GENERAL DYNAMICS
Armament Systems

Material Movement and Management (M^3) Technologies

High Volume Automated Naval Magazines

Objective

To introduce the burdens, compromises and performance interrelationships that govern the design of high volume automated naval magazines

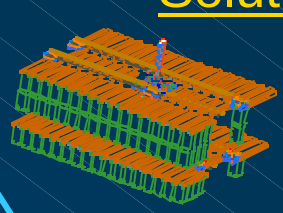
Agenda

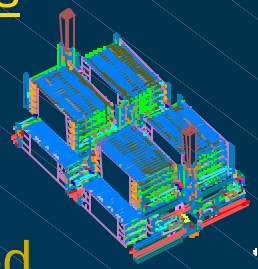
- Naval Trends
- Technical Solutions
- Technical Interactions and Relationships
- Conclusions

Emerging Requirements

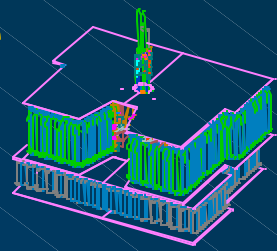
Requirements	Technical Impact
Volume of Fire	Large Magazines
	High Rates of Fire
	Multi-Mission Capable
Lethality	Electronic Fuzing
	High Accuracy
	Long Range
Cost Effectiveness	Low Mission Cost
	Low Operational Cost
	Integrated System
Reduced Manning	Easy repair
	Redundancy
	High Reliability
	Automation

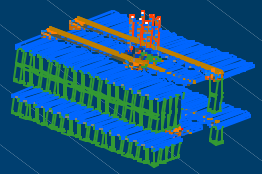
Solutions

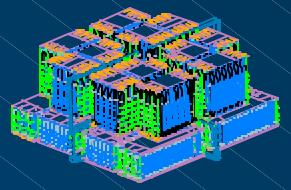




Automated Magazine Systems







Balanced within the context of Navy Environment

Shock

EMI

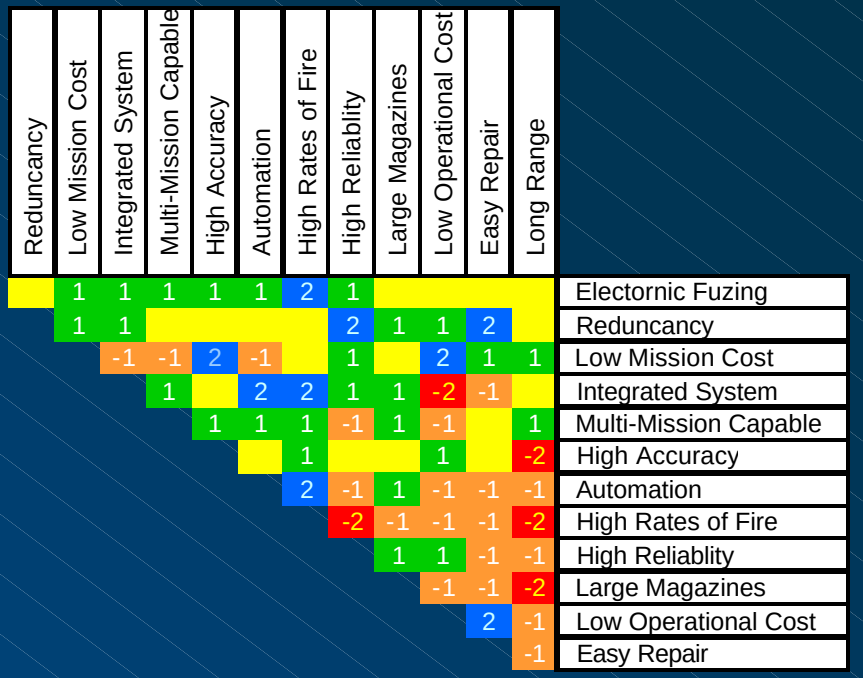
Salt Fog

Ship Motion

Insensitive Munitions

Requirement Compromises

- Large systems have unique issues
  - ➢Multiple round types
    - Typically between 2 to 20 different ammunition / propellant variants
    - Common interface is rare
  - ➢Installation complexity
    - Complexity increases proportional to magazine size
    - Munitions hand-offs increase in number

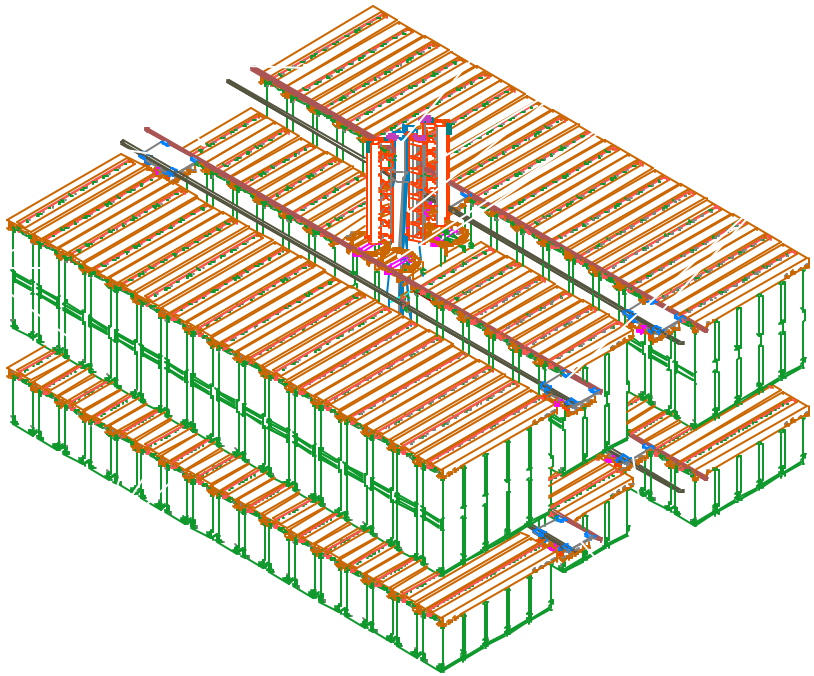


Requirements are also not complementary

Developed Systems

Indicates System Capacity (tons log scale)

Magazine Solutions – Passive Systems



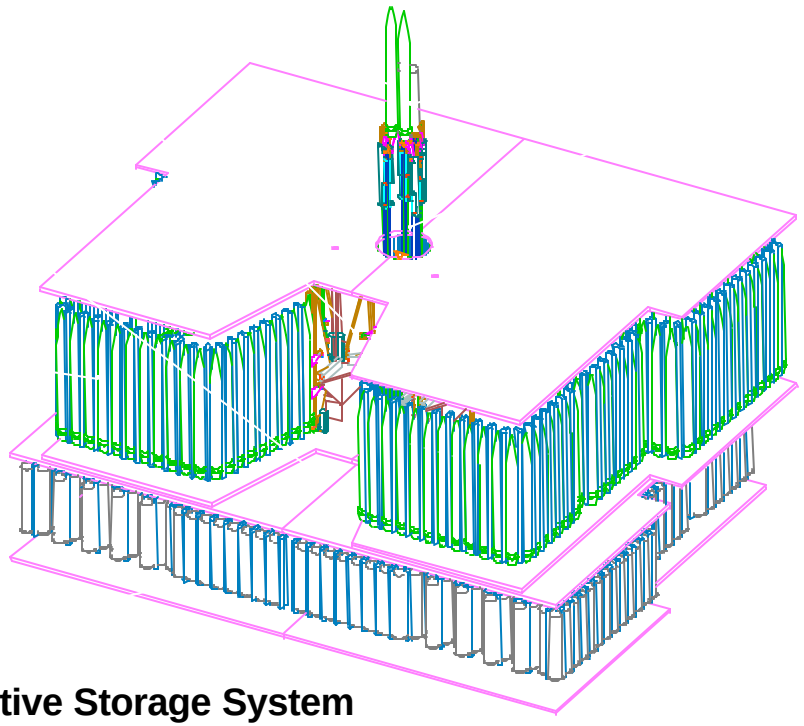
Passive Storage System

- Advantages
  - Low power
  - Reliable storage
  - Low cost
  - Easily repairable
  - Manually operational
  - Accessible
- Disadvantages
  - Low feed rates
  - Storage density versus selectability
  - Packaging efficiency
  - Mechanism Coordination

Definition:
One munitions set (projectile and propellant) is moved at a time

Note: AGS Phase I, Core developed, Non-competition sensitive AGS design efforts displayed

Magazine Solutions - Active



Active Storage System

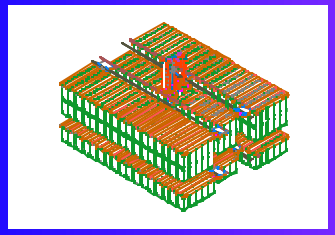
Definition:
All munitions move simultaneously

- Advantages
  - Reliable Storage
    - Yet less redundant
  - High feed rates
  - Simple orchestration
  - Flexible configuration
  - Selectability
- Disadvantages
  - Packaging Density
  - High Power Demand
  - Difficult to maintain
  - Cost efficiency

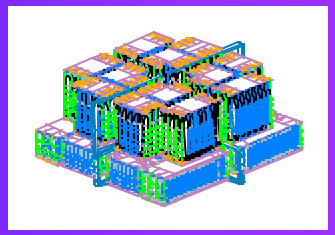
Note: AGS Phase I, Core developed, Non-competition sensitive AGS design efforts displayed

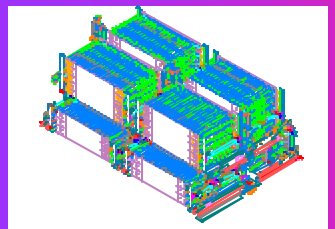
Magazine Solutions - Hybrids

Solutions

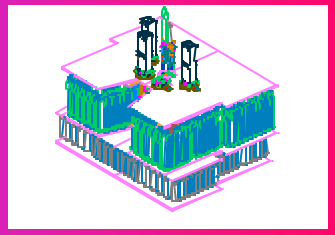


Passive Systems





Hybrids

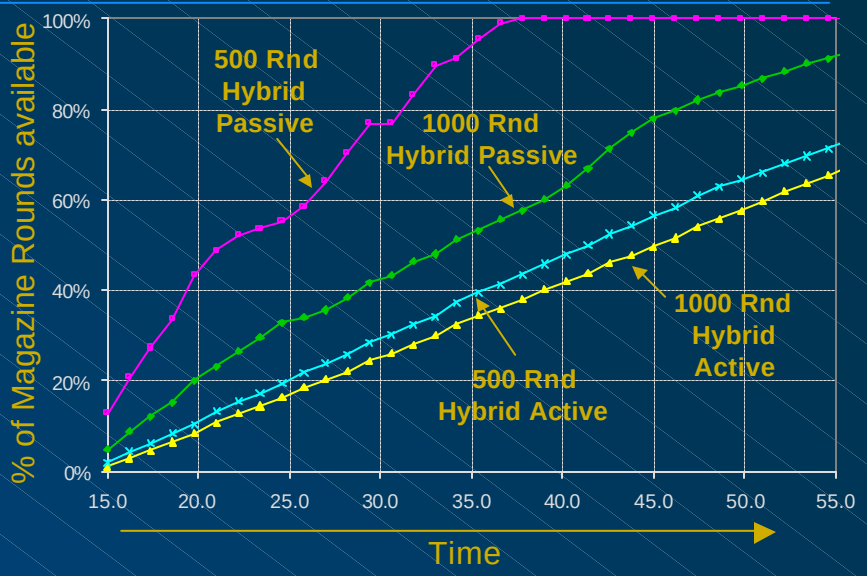


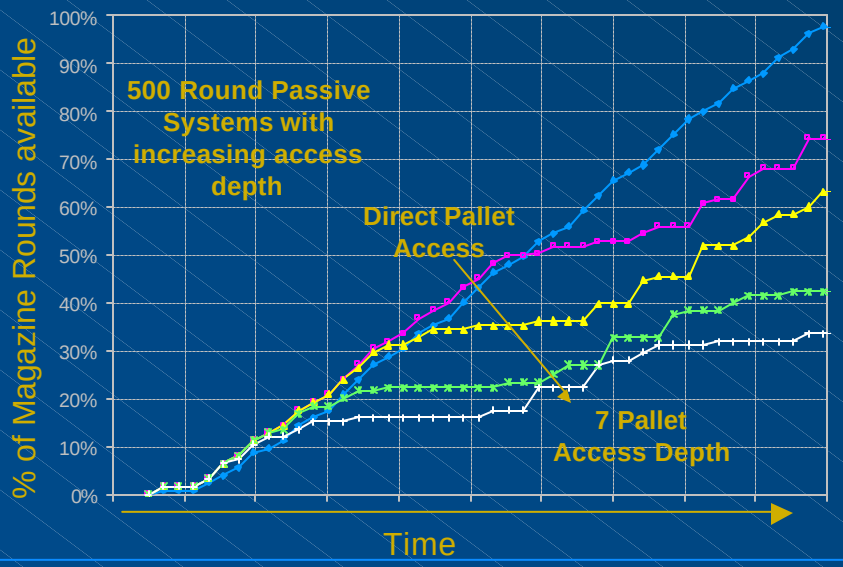
Active Systems

	A Single Munitions set Moves	A few Munitions sets Move	~half of Munitions sets Move	More than half Munitions sets Move	All Munitions sets Moves
Selectability	↑↓	↔↑	↔	↔↑	↔
Reliability	↓	↑	↑	↑	↓
Power / Rate of Fire	↑	↑	↔	↓	↓
Storage Density	↔↓	↔↓	↔	↑	↑

Selectability: Size and Packaging

The greater the capacity: The slower a possible round selection

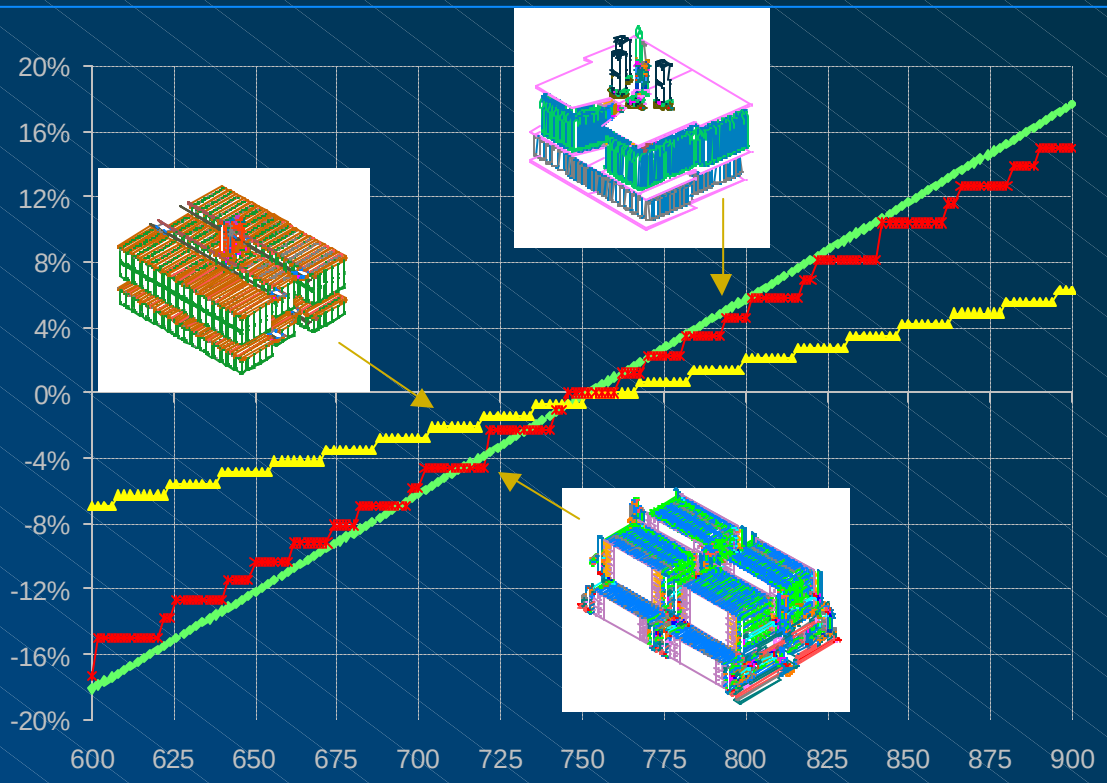




The greater the number of independent storage cells: The faster the round selection

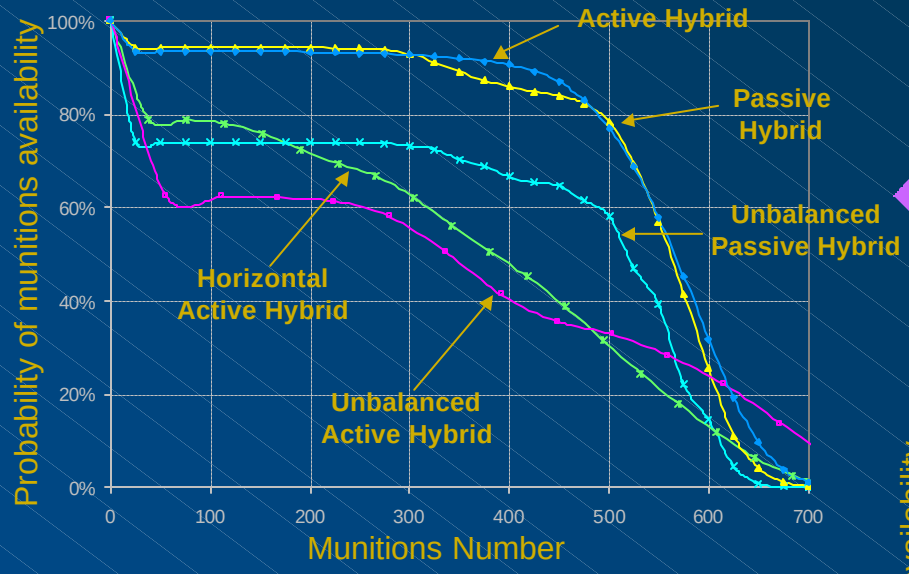
Analysis – Cost vs. Capacity

- Cost efficiency is dependent on magazine technology
  - ➢ Passive systems:
    - Small change in cost vs capacity
    - Base price is large
  - ➢ Active Systems:
    - Moderate change in cost vs capacity
    - Base price is low
  - ➢ Hybrid Systems are a compromise between these two



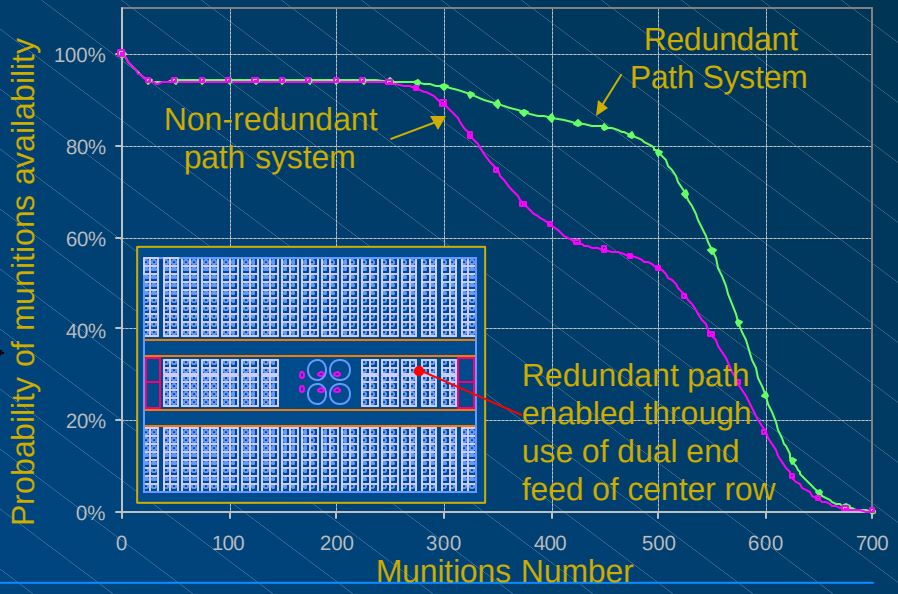
The cost efficiency of a technology will depend on the capacity required

Analysis – Reliability at capacity

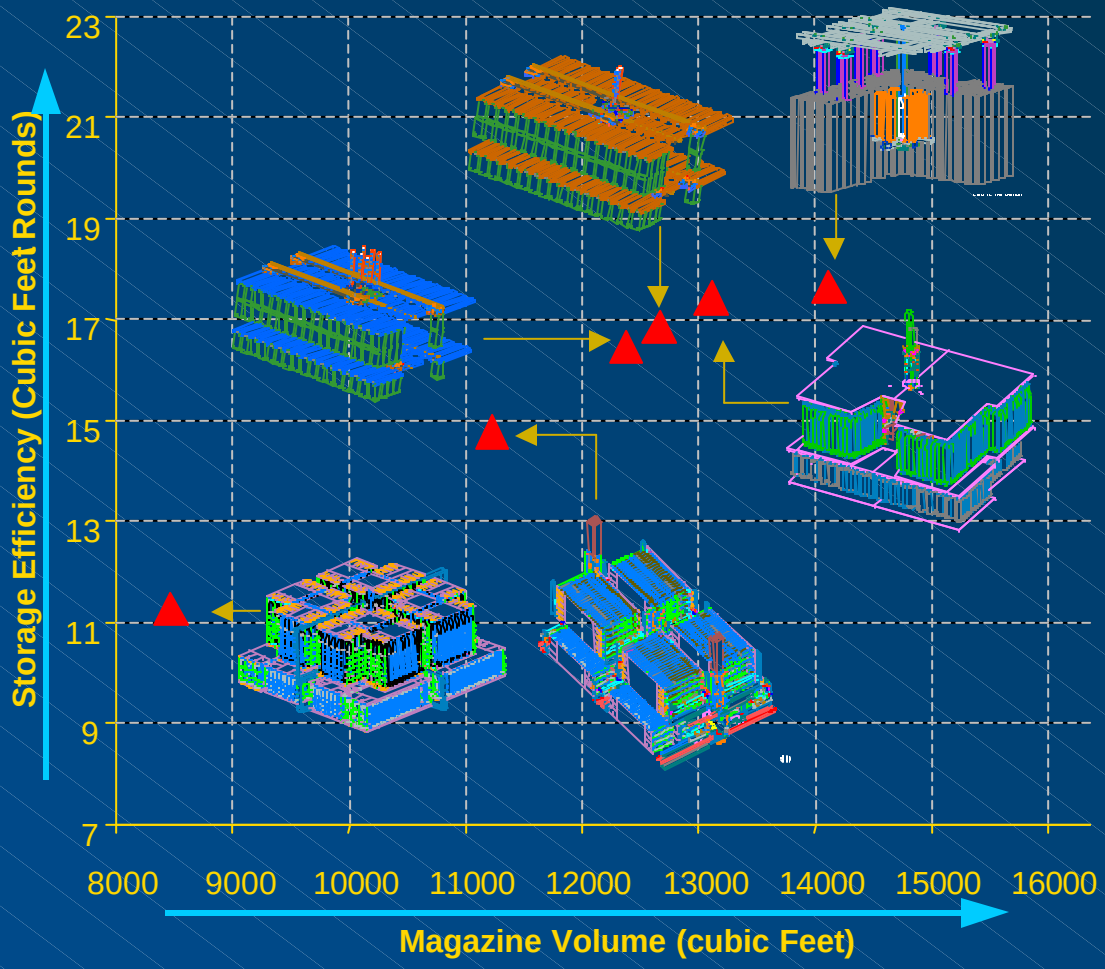


Active and passive hybrids may achieve the same reliability when storage and transfer rates are balanced

Redundant paths augment a system's reliability



Storage Efficiency and Magazine Volume



- A linear relationship exists between magazine weight and volume
- Active magazine technologies possess the highest storage efficiency

Conclusion

Magazine designs need to fit the requirements of a system

Appropriate Technology

Optimum Packaging

Acceptable Reliability

Desired Selectability

The Right Cost

The Best Solution for the Job