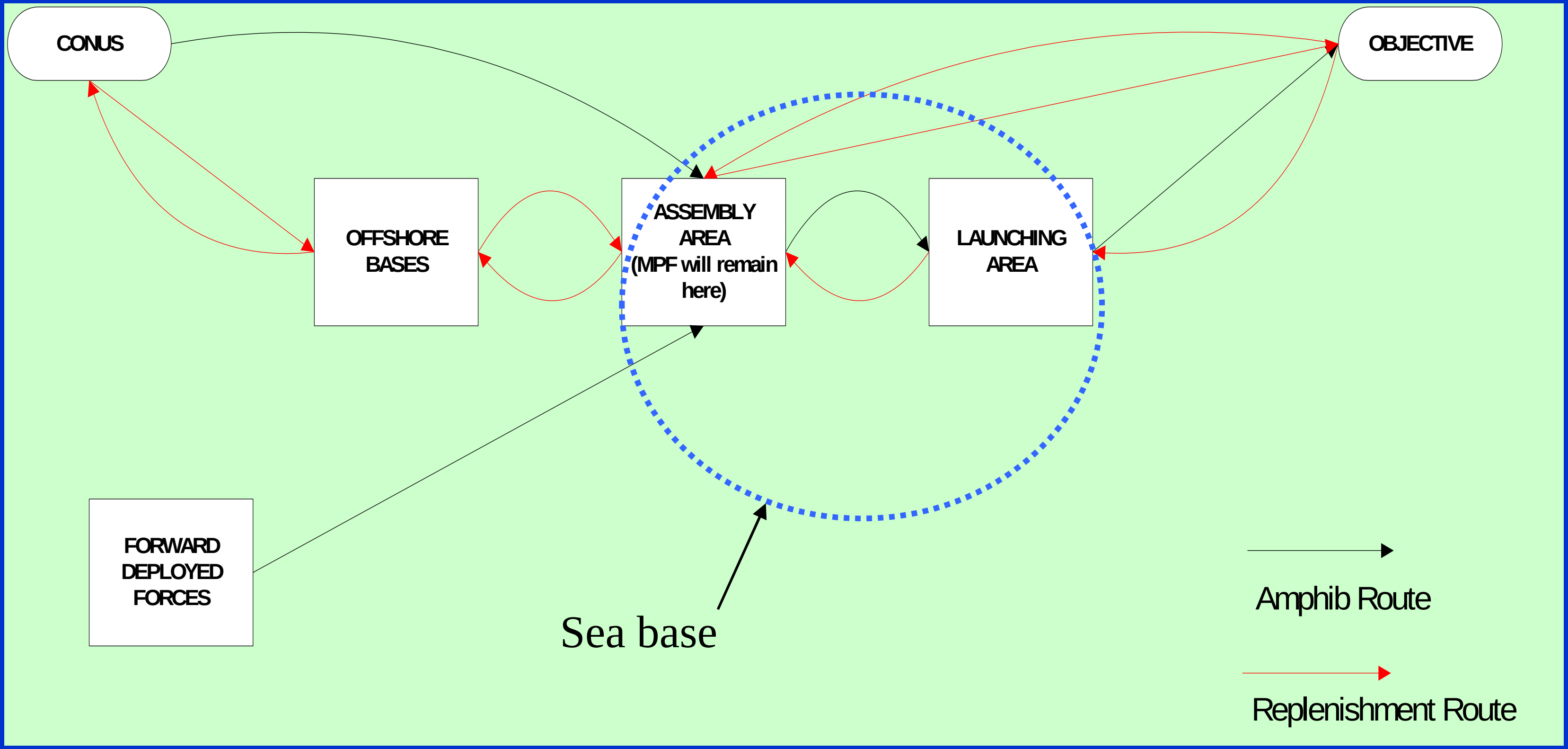
The Two EXTEND™ Models

- Model 1: Current Architecture



The Two EXTEND™ Models

- Model 2: Planned/Conceptual Architecture



What Can The Model Do ?

- Enables total system of systems analysis within and between architectures
- Controls experimental studies of interfaces and synergies among ships, aircraft and other systems within an architecture
- Identifies the most significant factors in the ExWar architectures
- Answers questions on use of
  - HSV
  - Sea Basing

Factors Taken Into Account In The Models

- Environmental Effects
- Mine Threats
- Attrition of troops and vehicles
- Reliability/serviceability of vehicles/equipment

Of all simulation models that we are aware of, no other captures all of these factors

Validation

- Validated with results from a published technical paper:

An Analysis of STOM (Ship to Objective Maneuver) In Sea Based Logistics

by Kang, Doerr, Bryan, and Ameyugo, 2002.

  - Conclusions from EXTEND™ modeling results consistent with verified findings about the logistics sustainment using Sea Base for STOM
  - Some slight, but consistent, differences in the exact data output due to slightly different design considerations and assumptions

Design of Experiment (DOE)

- Systematic approach to run model and obtain the desired results
- Half factorial runs to capture essential data
- Design Factors
  - Architecture
  - Replenishment means between Offshore Base and the logistic depot
  - Proximity of the ships to the Objective
- Noise Factors
  - Attrition rate
  - Weather conditions
  - Mine threats
  - Consumption rate

Optimized DOE Matrix

Noise Factor								
Cons. Rate	High	Low	High	Low	High	Low	High	Low
Mine Threat	Low Threat	Low Threat	High Threat	High Threat	High Threat	High Threat	Low Threat	Low Threat
Weather	Good	Good	Poor	Poor	Good	Good	Poor	Poor
Attrition	High	High	High	High	Low	Low	Low	Low
Sim. Run	1	2	3	4	5	6	7	8

Sim Run	Design Factors			Results							
	Architecture	Reple. Means	Ship to Obj Proximity	1	2	3	4	5	6	7	8
1	Current	LMSR	Close								
2	Current	LMSR	Far								
3	Current	HSV	Close								
4	Current	HSV	Far								
5	Planned	LMSR	Close								
6	Planned	LMSR	Far								
7	Planned	HSV	Close								
8	Planned	HSV	Far								
9	Future	LMSR	Close								
10	Future	LMSR	Far								
11	Future	HSV	Close								
12	Future	HSV	Far								

Measures of Performance (MOPs)

- 4 MOPs in 2 categories:
  - Assault Phase
  - Logistic Sustainment Phase

Performance Metric

Assault Phase

- Combat Power Ashore
  - Summation of the Combat Power Indices (CPIs) of entities that contribute combat power to the force
  - The CPIs allocated were based on a RAND® study:

"Situational Force Scoring: Accounting For Combined Arms Effects In Aggregated Combat Models"

By Patrick Allen

RAND ® Strategy Assessment Center, 1992.

Performance Metric

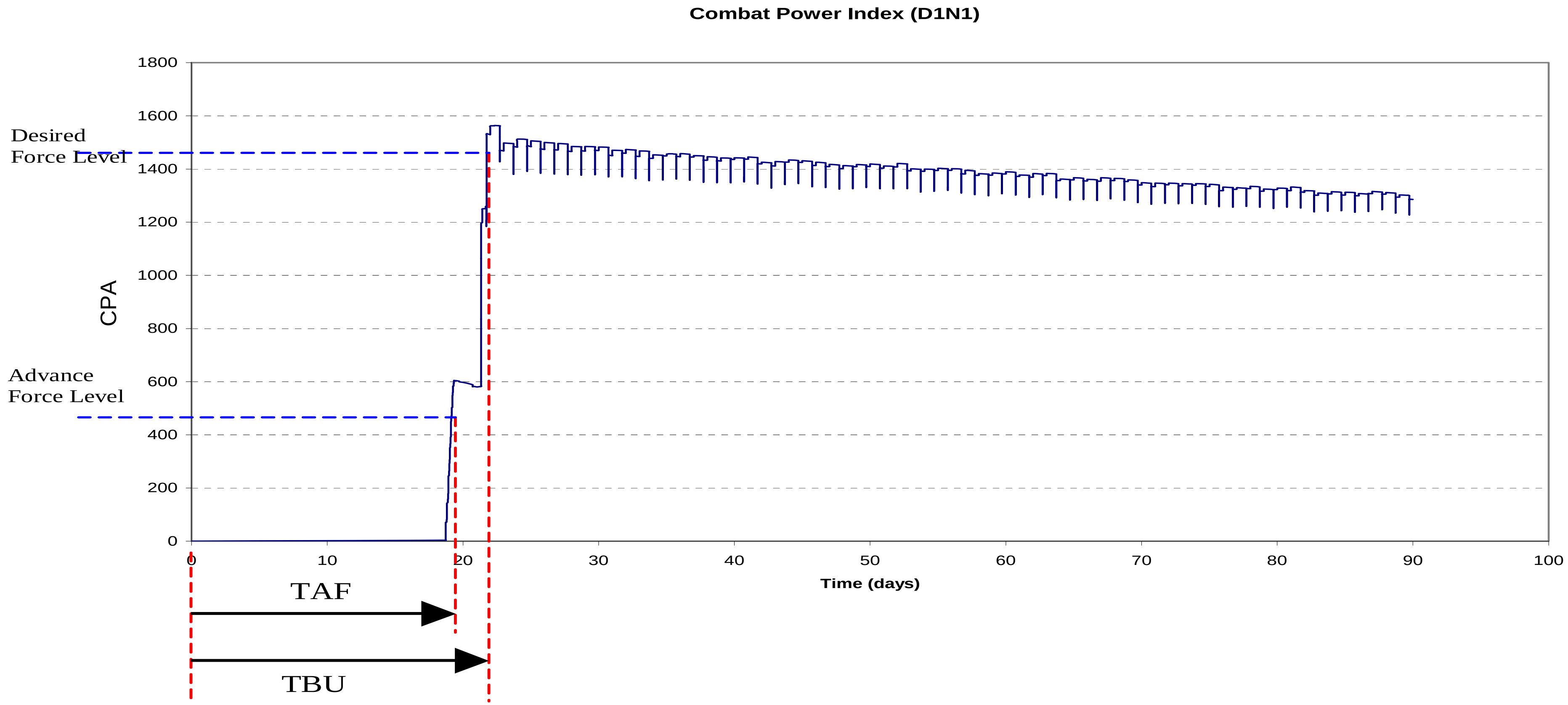
Assault Phase

- The entities contributing towards combat power defined for this analysis were:
  - M1A1 Tank
  - Light Armored Vehicle (LAV)
  - Assault Amphibious Vehicle (AAV)
  - Advanced Assault Amphibious Vehicle (AAAV)
  - M198 155 mm Howitzers
  - High Mobility Multipurpose Wheeled Vehicle (HMMWV)
  - Troops

Measures of Performance

Assault Phase

- Time to build up an Advance Force (TAF)
- Time to build a Desired Force Level (TBU)



Measures of Performance

<u>Desired Levels for TBUs</u>

- Within Architecture Analysis
  - CPAs as a result of assault assets ONLY
- Between Architectures Analysis
  - Total force build-up CPAs
  - Results of

Initial Force Built-Up (by assault asset)

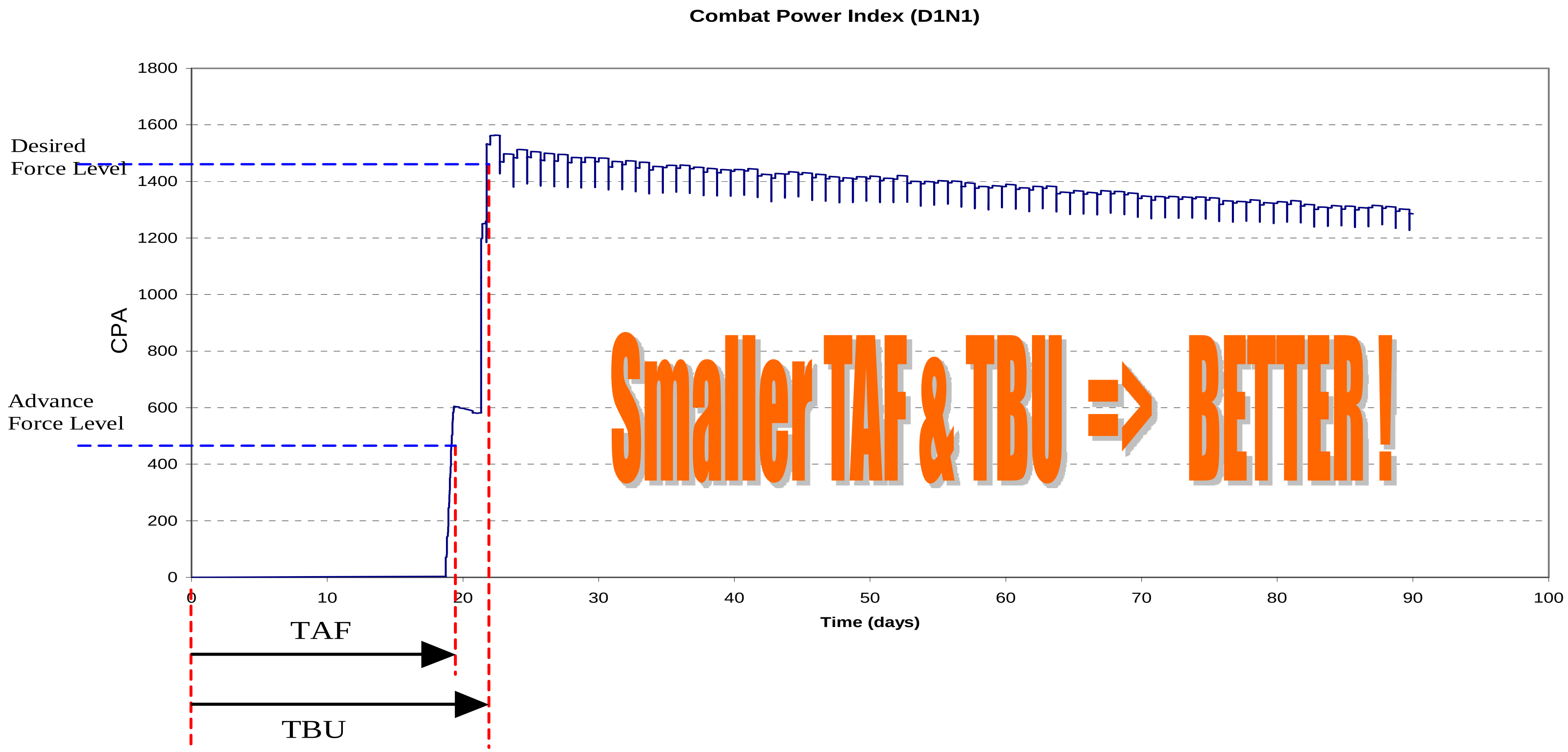
+

Remainder Force Build-Up (by Logistic Elements)

Measures of Performance

Assault Phase

- Interpretation of TAF & TBU from graph.



Measures of Performance

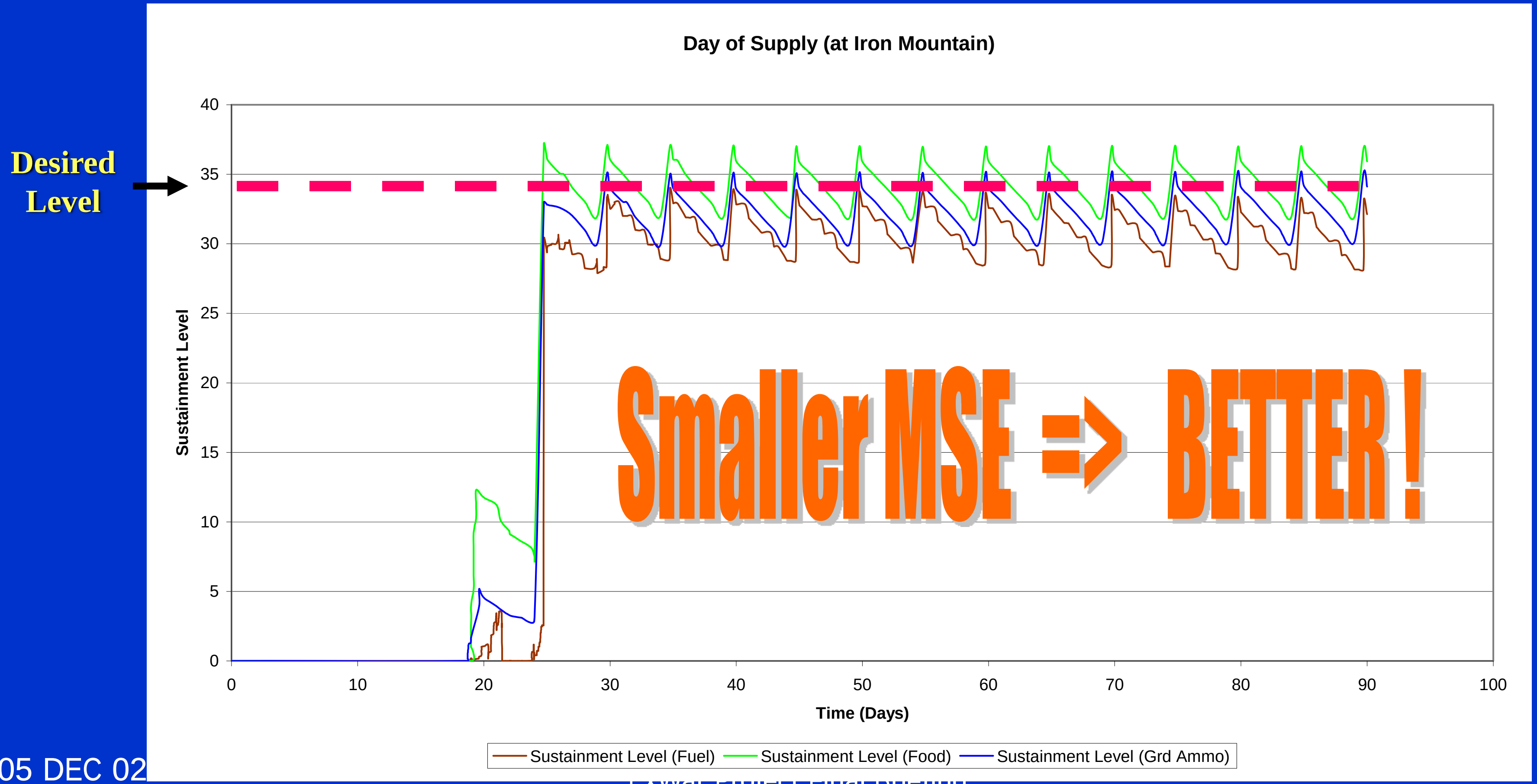
Logistic Sustainment Phase

- Logistical Sustainment Mean Squared Error (MSE)
  - MSE accounts for the bias and variability in the Days-of-Supplies (DOS) for the 3 resources from the desired level at the logistic depot and the Objective
    - Food
    - Fuel
    - Ground Ammunition

Measures of Performance

Logistic Sustainment Phase

- Mean Squared Error (Iron Mountain/Sea base) – MSE (IM/SB)
- Mean Squared Error (Objective) – MSE (Obj)



Extend Model Analysis Results

CPT Lau, SAF

Analysis Results

- Time to Build Up Advance Force (TAF)
  - The time to build up the advance force for each architecture was unaffected by the factors studied in the model
- Time to Build Up Desired Force Level (TBU)
  - Proximity of the ships to the Objective and weather conditions are the 2 main determinants
  - Under good weather conditions, launching the MEB further out to sea does not increase the build up time significantly

Analysis Results

- Resource levels at the Iron Mountain / Sea Base (MSE IM/SB)
  – Using HSV to replenish the logistic depot rather than the LMSR results in the least variation in the resource levels
- Resource levels at the Objective (MSE OBJ)
  – Proximity of the ships to the Objective and weather conditions are the 2 main determinants for the Current and Planned Architectures
  – Weather is the main determinant for the Conceptual Architecture

Analysis Results

- Time to Build Up Force
  – Conceptual Architecture projects the forces ashore in the shortest time
    - Newly designed ExWar Ships were able to get on station fastest
    - Increased number of aircrafts coupled with increased lift capability were able to project the force with fewer trips

Analysis Results

- Time to Build Up Force
  - Current Architecture takes the longest time to project the force ashore
    - Requires additional delay to capture Iron Mountain
  - Planned Architecture is most affected by weather than the current and conceptual Architecture
    - Higher usage of sea transports; sea craft suffer a greater degradation in poor weather

Analysis Results

- Logistical Sustainment at the Objective
  - Current Architecture is the most robust in sustaining the Objective, if you're willing to accept the accompanying operational pause
    - The Iron Mountain has a highly capable overland transportation, which is not affected significantly by weather or attrition in the scenario

Analysis Results

- Logistical Sustainment at the Objective
  - Conceptual Architecture performs just as well as Planned Architecture
    - Greater reliance on its air assets made the aircrafts more susceptible to attrition
    - Conceptual Architecture uses 75% air/25% sea
    - Planned Architecture uses 50% air/50% sea
  - With better aircraft survivability, the Conceptual Architecture will perform better than the Planned Architecture

Analysis Results

- Logistical Sustainment at the Objective
  - Planned Architecture is more affected by distance between Launching area and the Objective
    - Greater usage of sea transports
    - Sea crafts are disadvantaged in longer distances due to their slower transit speeds

Analysis Results

- Logistical Sustainment at the Objective
  - Planned Architecture is able to sustain the Objective as well as the Current Architecture under good weather conditions
    - Planned Triad of LCAC(H), AAAV and MV-22 can sustain the Objective indefinitely
    - However, under inclement weather, the Sea Base will not be able to maintain the desired level of resources at the Objective
    - Having better sea keeping and transloading capabilities, the Planned Architecture can perform as well as the Current Architecture

Summary of Key Findings

- Projection of Forces Ashore
  - Conceptual Architecture is able to project forces ashore in the shortest time
    - Air assets are better able to project forces ashore
    - However it is necessary to improve aircrafts' survivability
    - Reducing sea crafts susceptibility to weather effects will also lead to better forces build up time

Summary of Key Findings

- Logistical Sustainment at the Objective
  - Sea Base is able to sustain the Objective without the Iron Mountain under good weather conditions
    - Inclement weather will decrease throughput from the Sea Base to the Objective
  - Establishing an Iron Mountain, whenever possible, can reduce the effects of weather on the re-supply process

Summary of Key Findings

- Logistical Sustainment at the Objective
  - Logistic Sustainment of the Objective can be improved by reducing the effects of weather and attrition
    - Reduce the effects of weather by improving design of transports to allow for better sea keeping capabilities
    - Reduce the effects of attrition by having better aircraft survivability

Excursion Analysis: The Effect of Speed

MAJ Teo, RSAF

SPEED EXCURSION

- OPNAV Tasker
  - Effects of speed of platforms on both logistics and war fighting
  - HSV type of high-speed platforms

SPEED-CRITICAL AREAS IN EXWAR AND POSSIBLE ROLES FOR HSV

- Equipment / Logistics Transfer
- Mine Warfare
- Special Operations
- Other Operations

HSV SPECIFICATIONS

- HSV-X1 Joint Venture
- Length: 313.22 ft, beam: 87.27 ft
- Full Load Displacement: 1872 tons, max draft: 13 ft
- Loaded Speed: 38 knots, Lightship Speed: 48 knots
- Loading / Unloading time (Average): 2 hours
- Deadweight: 828.8 tons
- Payload: 308 tons
- Range
  - 1200 Nautical miles (Full load) – 1 way
  - 3000 Nautical miles (Empty load) – 1 way

HSV ASSUMPTIONS

- Effective cruising speed at a sea state 3
- Linear speed versus payload relationship
- HSV able to carry all variety of loads and vehicles, limited only by the weight of the item to be transported
- Refueling of HSV conducted at 1000 nm intervals by Strategic Refueler tankers at sea
  - At-sea refueling takes 2 hours (approach, set-up, refuel, disengage and pull off)

SETUP OF ANALYSIS

Factor	Level	Description
Re-Supply Line Distance	CONUS to Sea Base	7,037 Nm
	Offshore Base to Sea Base	1,765 Nm
Ship Type/ Payload (Full)	FSS	27 knots, 32,295 tons deadweight
	HSV	38 knots, 828.8 tons deadweight
Re-supply Practices	Min Dev Minimum deviation from initial inventory level	Re-supply a certain number of days of supply once that number of days of supplies are utilized at the Sea Base so that there is minimum deviation at the Sea Base; if there are 45 days of supplies at the onset, then there will be approximately 45 days of supply throughout the operation
	Min Reqt 30 At least 15 days of supplies at the end of the 90-day operation (with initial supply set at 30 days)	Re-supply schedule is set such that there will be at least 15 days of supply at the Sea Base at the end of the 90-day operation, with Sea Base having an initial supply of 30 days
	Min Reqt 45 At least 15 days of supplies at the end of the 90-day operation (with initial supply set at 45 days)	As above, except that Sea Base has an initial supply of 45 days

- 12 different combinations

SETUP OF ANALYSIS

- Assumptions
  - HSV assumptions as presented previously
  - Fast Sealift Ship (FSS) / T-AKR
    - Loaded Speed: 27 knots
    - Deadweight: 32,295 tons
    - Refueling Time: 1 day (refueled concurrently during loading / unloading process)
    - Range: Able to sustain without refueling for single way trip for the particular scenario investigated

SETUP OF ANALYSIS

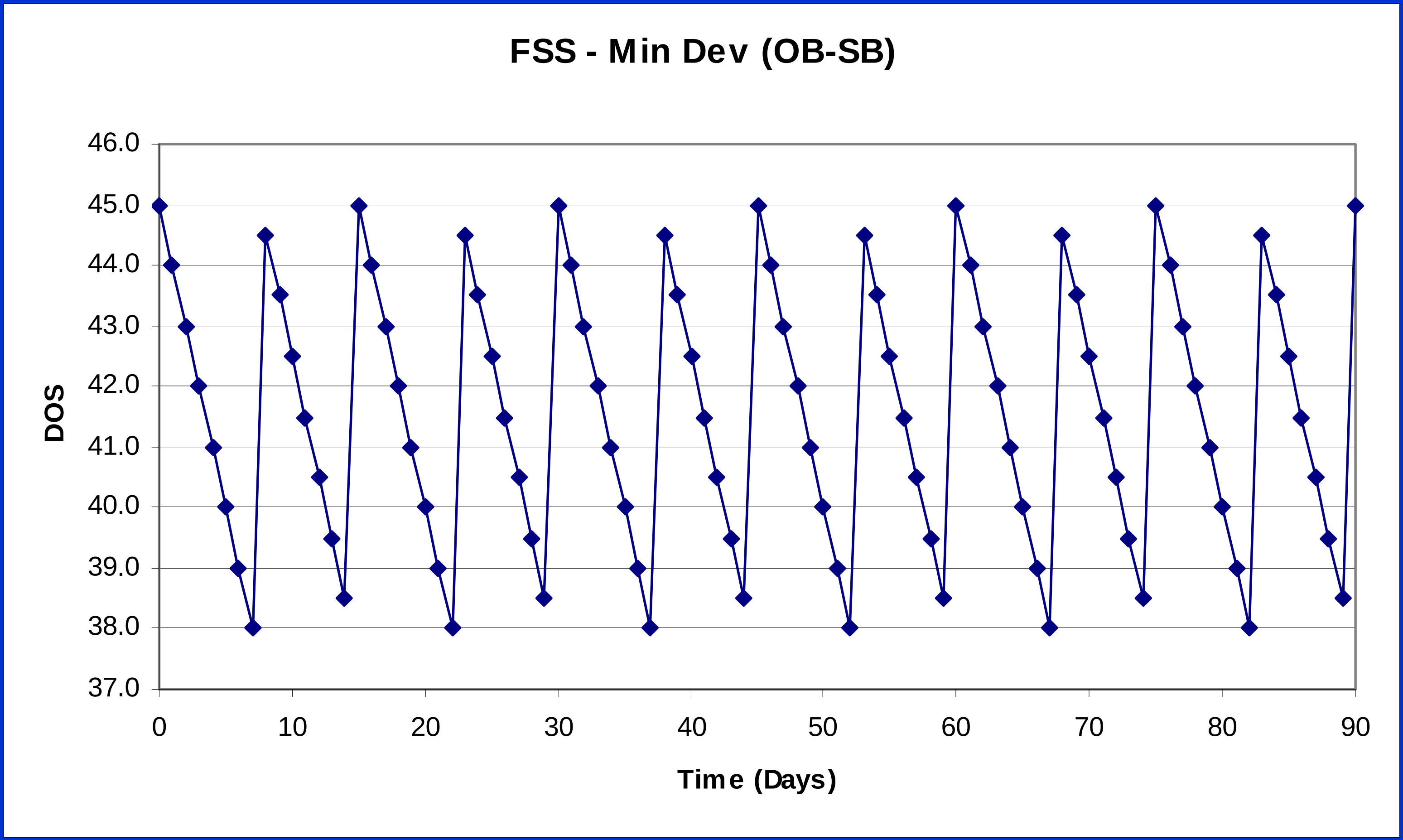
- Assumptions
  - Unit of measurement for Payload Transferred is Day of Supply (DOS)
    - FSS carries approximately 7.5 DOS
    - HSV carries approximately 0.19 DOS
      - Squadron of 12 HSVs carries approximately 2.3 DOS
  - Cost ratio of FSS to HSV is 6:1
  - Speed ratio of FSS to HSV is 1:1.4
  - Payload ratio of FSS to HSV is 39:1

SETUP OF ANALYSIS

- Methodology
  - Timeline Analysis / Replenishment Model
  - Equal Payload Transferred
  - Equal Cost Comparison

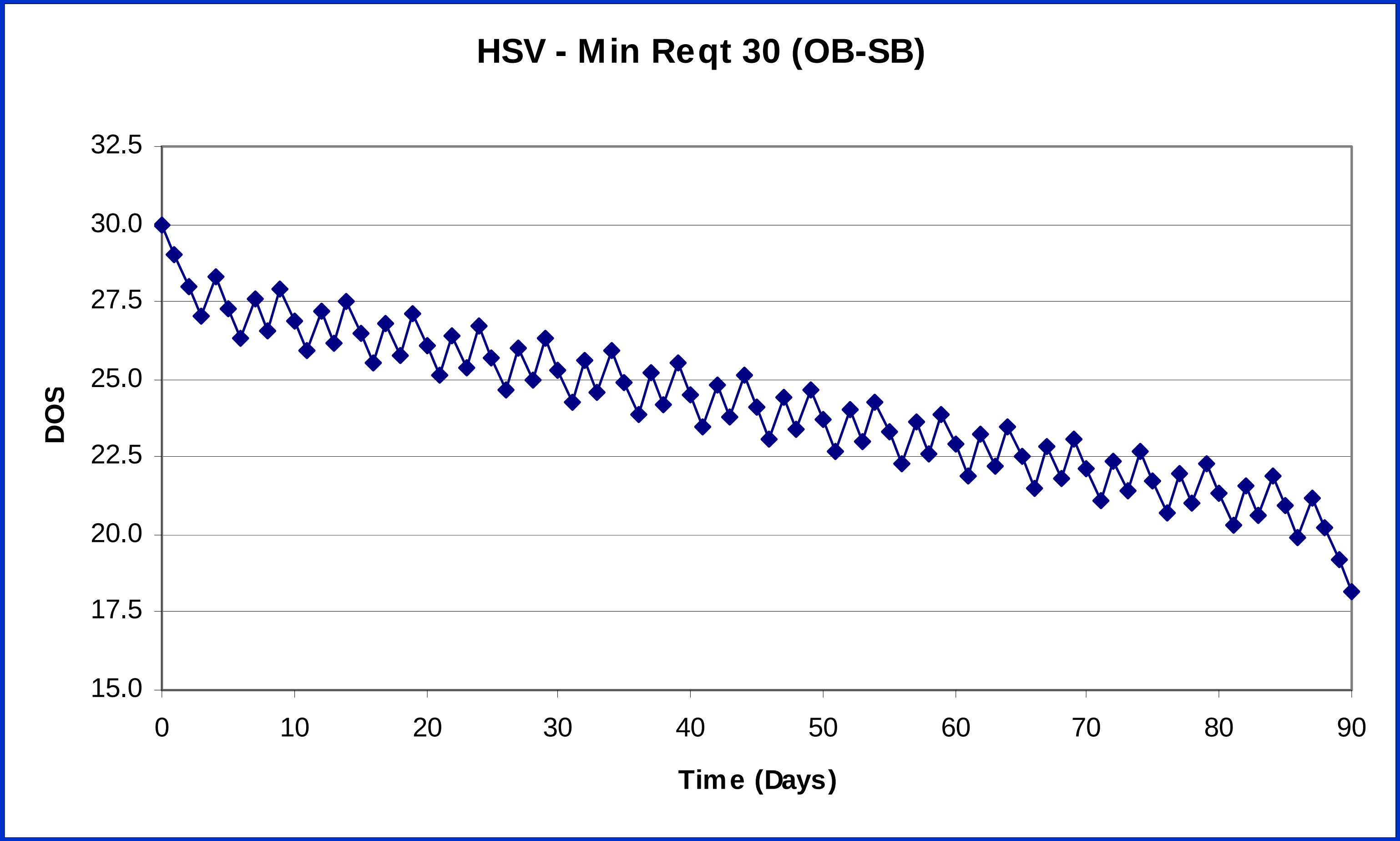
RESULTS OF ANALYSIS

- Sample Output Graph



RESULTS OF ANALYSIS

- Sample Output Graph



RESULTS OF ANALYSIS

- Offshore Base to Sea Base

	Min Dev		Min Reqt 30		Min Reqt 45	
	FSS	HSV	FSS	HSV	FSS	HSV
Number of Ships Required	2	36	2	24	2	24
Number of Runs per Ship	6	13	5	17	4	14
Rest Day between Runs	4	2	5	0	9	1
Number of Equal Cost HSVs Available	12		12		12	
Ratio of HSV to FSS	18:1		12:1		12:1	
Exceeds Equal Cost by Factor of	3		2		2	

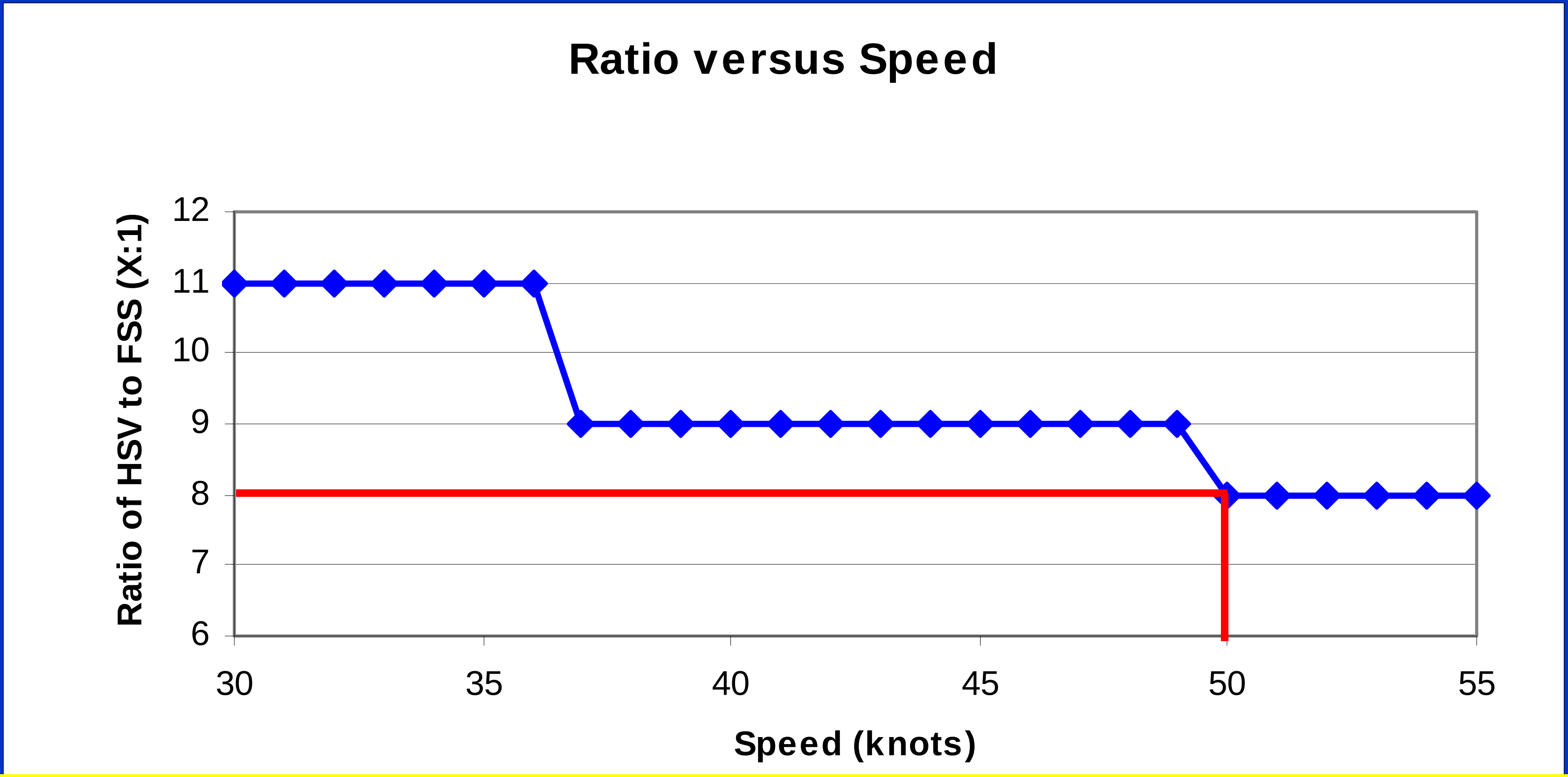
- CONUS to Sea Base
  - Exceeds equal cost by factor of 3.5 to 4

RESULTS OF ANALYSIS

- Recommended Distance for HSV Operation
  - At current cost and performance, HSV can only match or better the performance of FSS at short distances
  - Should be limited to 250 nm runs, until cost can be lowered or performance improved

RESULTS OF ANALYSIS

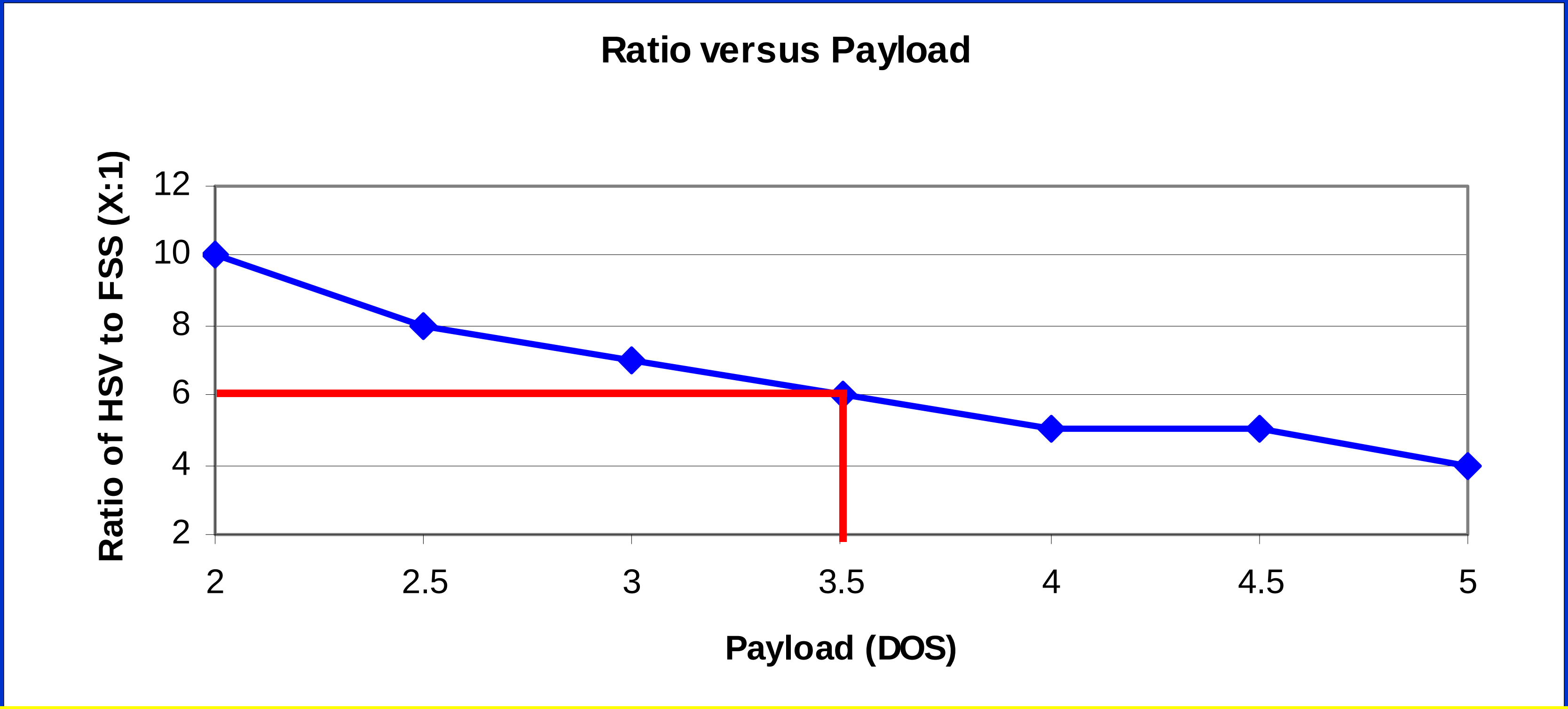
- Recommended HSV Speed (Fixed distance, payload)



- Still requires 8 HSVs to replace a FSS even if speed increased to between 50 to 55 knots

RESULTS OF ANALYSIS

- Recommended HSV Payload (Fixed distance, speed)



- Requires payload of 3.5 DOS per Squadron of HSV to effectively replace a FSS
- Approximately 1.5 times current payload

RESULTS OF ANALYSIS

- Summary of Results

ITEM	RECOM.	REMARKS
Maximum Distance for Re-supply Runs (Speed and Payload fixed)	250 nm	At the lowest possible cost ratio of 7:1
Cost Ratio Required at Various Distances (Speed and Payload fixed)	Varies	Nil
Speed Required to Fulfill Current Cost Ratio of 6:1 (Distance set at 1,765 nm, Payload fixed)	> 55 knots	Cost ratio at 55 knots is 8:1 Higher speeds not investigated
Payload Required to Fulfill Current Cost Ratio of 6:1 (Distance set at 1,765 nm, Speed fixed)	3.5 DOS per Squadron	Approximately 1.5 times of current payload

SPEED CONCLUSION AND RECOMMENDATIONS

- At current cost, speed, and payload, HSV not an effective replacement for FSS for re-supply missions
- To be effective replacement, implement either one of following for future HSV designs
  - Reduce cost of HSV
  - Increase speed of HSV
    - At 1,765 nm, speed required is beyond 55 knots, which may render HSV unstable or significantly reduce its practical payload capability
  - Increase payload of HSV
    - At 1,765 nm, the payload required is approximately 1.5 times the current payload
  - Exact requirements vary according to the distance that the HSV would be utilized for

SPEED CONCLUSION AND RECOMMENDATIONS

- Increasing speed and payload of HSV may bring about associated increase in cost
  - Need to balance between requirements
- At current cost and specifications, HSV is still useful in niche areas
  - Mine Warfare
  - Special Operations
  - Intra-theatre troop lift
  - Casualty evacuation

Excursion Analysis: The Effects of Sea Basing

LTC Loh, RSAF

Implications of the Sea Base

Focus Areas of Analysis:

1. Sea Base Sustainment of Forces Ashore – Using *Extend™*
2. Aerial Throughput of the Sea Base – Using *Excel™ Spreadsheets & ARENA™*
3. Protection Levels for the Sea Base – Using *EINSTein™*

Focus on Results and Significant Findings

Analysis of Sea Base Sustainment of Forces Ashore Using *Extend™*

Examined only the Planned Architecture for the focused areas below:

- Effects of Varying the Distance of the Sea Base Relative to the Objective

  At 58 nm, 108 nm, 158 nm & 208 nm

- Re-supply Options to Sustain Forces Ashore
- MOP:

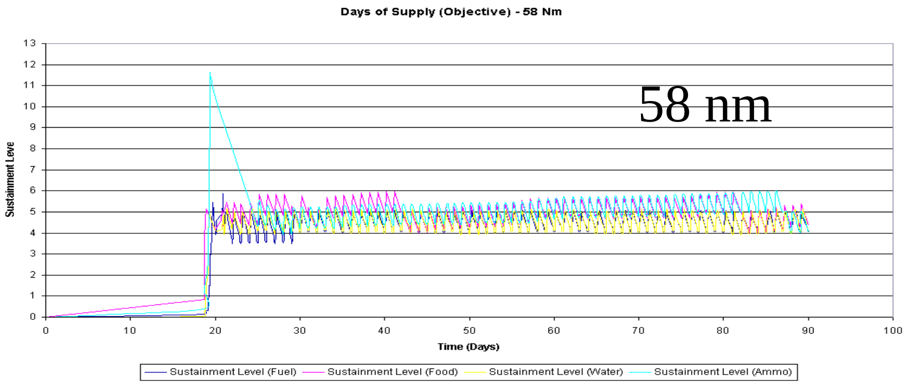
  Time to Build Up 80% of Forces at the Objective

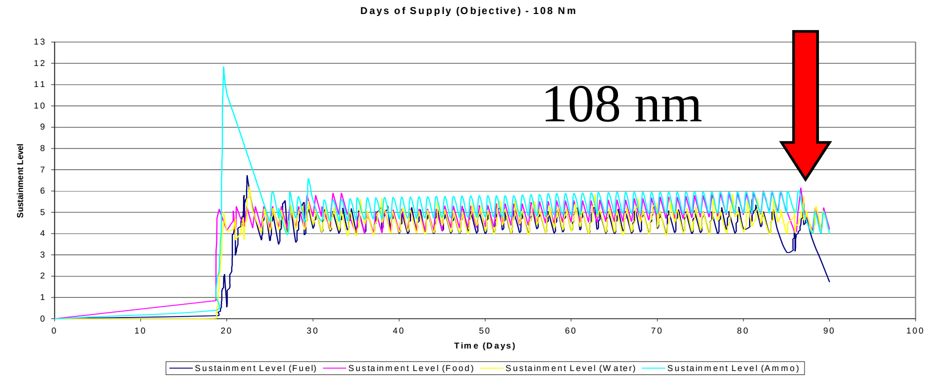
  Days of Supplies (DOS) maintained at the Objective

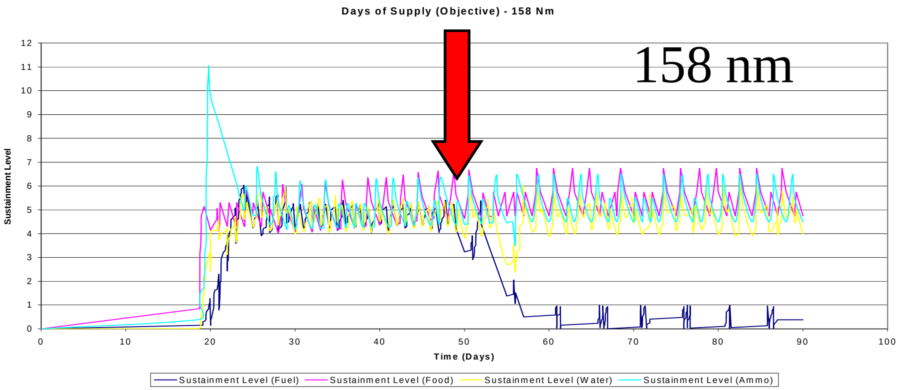
  Mean Square Error (MSE) of DOS maintained at the Sea Base and Objective

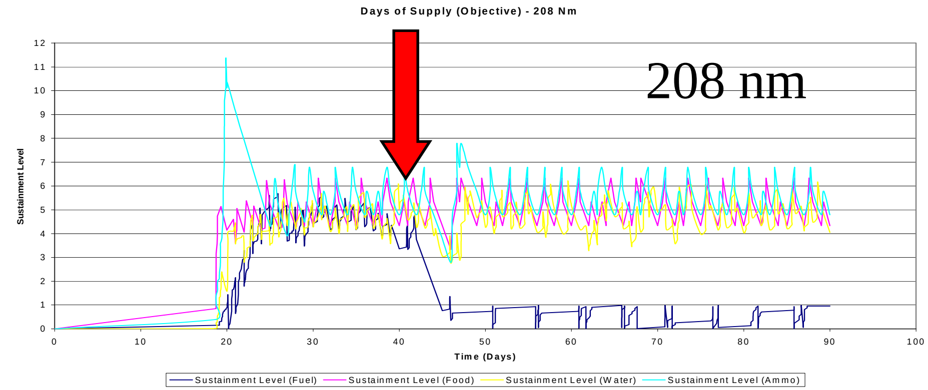
The re-supply of resources to the Sea Base is set as a fixed quantity

DOS Maintained at Objective for Varying Distances









	Distance of Sea Base from Objective			
	58 nm	108 nm	158 nm	208 nm
MSE (days)	0.707	0.784	1.673	1.812
System Fails (Due to Fuel Consumption)	-	65th Day	30th Day	20th Day

Re-supply Options for Sustaining Forces Ashore

	Mean Squared Error of DOS maintained at the Objective	
	Good Weather	**Poor Weather**
50% Air & 50% Sea	**0.784**	**2.824**
0% Air & 100% Sea	**0.957**	**2.877**
75% Air & 25% Sea	**0.737**	**2.847**
100% Air & 0% Sea	***0.677***	***0.777***

Summary of Findings from Analysis Using *Extend*™

1. Distance of the Sea Base to the Objective is critical to the overall sustainment effort.
2. The further the distance the more variability or difficulties in maintaining a desired level of DOS at the objective.
3. Air re-supply is <u>more robust in adverse weather</u> but it is highly dependent on survivability during transit.
4. Air re-supply is <u>more responsive and expedient</u> but it consumes a significant amount of fuel.

Aerial Throughput Study of the Sea Base

Objectives:

- To compare sustainment capabilities of Planned and Conceptual Architectures

  At 25 nm, 55 nm & 250 nm

- To calculate throughput capacity in tons delivered per day for the Conceptual Architecture

  At 225, 250 and 275 nm

- Analyze the Sea Basing replenishment throughput rate of the Aero Designed HLA using the Arena Model.

Comparison Between Planned and Conceptual Aviation Assets' Throughput Capability (Internal Load)

Planned Aviation Assets

Portion of Force Supported	*Tons Needed short tons*	*Number of Personnel*	250 nm	125 nm	55 nm
Full MEF (FWD)	*2,235*	*17,800*	15 percent	34 percent	62 percent
MEF (FWD) less ACE	*848*	*10,460*	40 percent	88 percent	165 percent
MEF (FWD) less ACE and CE	*785*	*9,660*	43 percent	95 percent	178 percent
Landing Force only	*490*	*6,800*	69 percent	153 percent	285 percent

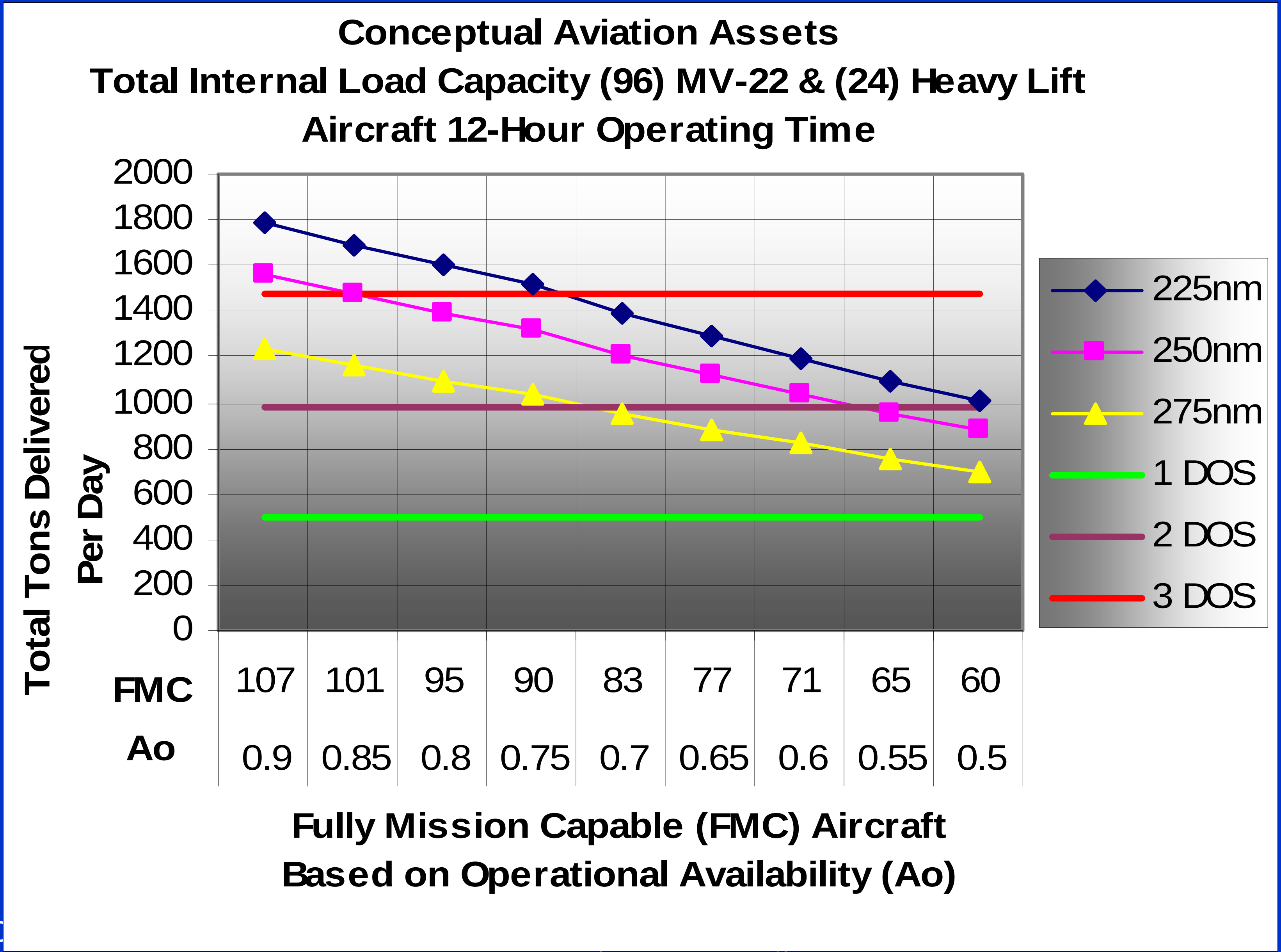
Conceptual Aviation Assets

Portion of Force Supported	*Tons Needed short tons*	*Number of Personnel*	250 nm	125 nm	55 nm
Full MEF (FWD)	*2,235*	*17,800*	49 percent	100 percent	172 percent
MEF (FWD) less ACE	*848*	*10,460*	128 percent	264 percent	454 percent
MEF (FWD) less ACE and CE	*785*	*9,660*	138 percent	285 percent	490 percent
Landing Force only	*490*	*6,800*	221 percent	456 percent	785 percent

(Based on 10-Hour Fight Day; Operational Availability of .75 for MV-22, and HLA and .7 for CH-53E)

Planned Assets: 36 MV-22 and 8 CH-53; Conceptual Assets: 96 MV-22 & 24 HLA

Throughput Capability of the Conceptual Aviation Assets



ARENA™ Model Analysis on the HLA

	Recommended Minimum No. of HLA Required	
Distance	Internal	External
225 nm	13	20
250 nm	15	20
275 nm	17	23

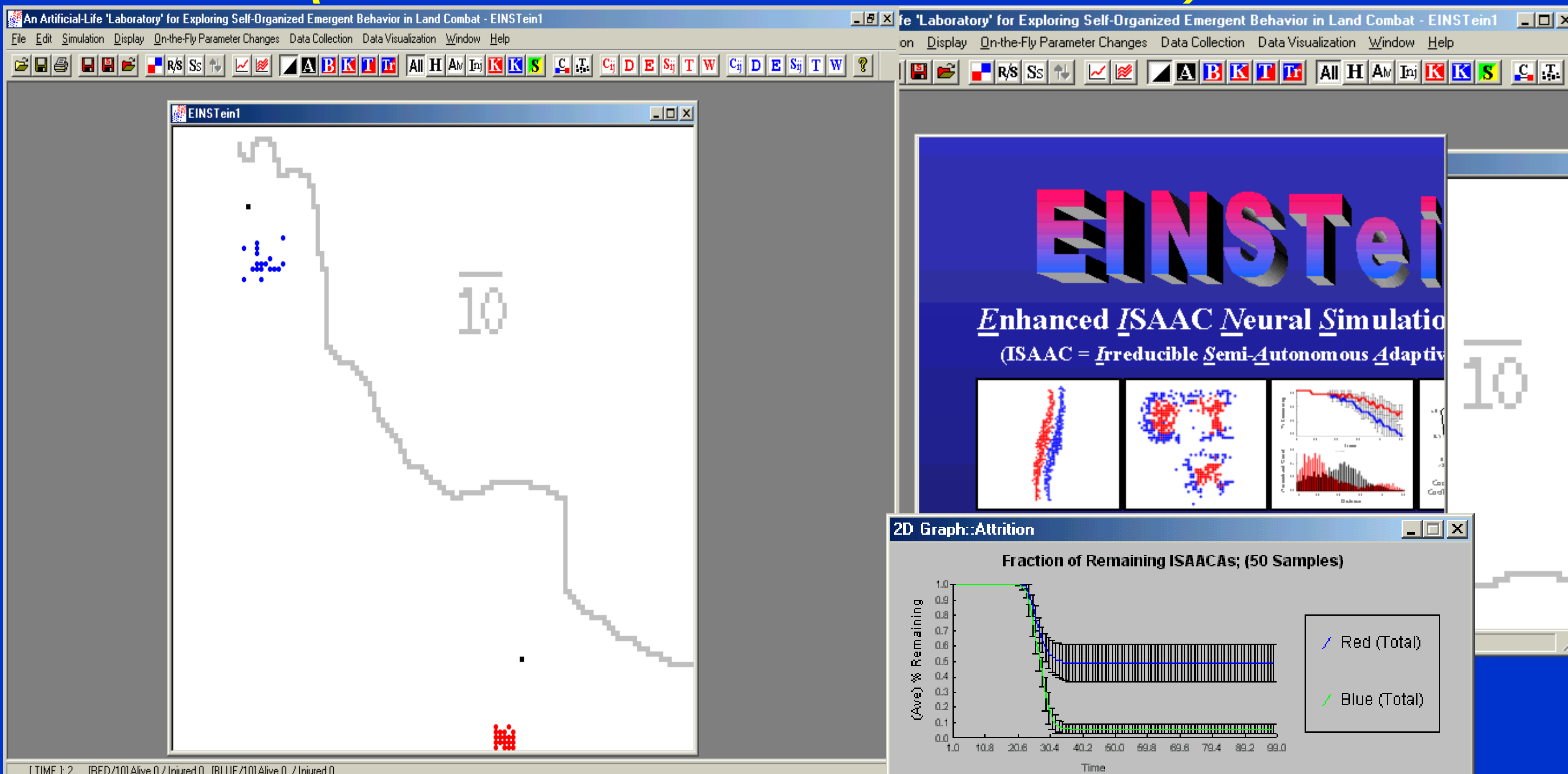
Based on 12-hour Operating Time flight day

Findings From Aerial Throughput Study

1. Planned Aviation Assets cannot meet sustainment needs of a MEB beyond 175 nm.
2. Conceptual with 24 HLAs and 96 MV-22s operating from the X-ships can surge and sustain MEB up to 275 nm from the Sea Base.
3. Conceptual aerial throughput capability has a surge capacity of 4 times the daily sustainment requirements at 225nm; 3 times at 250nm and 2 times at 275nm (12-Hour Operating Time).
4. Conceptual Architecture can accept up to 50% attrition or diversion of assets to other missions and still sustain a MEB ashore up to 275 nm daily (Ao = .75).

Protection of the Sea Base Exploratory Investigation Using *EINSTein*™

(Enhanced ISAAC Neural Simulation Toolkit)



An artificial-life laboratory for exploring self-organized emergence in land combat Written by Andrew Ilachinski and modified by Greg Cox of CNA for use in maritime warfare.

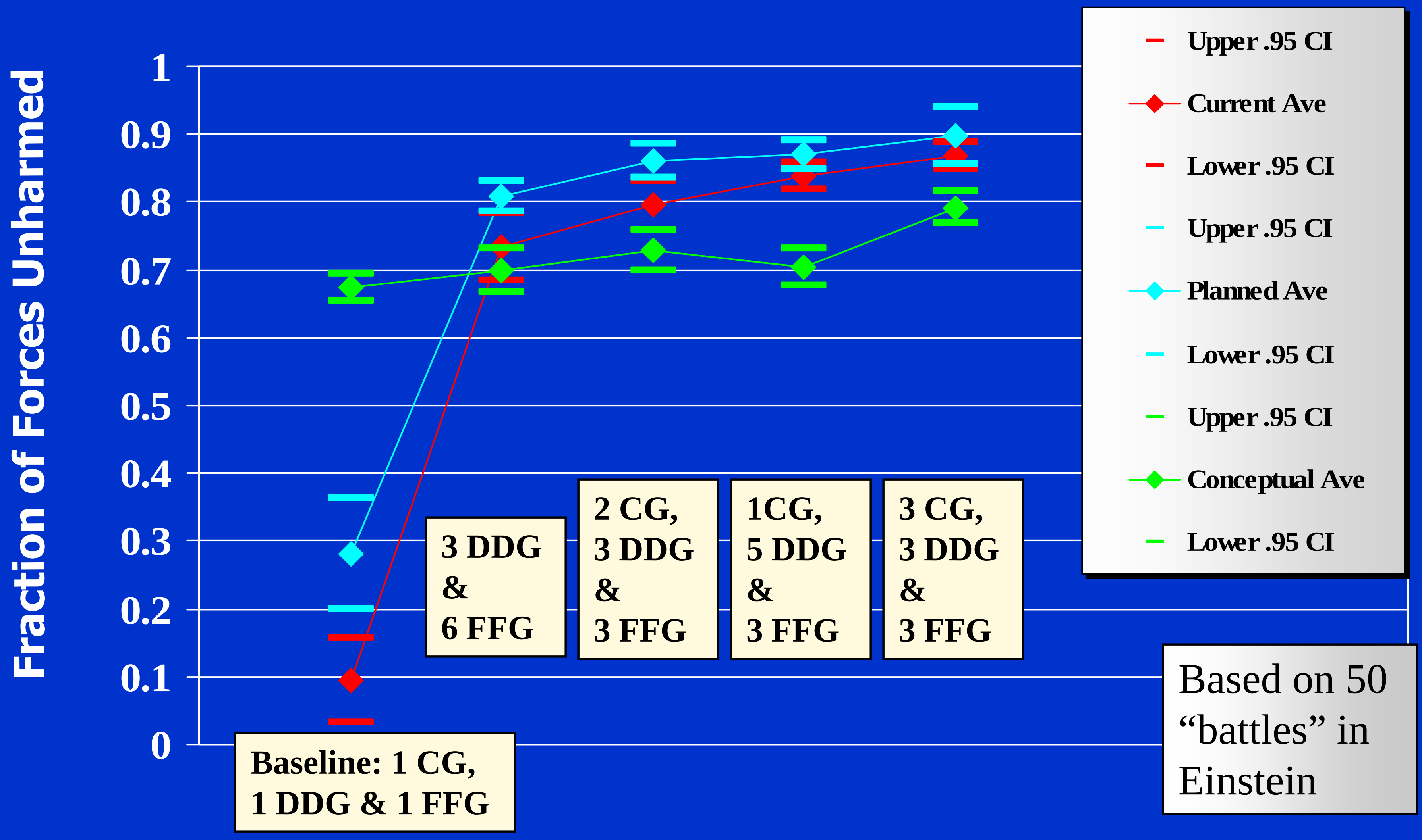
Model Inputs

- Context: Burma Scenario (2018).
- Potential defense assets include CG, DDG, FFG, and future LCS.
- Threat: Sea and land based surface threats (air and undersea not examined)
- Enemy: 18 enemy combatant ships (10 missile patrol craft + 8 FFG type ships).
- Each ship is given "attributes" that describes its mission, capabilities, and aggressiveness
- Current, Planned and Conceptual architectures' collection of ships created

MOE and Baseline

- The Measure of Effectiveness explored:
  - % of ExWar Task Force Alive (including escorts)
    - Based on 50 battle runs
- Goal:
  - Above 80% of Task Force ships alive.
  - Mission capable after an enemy missile task force attack (Unharmed)
- Baseline:
  - Escorted by 1 CG, 1 DDG & 1 FFG
- Approach:
  - Incremental increase of CG, DDG, FFG or LCS to achieve MOE

Comparison of Various Architecture's Protection Force Structure Options That Approach Goal of Above 80% ExWar Task Force Unharmed



Findings From EINSTein™ Simulations

- **Conceptual did not perform better than Current or Planned in terms of survivability.**
- **Less distributed Sea Base becomes less survivable.**
- **Mobile land-based ASCMs (Anti-Ship Cruise Missile) pose a threat to the Sea Base.**
- **The defense capabilities of the ships need to be increased.**
- **The simulations indicate the MOE for the Conceptual Architecture can be achieved with 16 LCS; 3CG, 3DDG and 3 FFG; or 3 DDG and 12 LCS.**

A Very Rough Order Equal Capability Equation for Anti-Surface Warfare: 1 CG, 1 DDG, and 1 FFG = 5 to 6 LCS

Conclusions on the Excursion Study on the Implications of the Sea Base

Conceptual Architecture allows Sea-Basing and STOM to be viable up to 275nm. But it is dependent on aerial throughput.

Additional MV-22s and HLAs are required to surge and sustain up to a MEB ashore.

Sea Base and Logistics Ships require enhanced self-protection.

Excursion Analysis: The Impact of Reduced Footprint Ashore

LTC Loh, RSAF

Reducing Footprint Ashore

The Study examined the following areas:

1. Reducing Weight of Equipment or Resource Consumption Rates
2. Reducing Troops Ashore
3. Increasing Reliability of Equipment

Reducing Weight of Equipment or Resource Consumption

Leveraging on Technology

1. Fuel efficient generators & engines for land platforms
2. Reduce spare consumption
3. Develop modular components that when assembled make-up the equivalent of the heavy tank and equivalent AFV
   - E.g. Add-on armor; efficient space-saving equipment designs.
4. Use of lighter composite materials
5. Water recycling, purification and harnessing kits

Reducing Troops Ashore

1. Down size physical troops required ashore possible by enhancing associated weapon capabilities and improving remote stand-off precision firepower
2. Remote C2 and Logistics Elements to Sea Base
3. Exploit unmanned assets

Portion of Force Supported	***Personnel***	***Daily Requirements (Tons)***
Full MEB	17,800	2235
MEB less ACE	10,460	848
MEB less ACE and CE	9660	785
Landing Force only	6800	490

Impact of Increasing Reliability (Using HMMWV ARENA™ Model)

Scenario	Tow Truck	Maintenance Personnel	MTBM	Average FMC
Baseline	3	8	(16,20,24)	71
Embellishment 1	6	8	(16,20,24)	72
Embellishment 2	3	16	(16,20,24)	85
Embellishment 3	6	16	(16,20,24)	85
Embellishment 4	3	8	(32,40,48)	89
Note: Mean Time Between Maintenance (MTBM) is a triangle distribution in hours minimum, most likely, maximum)				

Operational Availability

$$A_o = \frac{\textbf{Mean Time Btw Failure (MTBM)}}{\textbf{MTBM + Maintenance Down Time (MDT)}}$$

Conclusion on Reducing Footprint Ashore

- **Lighter and more resource efficient equipment**
- **Less equipment**
- **Less troops**
- **Less consumption**
- **The less glamorous but significantly crucial factor**

Reliability and Availability of Equipment!

Excursion Analysis: The Effect of Reduced Manning

LT Alvarez, USN

Reduced Manning

DEPARTMENT	LHA	LHD	EXWAR	APPLIED TECHNOLOGIES
Engineering	189	207	82	Electrive Drive Integrated Power System
Supply & Logistics	139	199	95	Automatic tracking no-load off-load system Advanced Weapons Elevators Linear Inductor Motor Conveyor Belts Automated Magazines
Air	162	165	74	Robotics (Fighter fighting and fueling systems)

TOTAL MANNING	**1118**	**1179**	**724**

Reduced Manning

BENEFITS	LHA	LHD	EXWAR
Crew volume / Cargo Capacity	1.84	2.26	0.15
Manning Cost per year	$95.5 M	$90.0 M	$55.5 M

ExWar ships carry considerably more cargo than current platforms

Conclusions

CDR Erhardt, USN

STOM Conclusions

- STOM is a viable operational concept, given a suitable force architecture
- Analysis results show that in order to conduct STOM:
  - Sufficient aerial throughput is essential in order to seize long range objectives
  - Need highly survivable transport aircraft to maintain the throughput
  - Need to plan for increased fuel consumption
  - Need capability for wide area surveillance and targeting

Sea Basing Conclusions

- The Sea Base concept is capable of achieving the throughput required to sustain a brigade size force ashore, given a suitable force architecture
- The Planned architecture, *under good weather conditions*, is able to sustain the Objective through the Sea Base as well as the Current architecture via the Iron Mountain
- Need capability to quickly deliver combat power to theater

Sea Basing Conclusions

- As the distance to the objective increases, however, fuel consumption markedly increases and must be taken into account in planning factors
- Need a robust organic MCM capability
  - Manned and unmanned

Planned Architecture Conclusions

- While the programs of record provide a level of STOM capability, this capability could be further enhanced by the addition of specifically designed air and surface craft
- Conceptual architecture projects the forces ashore in the shortest time
- While they are capable of inserting the force, Planned architecture aviation assets are not able to meet the Sustainment (vice insertion) needs of a MEB size force adequately from the Sea Base beyond 175 nm.

Planned Architecture Conclusions

- The reduction of footprint ashore requires :
  - Lighter and More Resource Efficient Equipment
  - Less Equipment
  - Less Troops
  - Less Consumption
  - *High Reliability*

Additional Conclusions

- The Current architecture, with the Iron Mountain, is the most robust in sustaining the Objective, if you can accept the accompanying operational pause
- Although there are potential roles for the HSV, at the current cost, speed, and payload it is not an effective replacement for a conventional FSS for re-supply missions

Additional Conclusions

- The reduction in the number of ships between the Planned and Conceptual architectures results in a less distributed, and therefore more vulnerable, Sea Base without a corresponding increase in self defense capability over Planned Sea Base ships

The Systems Engineering and Integration Team

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• MAJ Ong Hoon Hong	SAF	Combat Engineer
• LT John Stallcop	USN	Submariner
• LT Luis Alvarez	USN	SWO
• CPT Lau Hui Boon	SAF	Guards
• LT Matt Steeno	USN	SWO
• CPT Tan Choo Thye	SAF	Armor

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Questions?

A copy of our Final Report will be available in January at www.nps.navy.mil/sea/exwar/