Advanced Logistics Delivery System

Original Concept by Carderock Innovation Center

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Industry Contacts

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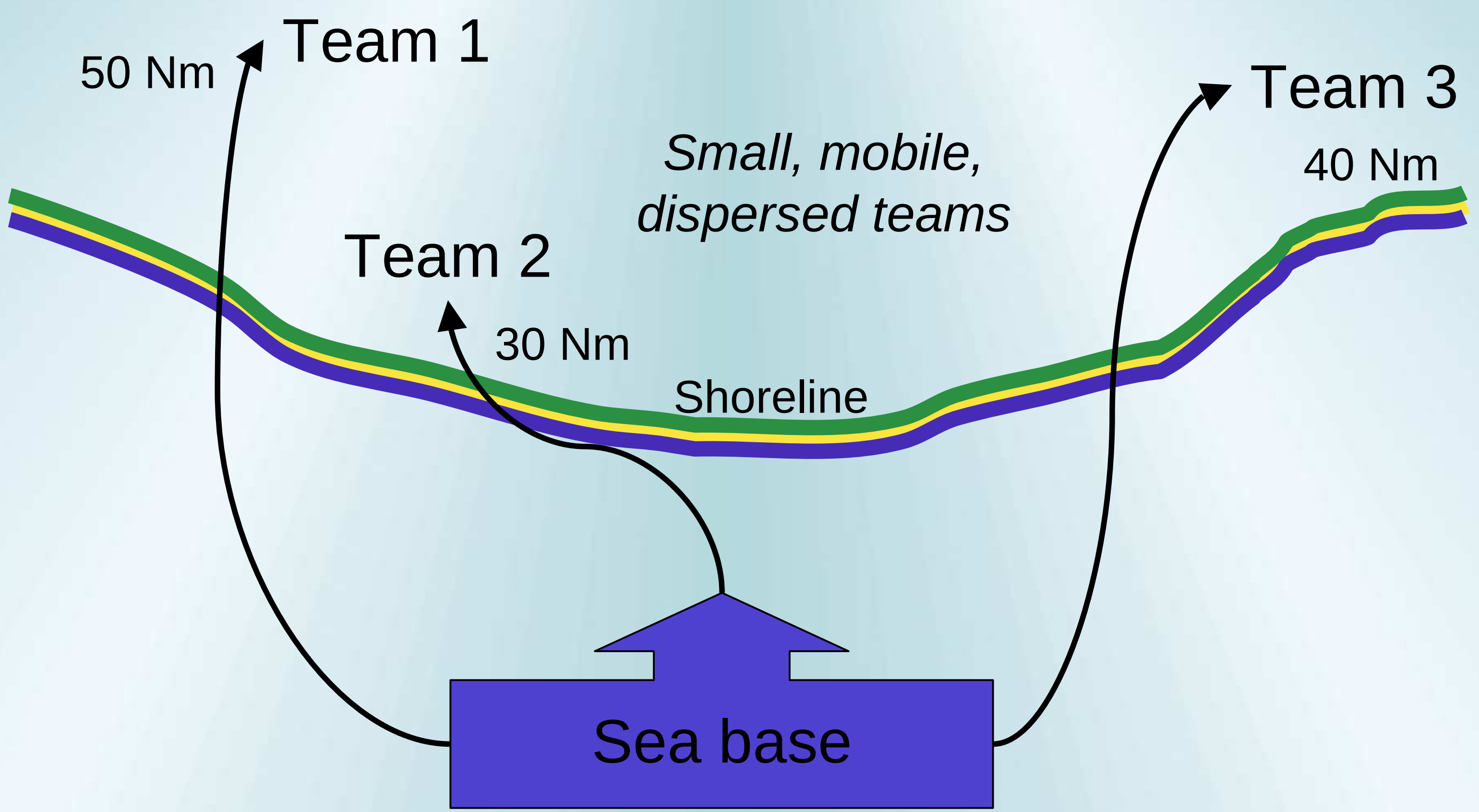
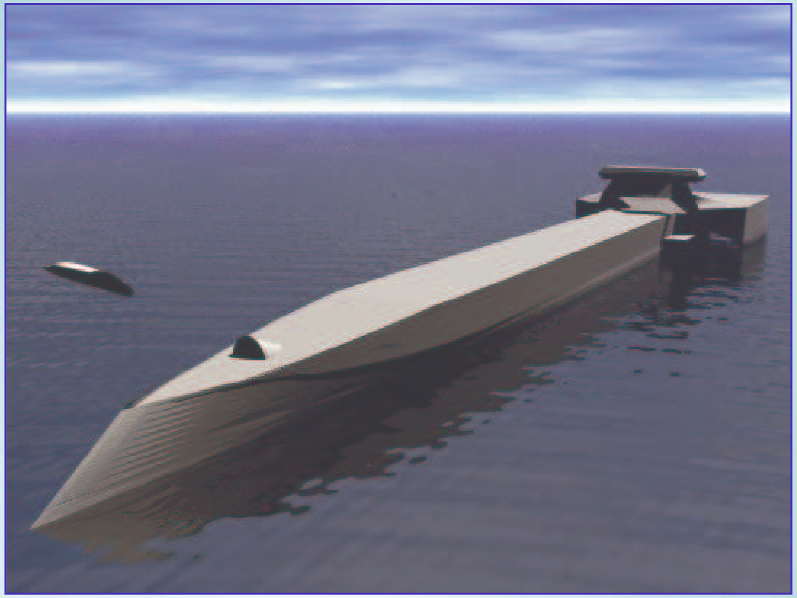
Vertigo Inc.

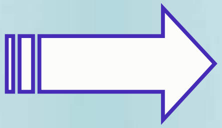
General Atomics and Affiliated Companies

Logistics Requirement ~ 75 tons/day (dry cargo)



Advanced Logistics Delivery System





- Payload = 1,000 lbs
- Basic Range = 50 miles
- Launch speed = 500 knots
- Required acceleration = 30g

Agenda

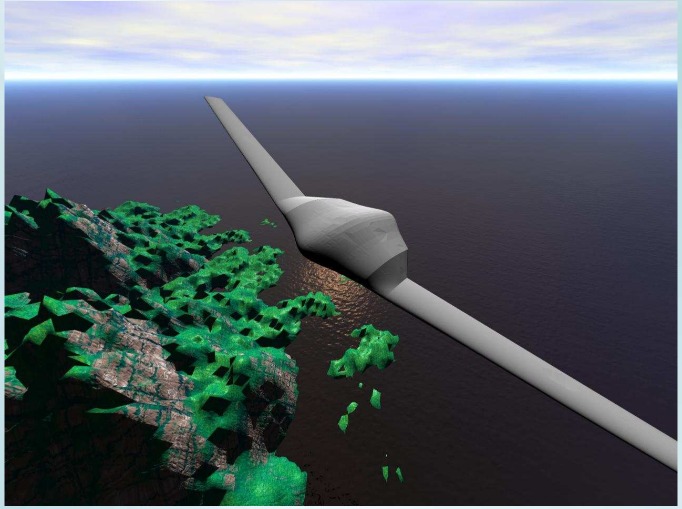
- Objectives
- Advanced Logistics Delivery System
    I. Glider/ Inflatable Wings
    II. Launch Ship
    III. Mechanical Launch System
- Summary
- Conclusion

Center for Innovation in Ship Design

Knowledge People Innovation

Objectives

- Develop a conceptual design for the glider.
- Investigate inflatable wing technology.
- Identify the operational use of ALDS.
- Develop a trimaran ship design.
- Investigate a ship based launch mechanism.



Sponsor

Office of Naval Research

Deliverables

A final report:

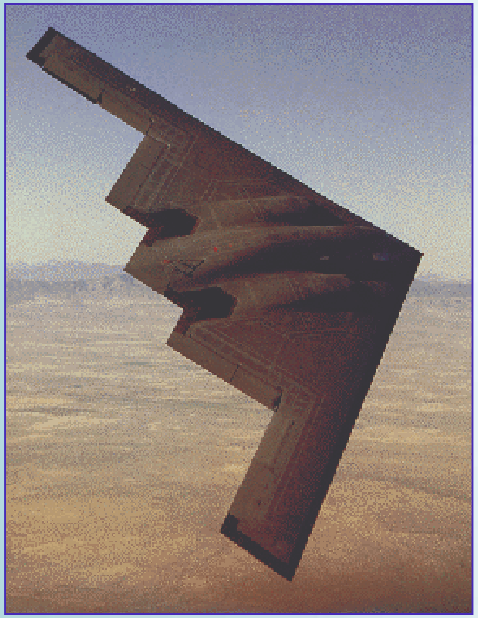
1. Feasible glider concept.
2. A ship based mechanical launch system.
3. Summary of current inflatable wing technology.
4. Mission profile & operational envelope of ALDS.
5. Launch ship design.

Part I
Unmanned Glider / Inflatable Wing Technology

Tailless Aircraft & Flying Wings

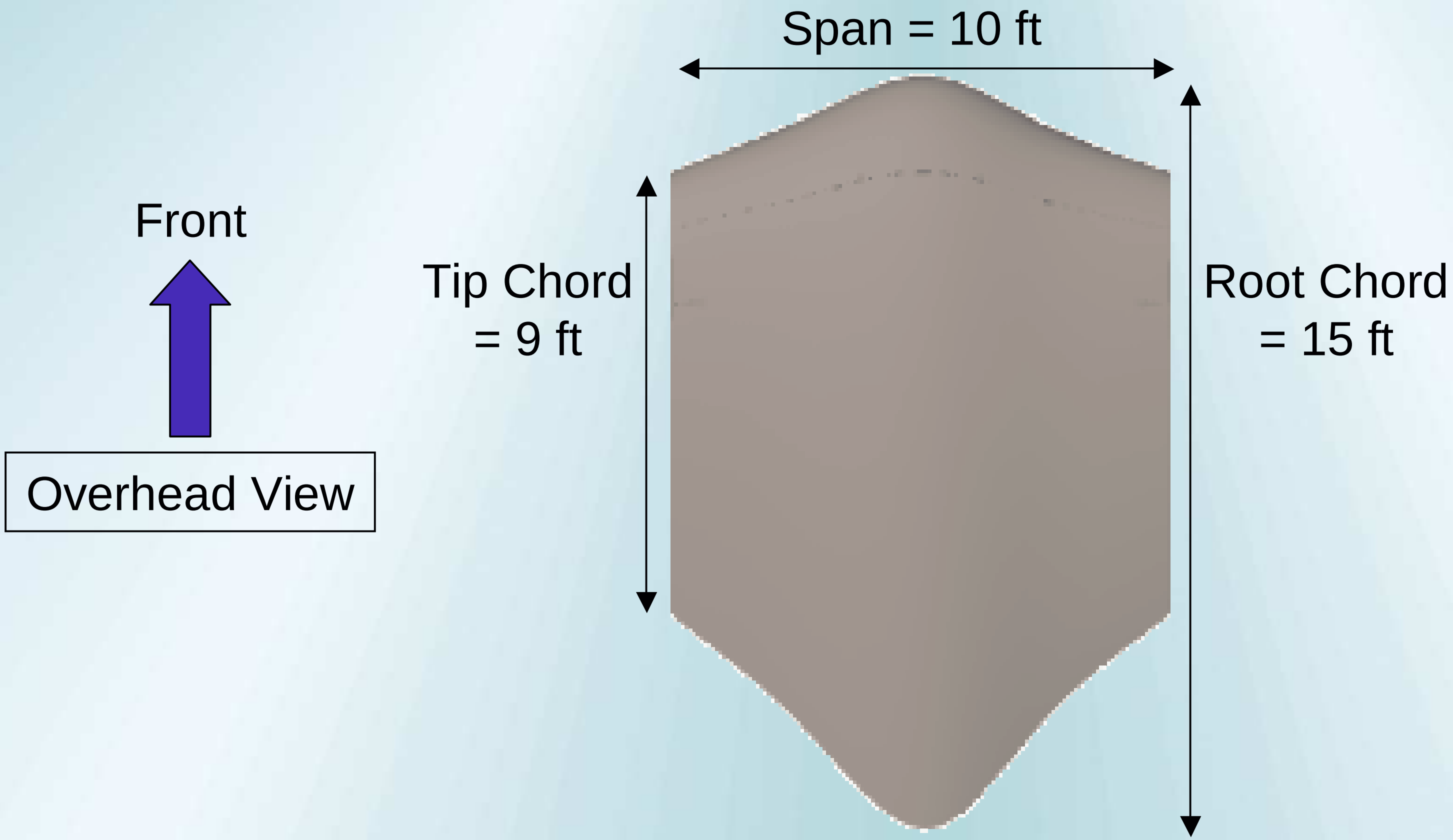
Advantages of Flying Wings
- Increased Performance
- Easier to Assemble
- Less Structure

Issues with Flying Wings
- Stability
- Trim
- Controls



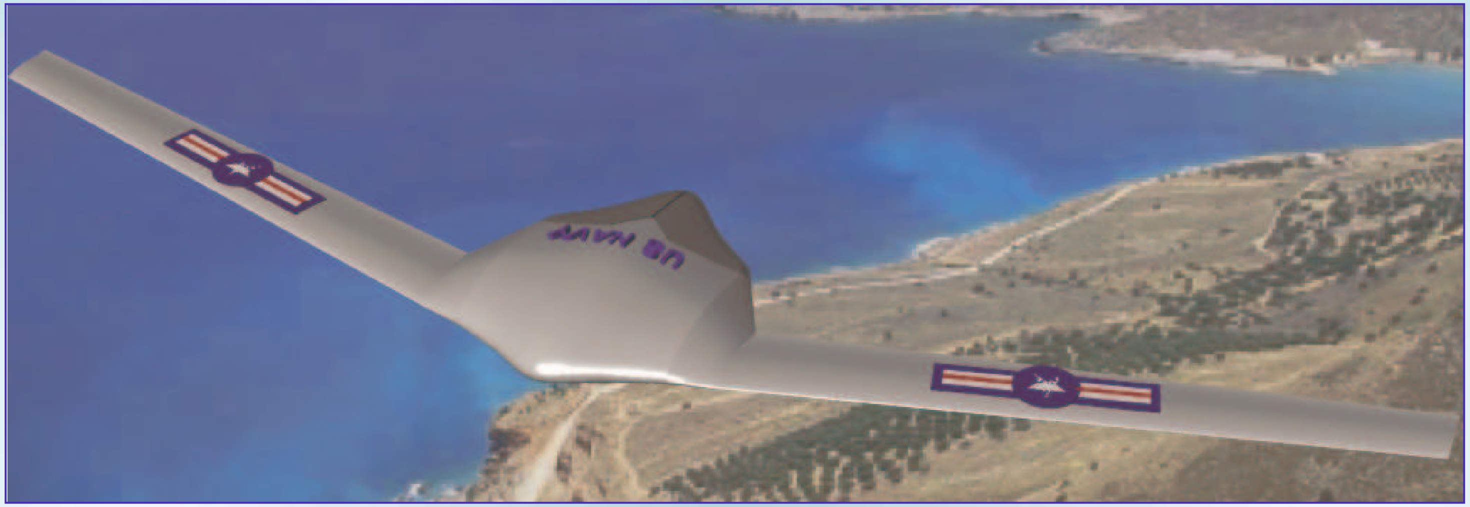
Launch Vehicle: Centerbody

The centerbody is launched from a dedicated launch ship at a speed of 500 knots with an acceleration of 30g's.



Glide Body

At the apogee of its flight, the Centerbody deploys inflatable wings and becomes a flying wing glider



Specifications

Wing Span = 70ft
Gross Takeoff Weight = 1500lbs
Glide Ratio = 33
Cruise Speed = 60kts

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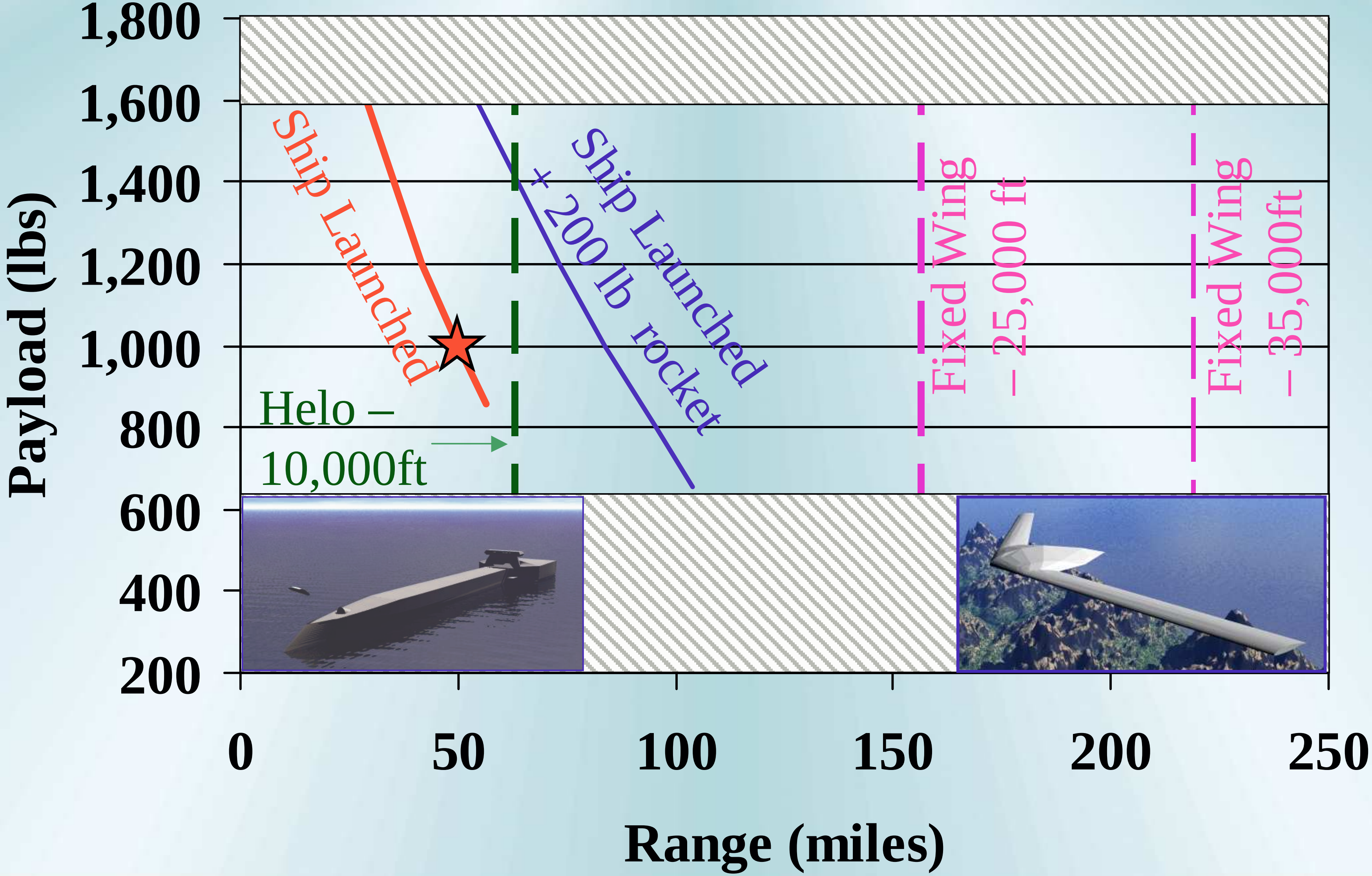
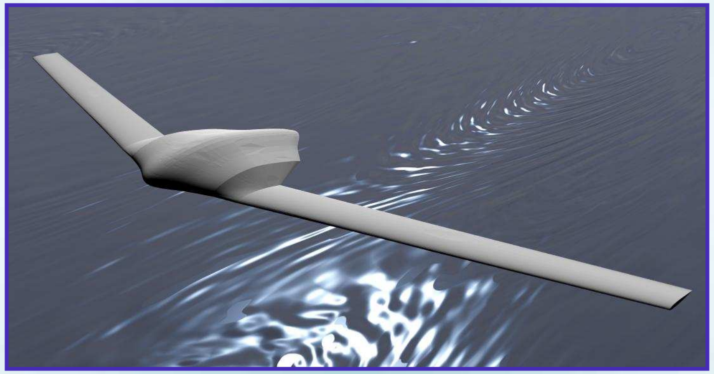
Performance Range v. Payload



Other Logistics Delivery Systems



ALDS (Ship Launch or Air Drop)

Snowgoose
(Air Drop)

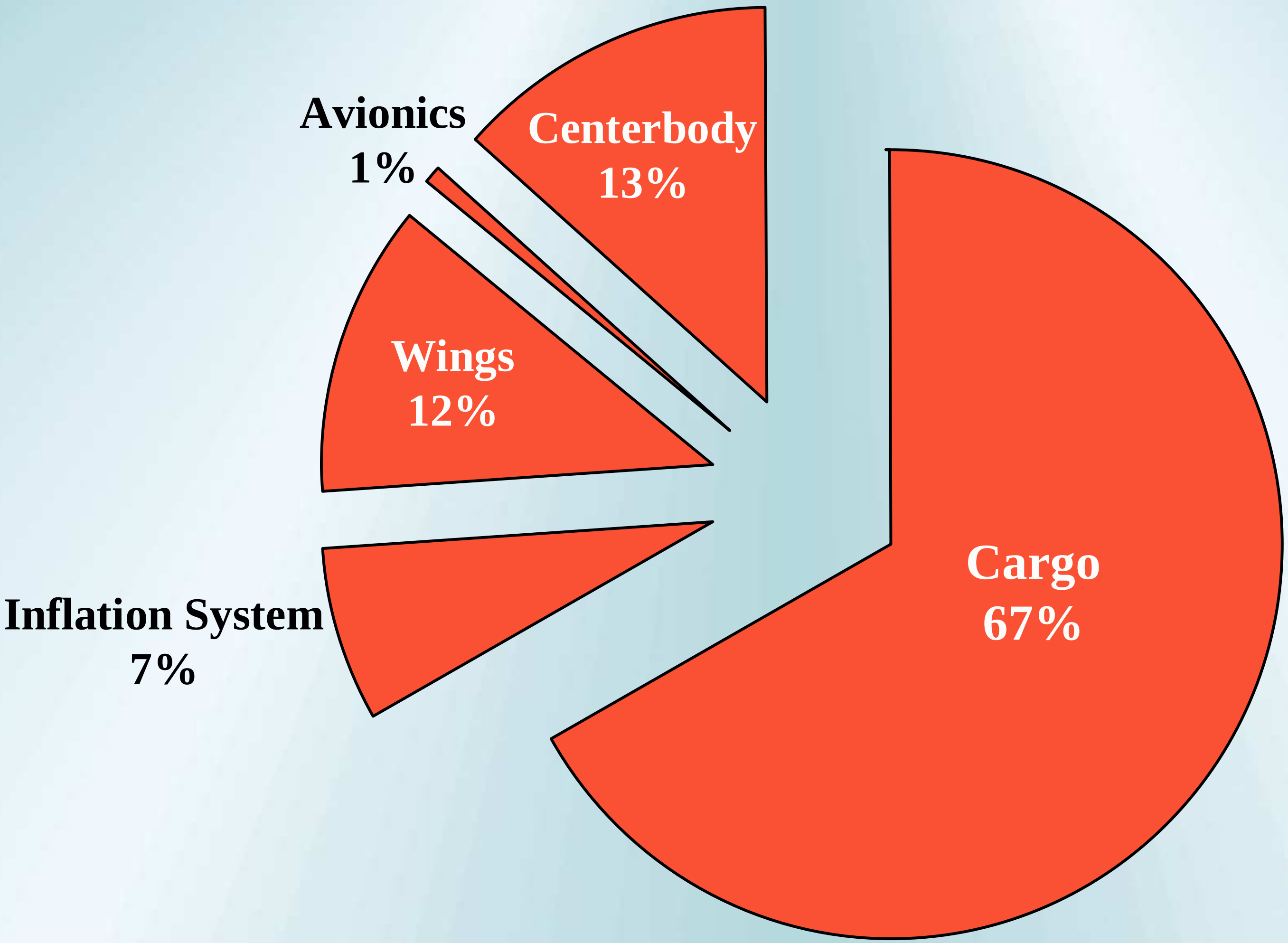
ERADS
(Air Drop)

SRDW
(Air Drop)

GPADS
(Air Drop)

Inflatable Wing Aircraft

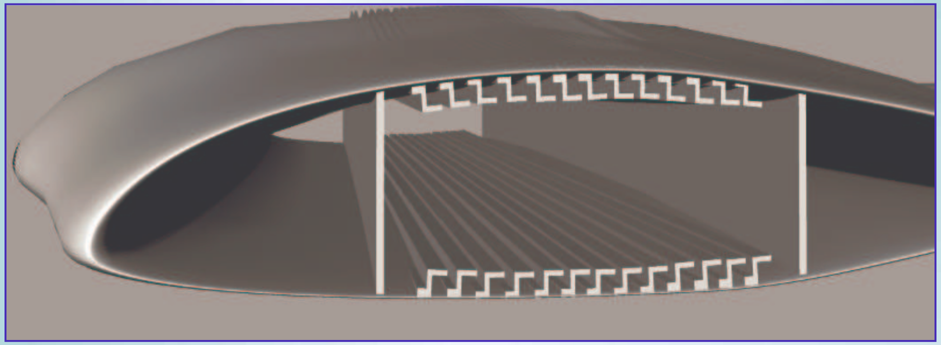
Glider System Weight Breakdown

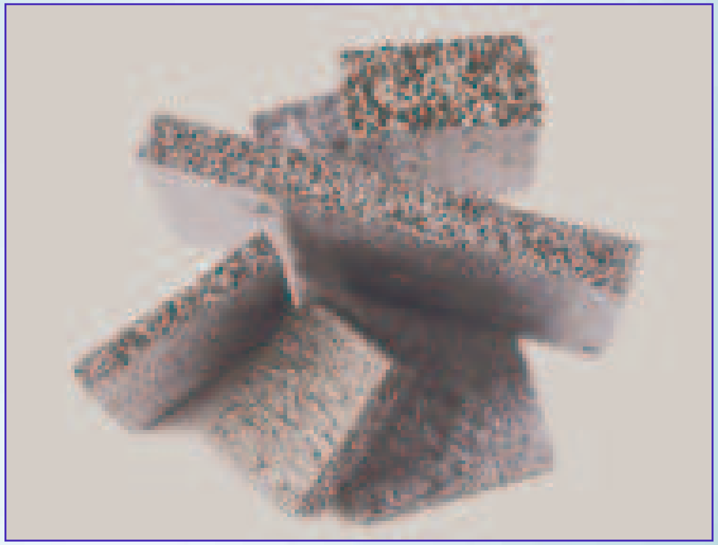


ALDS Centerbody Structure

<u>*Loading Cases Analyzed*</u>

- Acceleration (30g)
- Steady Level Flight
- Landing
  i.) Vertical-Impact
  ii.) Horizontal-Friction

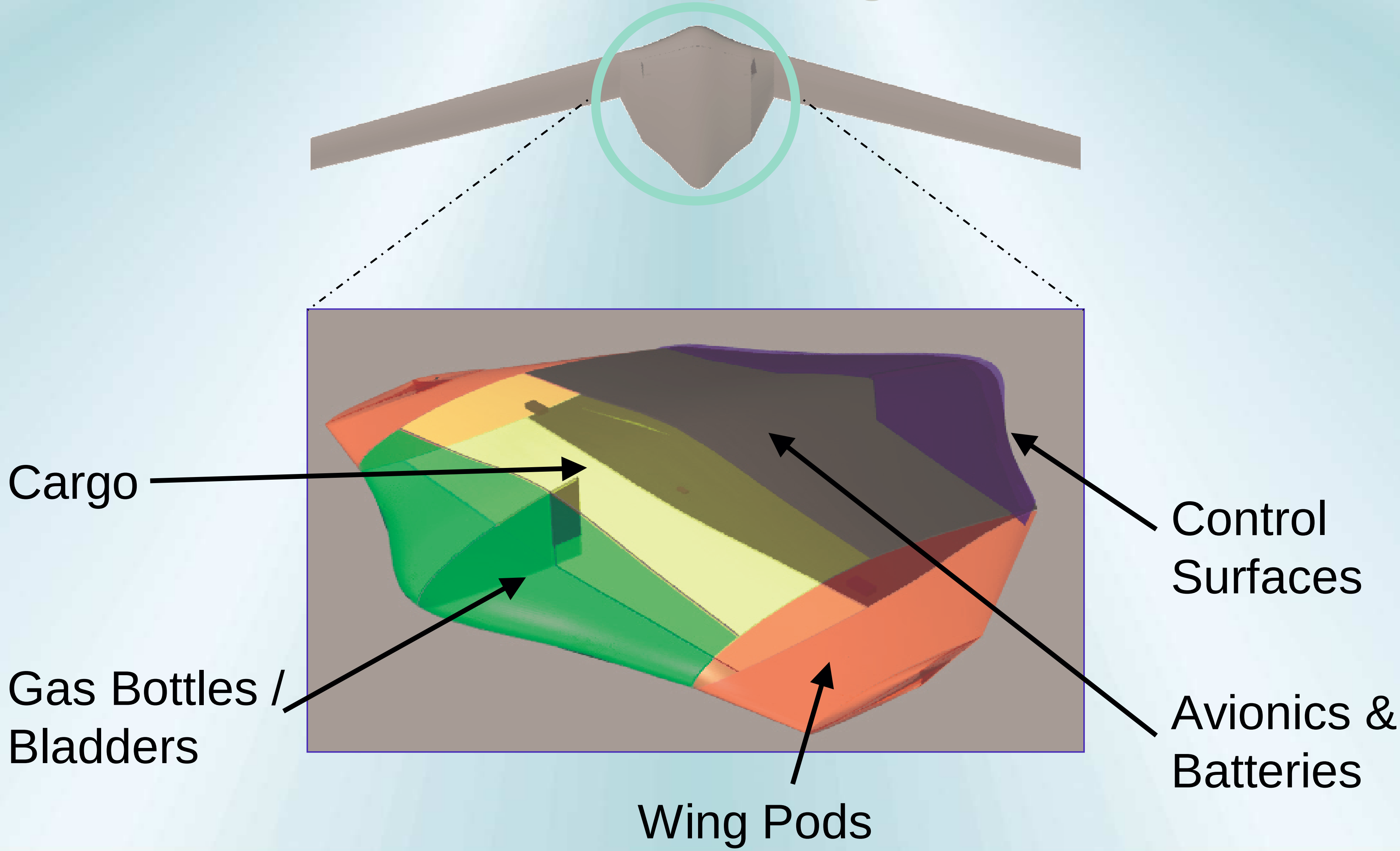




Additional material is required to accommodate landing impact forces.

An Option ⇒ **S**tabilized **A**luminum **F**oam

ALDS Centerbody Configuration



Avionics Package

Example System

Piccolo Plus by Cloud Cap Tech

Integrated GPS, Sensors and Communications Package

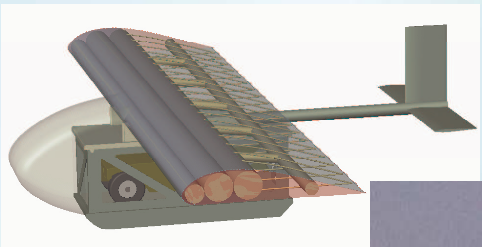
Accuracy:
Current < 20m

Inflatable Wing Technology

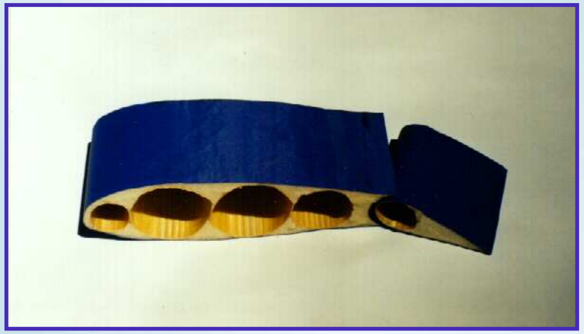
The wing consists of foam wrapped over inflatable spars and covered with cloth.

- High packing efficiency
- Long Storage life & Low Cost
- Recoverable / durable / reusable

Gun Launched Observation Vehicle



Extended Range Aerial Delivery System (ERADS)

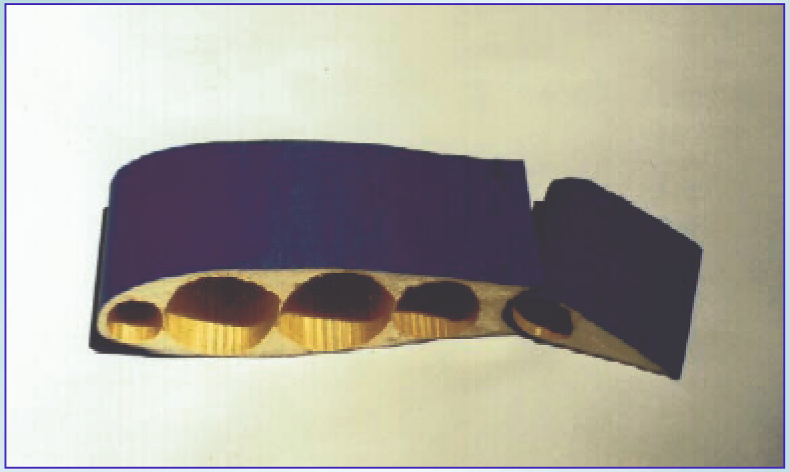


NASA Inflatable Wing Technology Demonstrator

Goodyear Inflatoplane, 1957

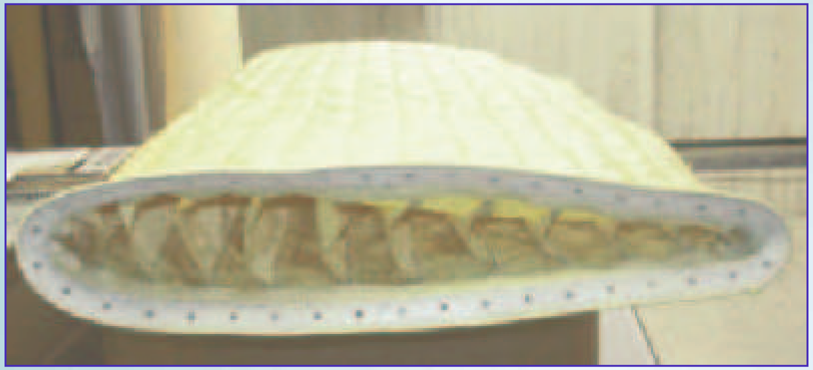
Internal Wing Structure

Inflated Tube Spars

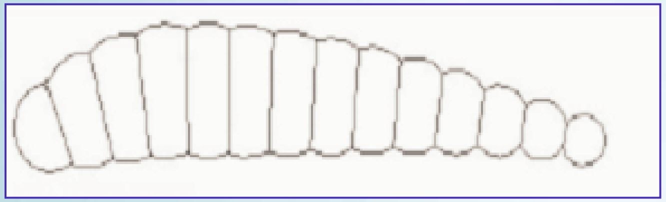


• Use of braids, help resist wrinkle moment

Multi-spar



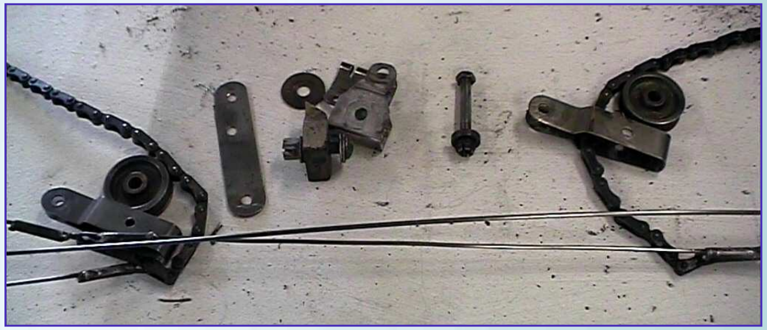
• Stiffness determined by internal pressure and modulus of elasticity of restraint material
• Better adaptation to morphing technology



Control Options

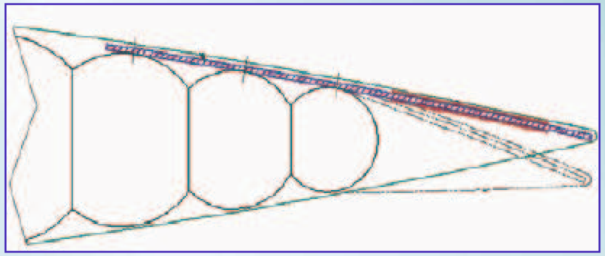
Wing Warping

Wright Flyer

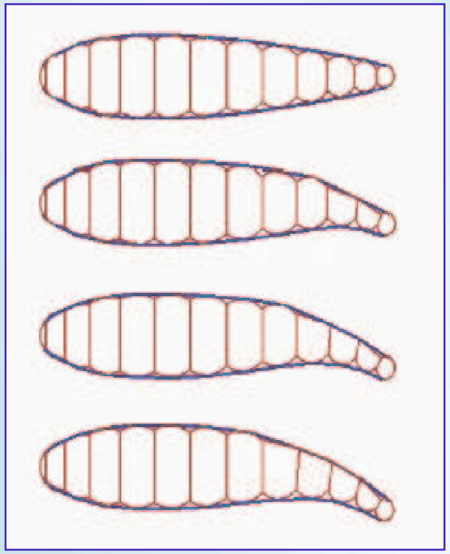


Control Cables

Wing Morphing



Trailing Edge Deflection

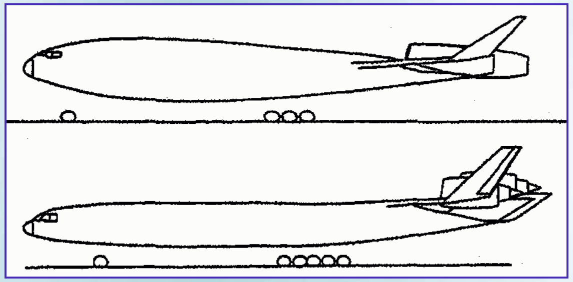


Bump Flattening

Glider and Inflatable Wing - Related S&T Issues

CFD

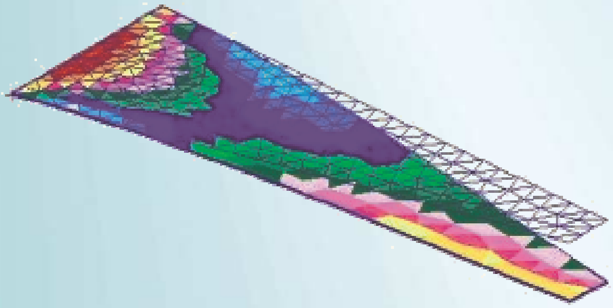
• Optimize centerbody design



Finite Element Analysis

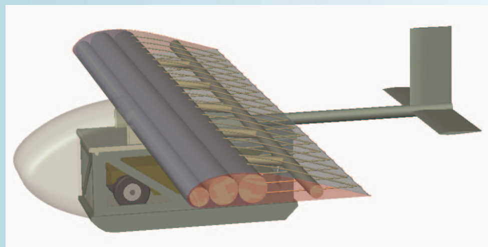
• Confirm structure can withstand loads

• Optimize to minimize weight, while maintaining integrity



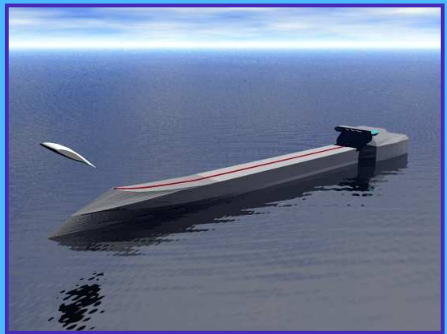
Inflatable Wing Technology

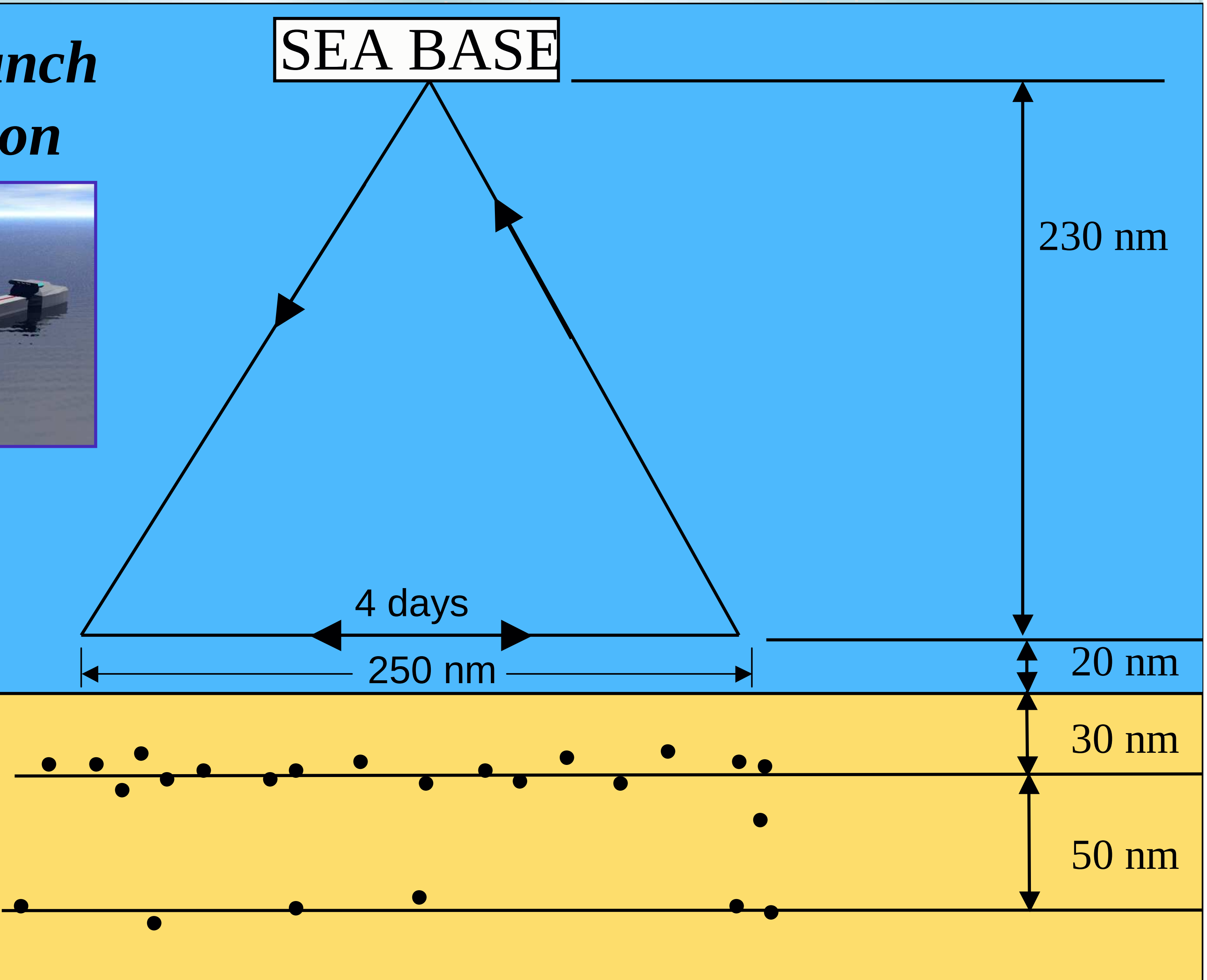
• Wing Span currently larger then existing inflatable wing designs



Part II
Trimaran Launch Ship

ALDS Launch Ship Mission





Center for Innovation in Ship Design

Knowledge People Innovation

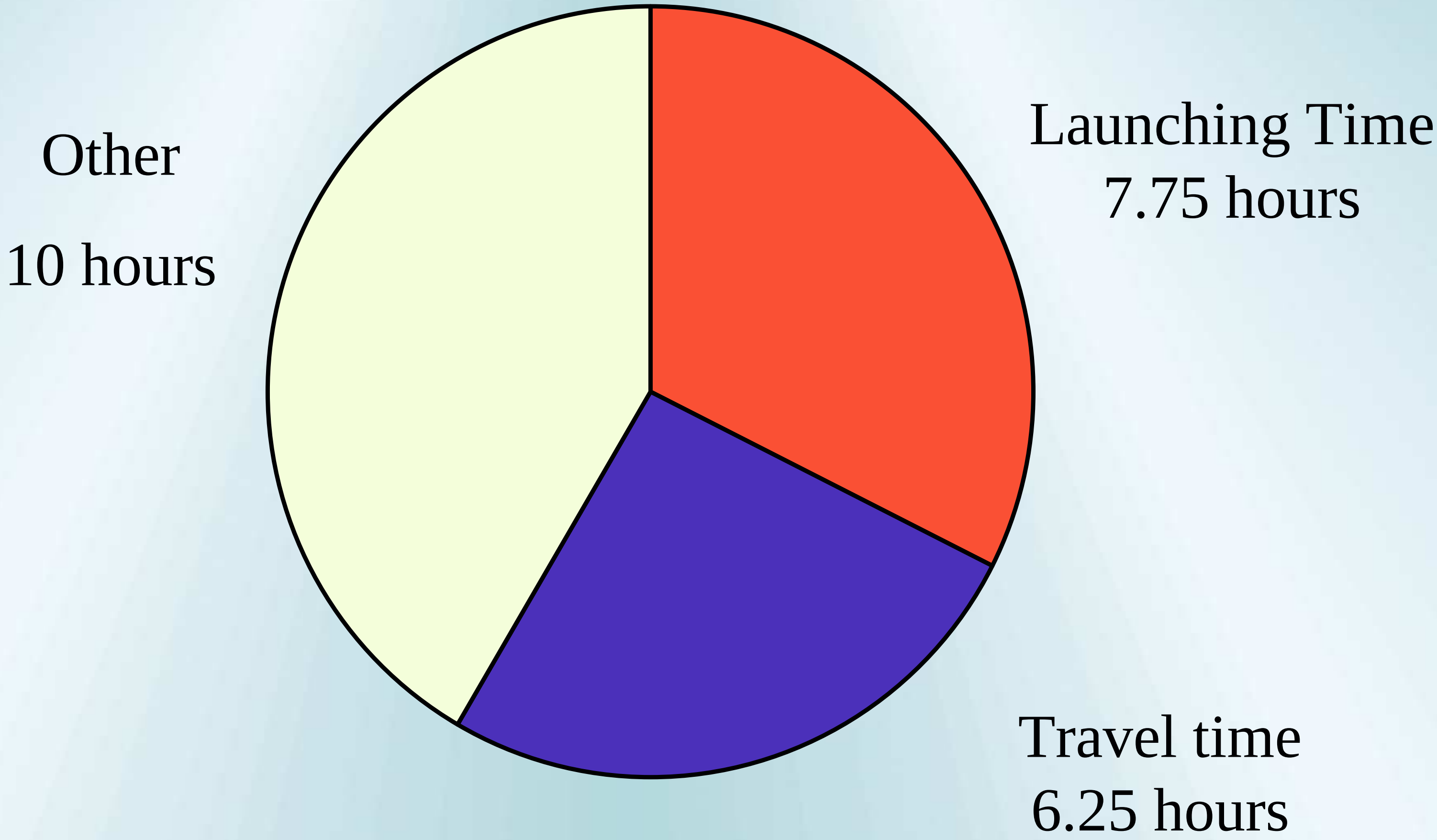
Ship Comparison

Monohull

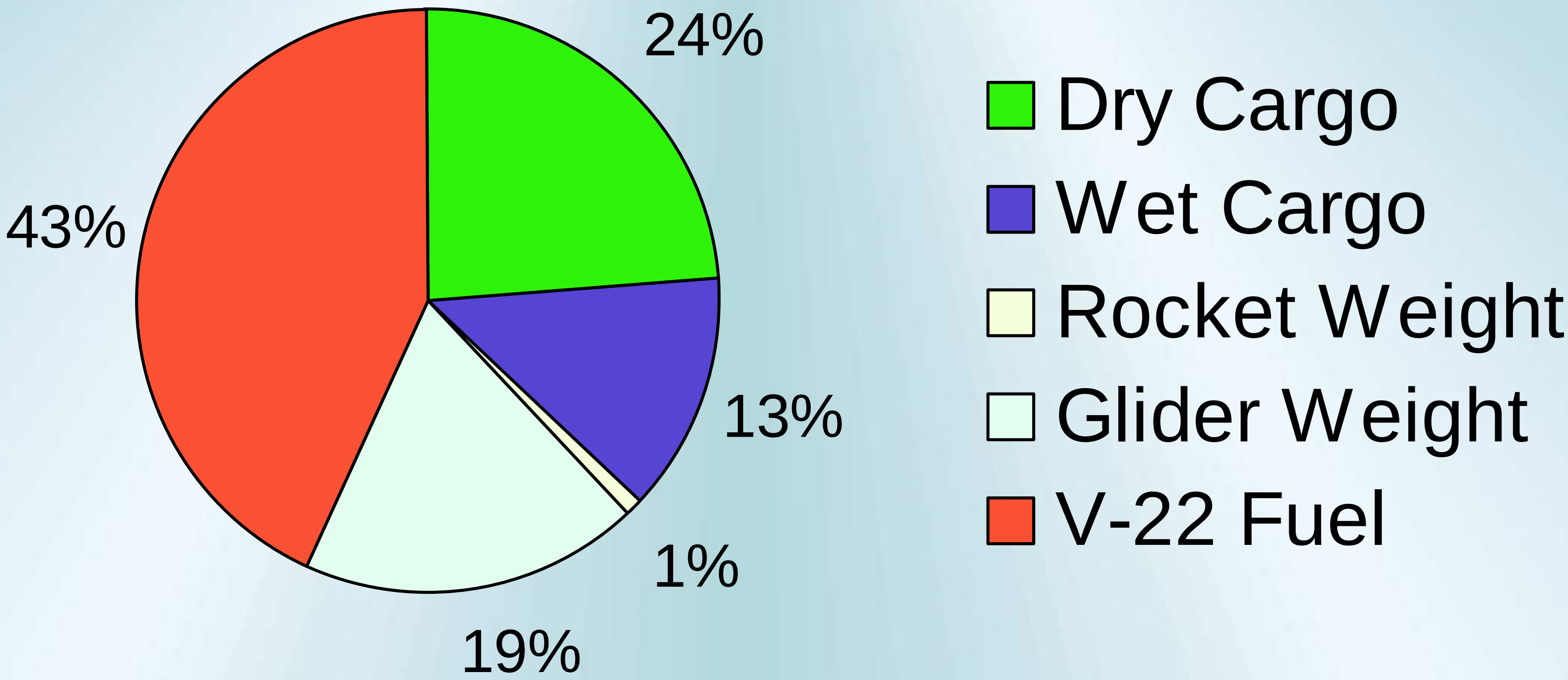
Catamaran

Trimaran

Typical 24 hour day breakdown



ALDS Ship Payload Breakdown



ALDS Cargo Handling Options

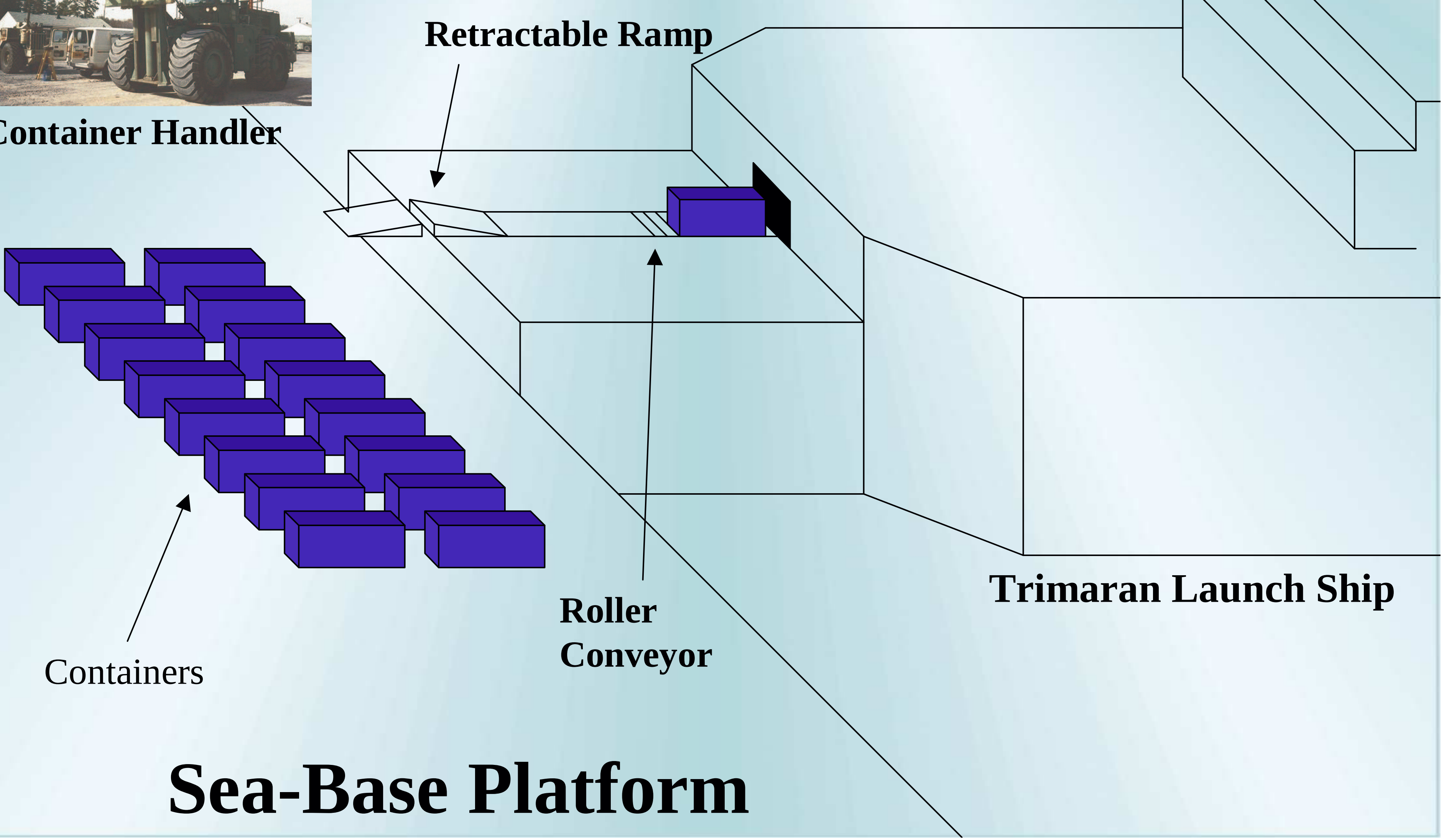
Sea-base logistics presents the challenge of sorting and picking cargo at sea.

3 cargo handling options:

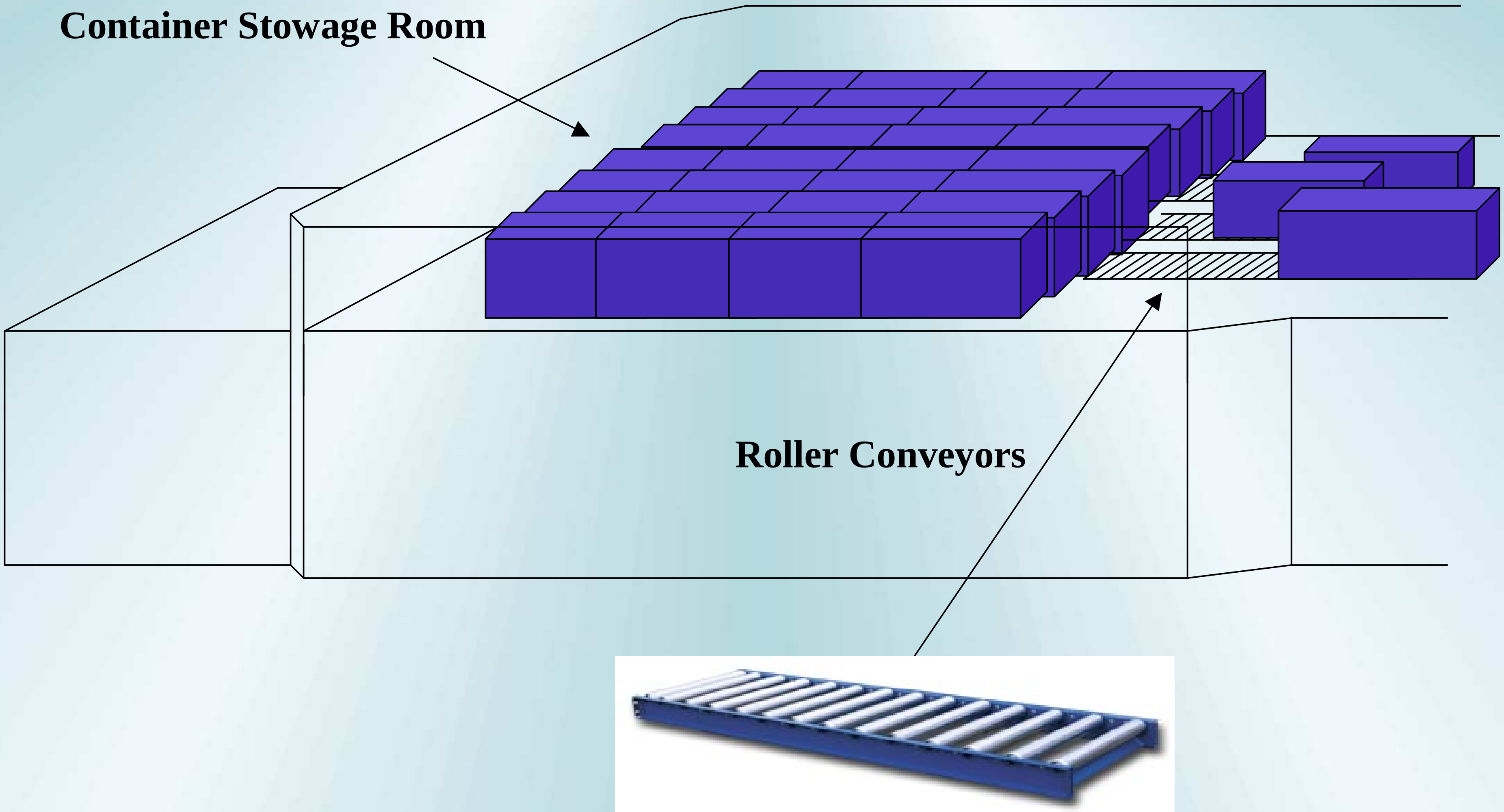
- "Container Depot" Option
- "Vending Machine" Option
- "Hallway" Option

Containers on ship (applies to the "Container Depot" and "Vending Machine" options)

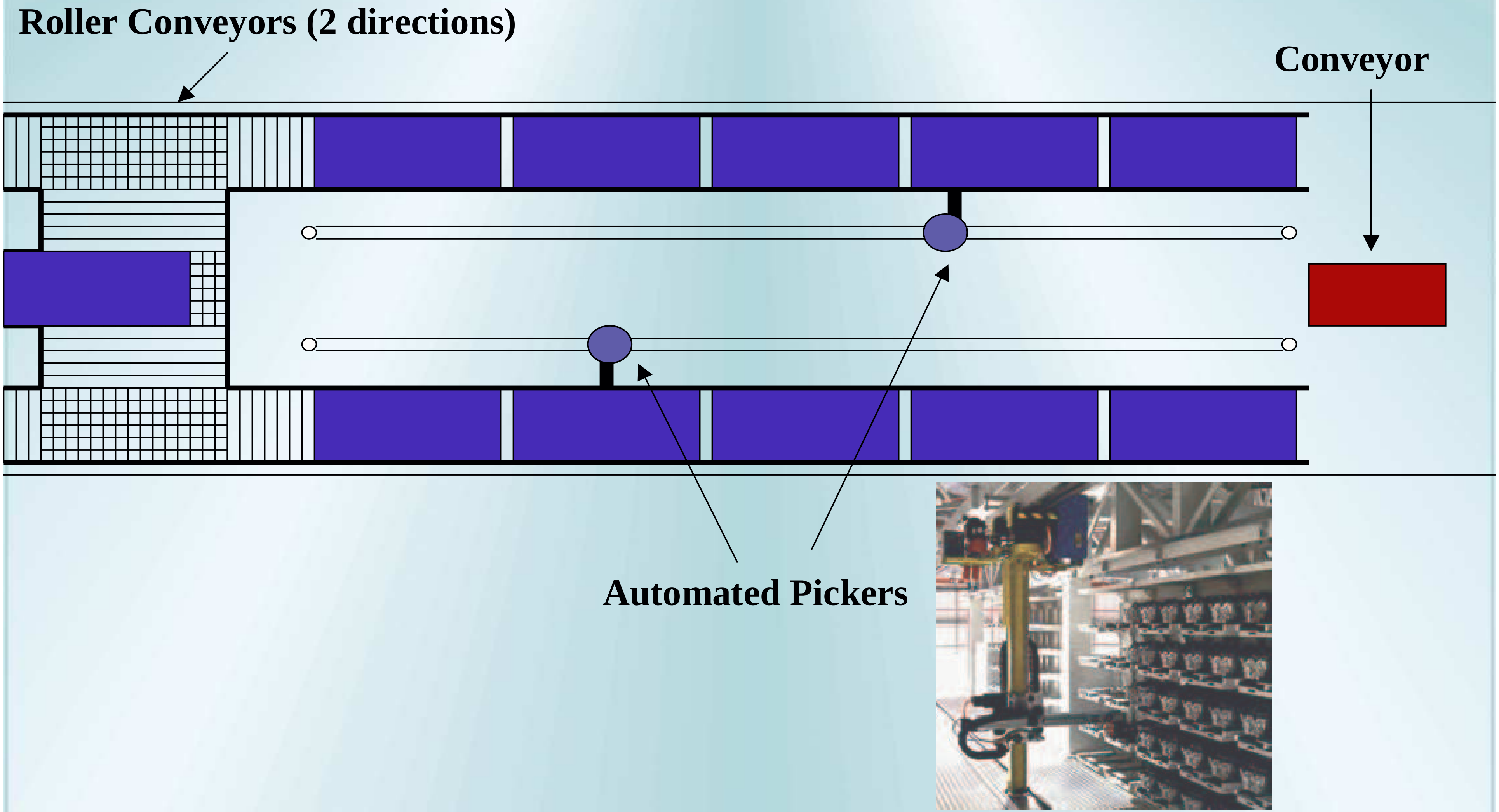
Container Handler



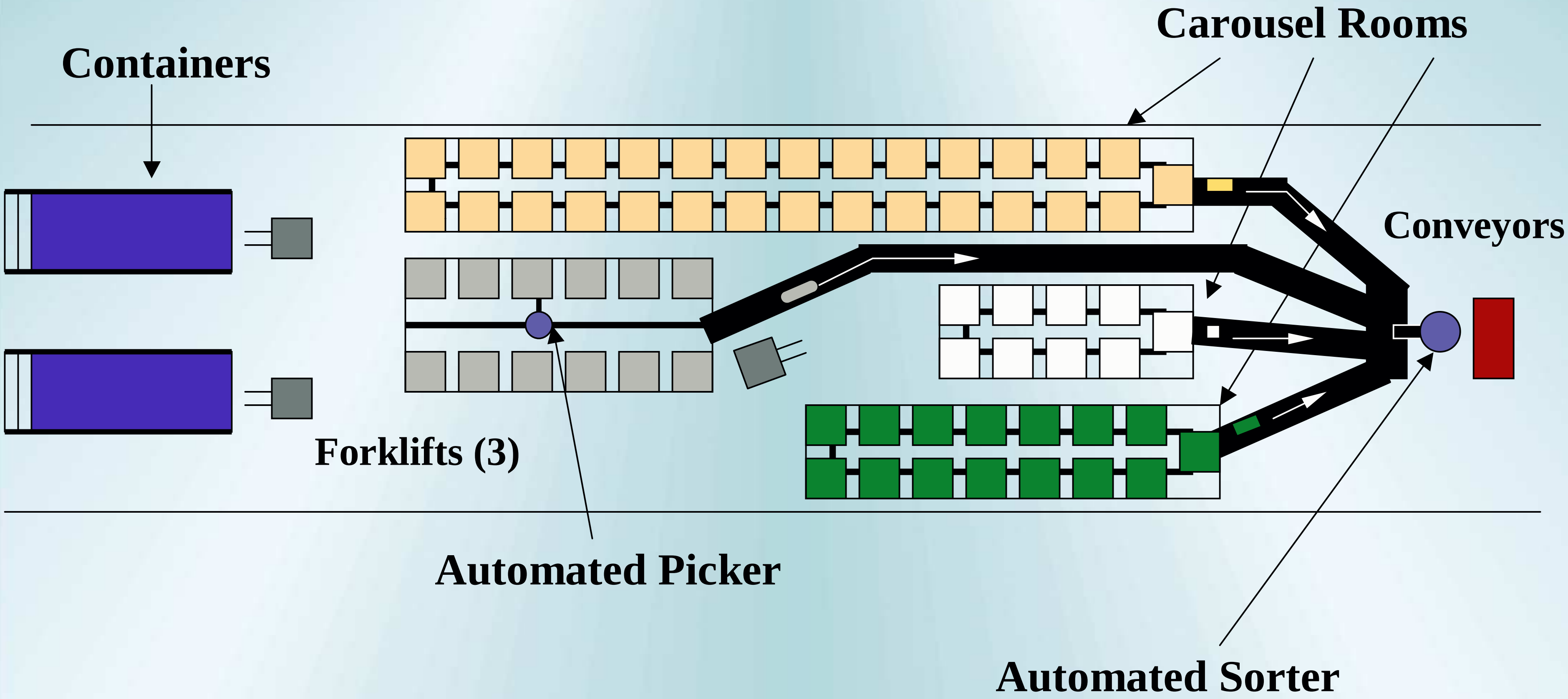
Sea-Base Platform

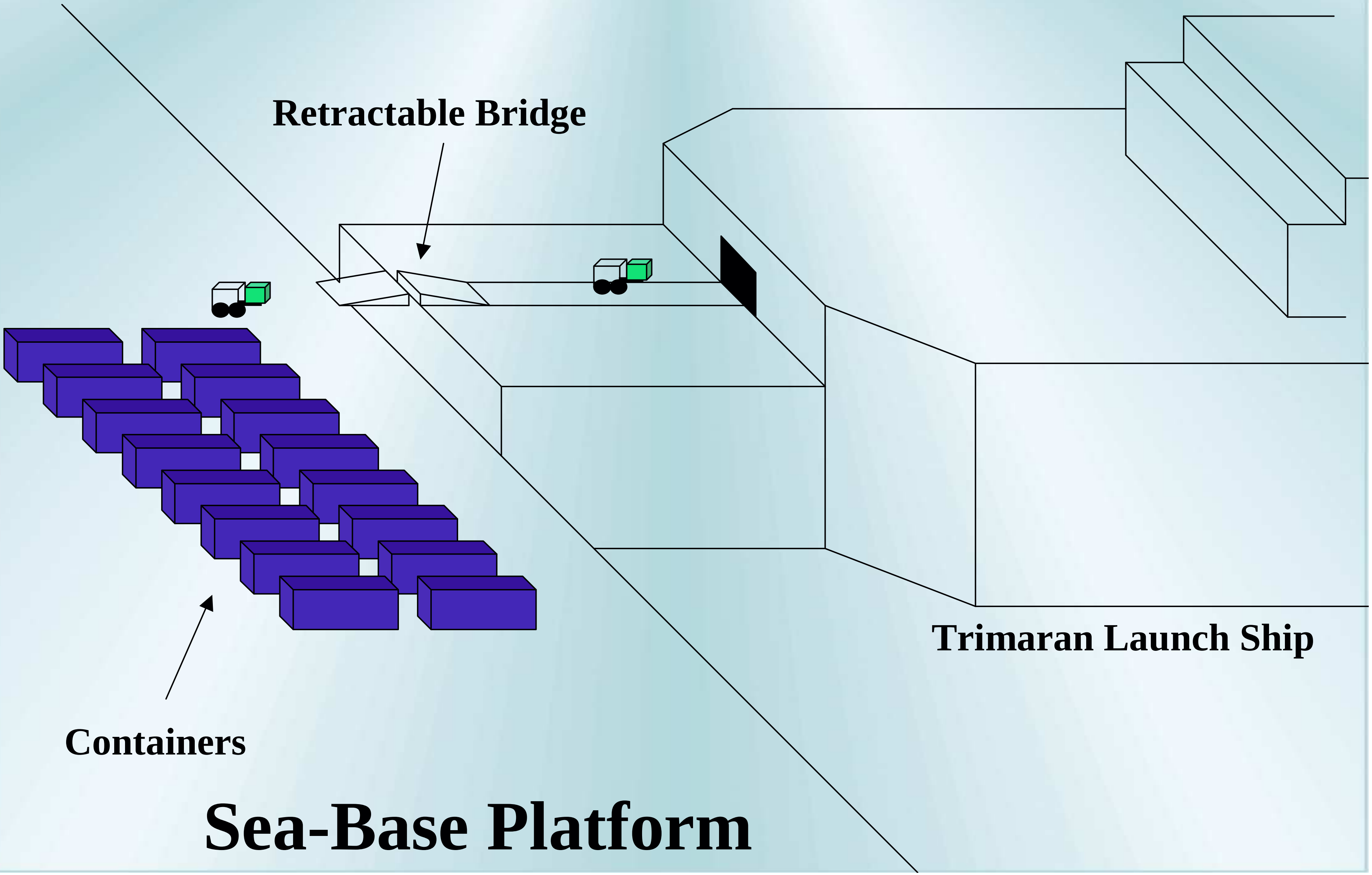

Container Stowage Room
Roller Conveyors

"Container Depot" Option



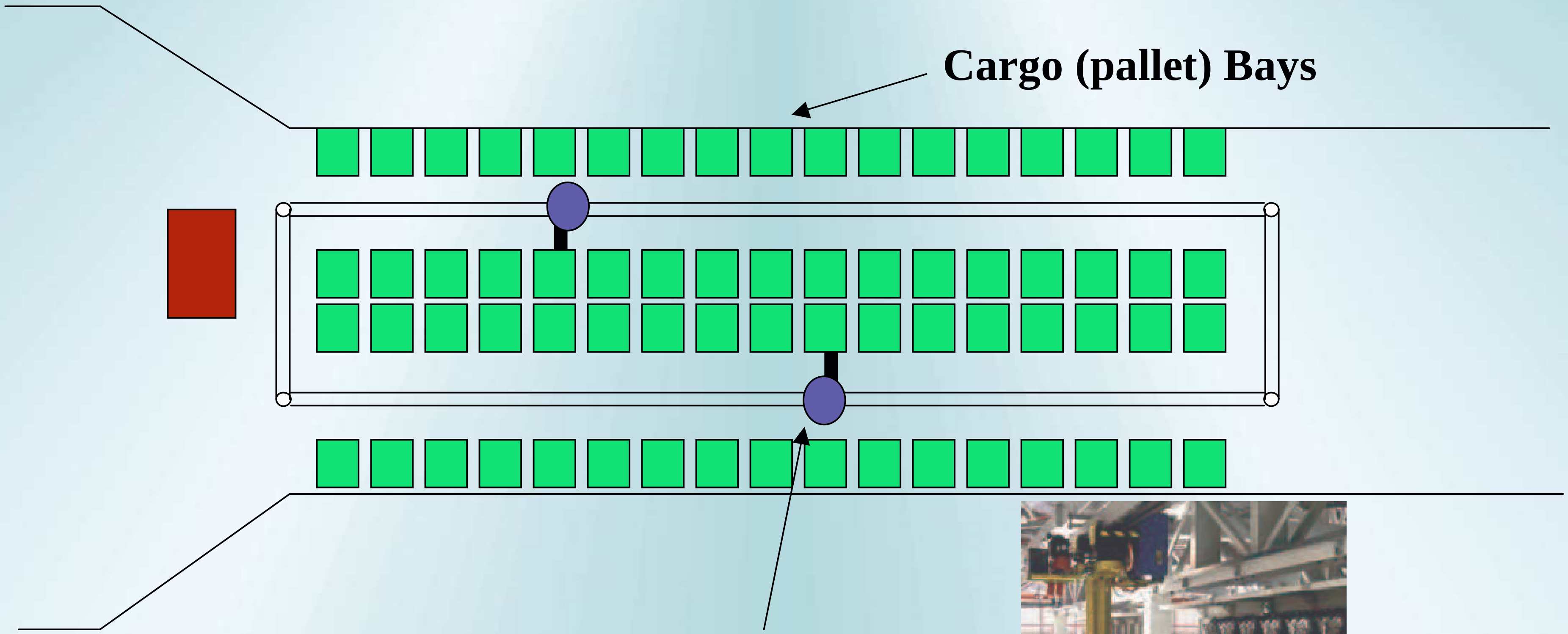
“Vending Machine” Option



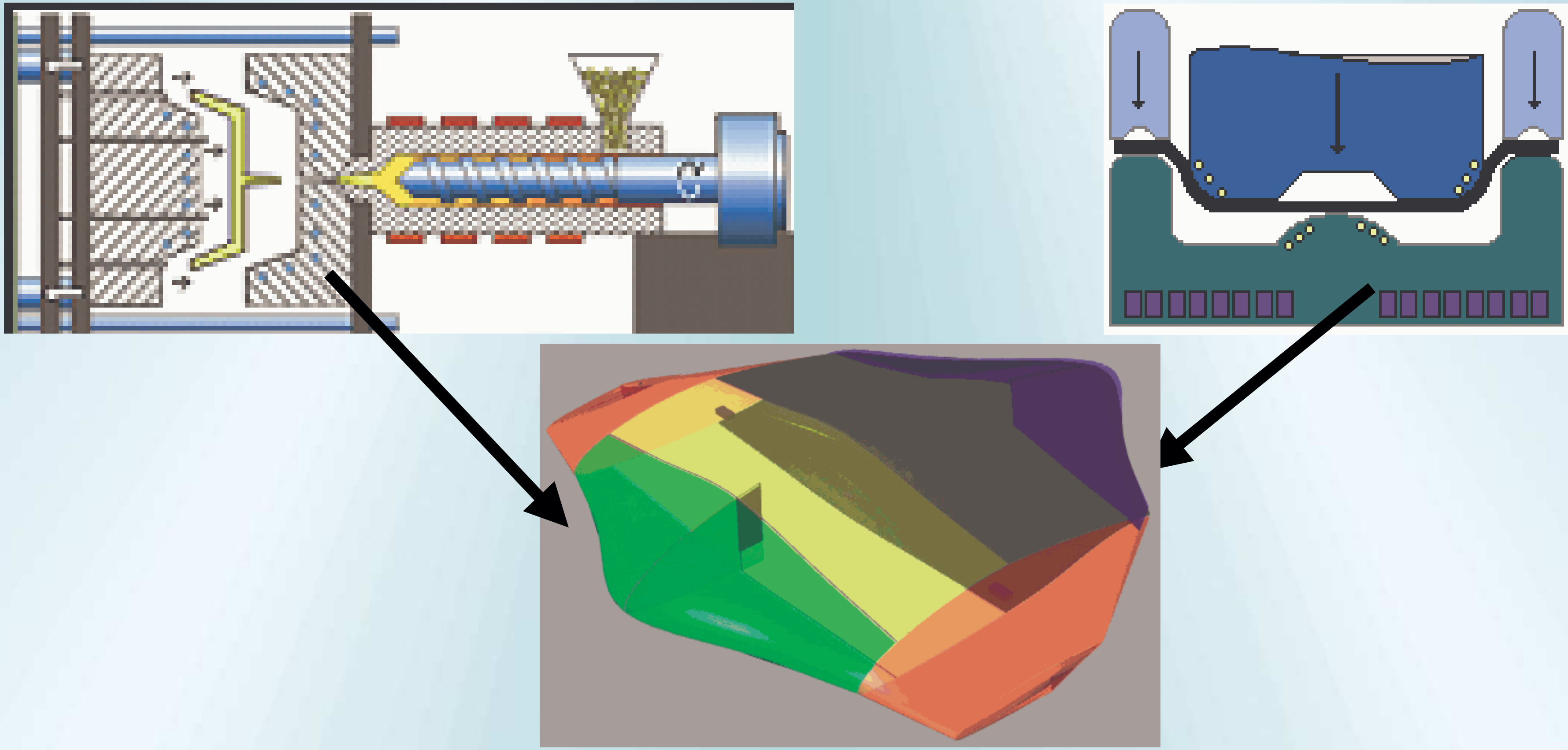


Sea-Base Platform

“Hallway” Option

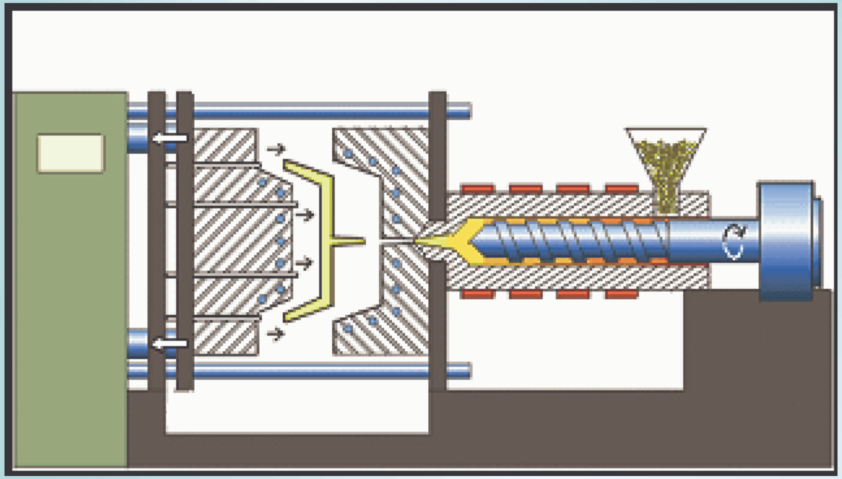


ALDS Manufacturing & Assembly: Offboard vs. Onboard

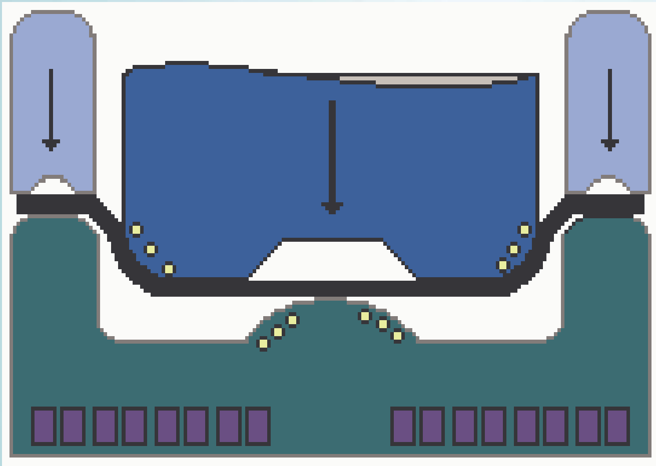


Manufacturing Options

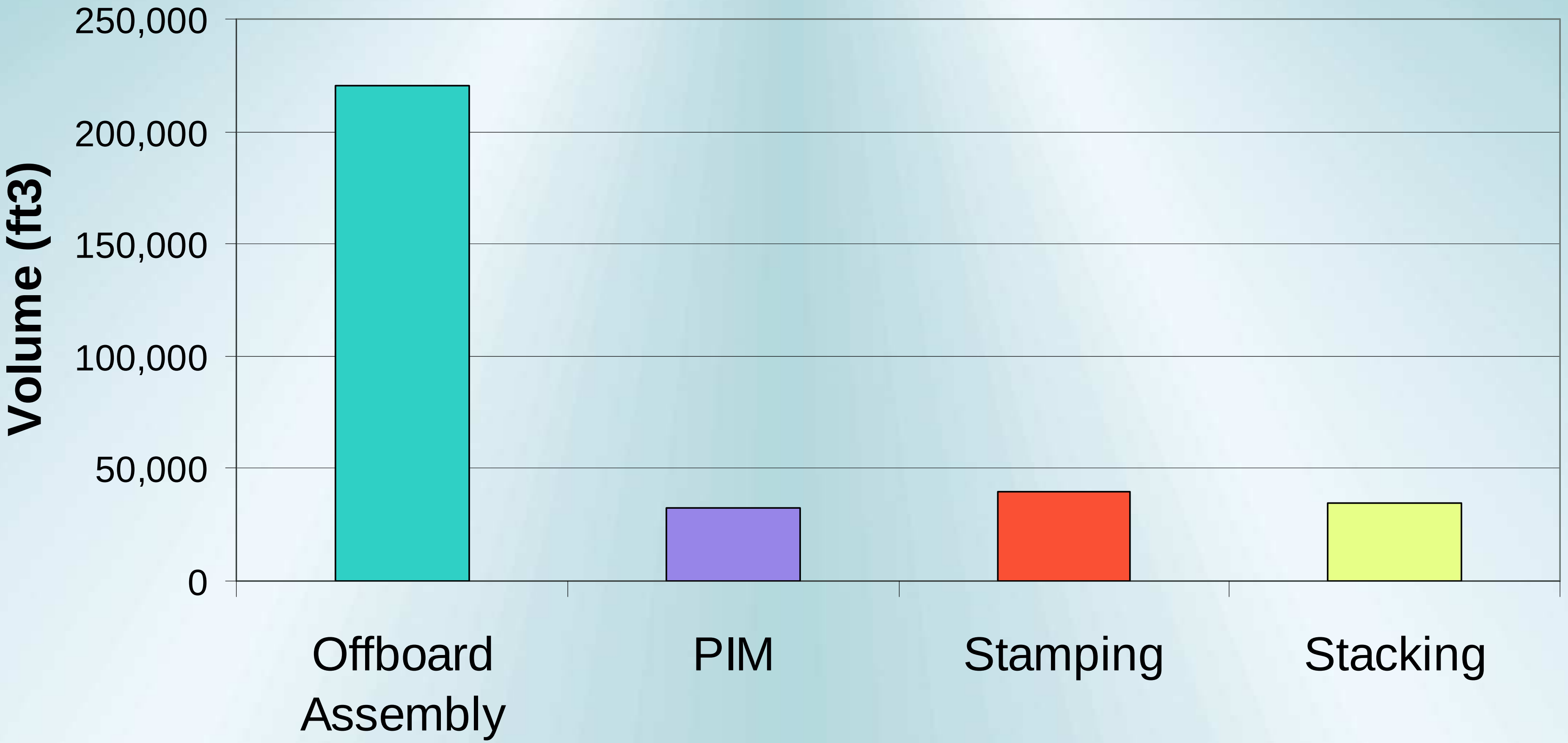
Plastic Injection Molding



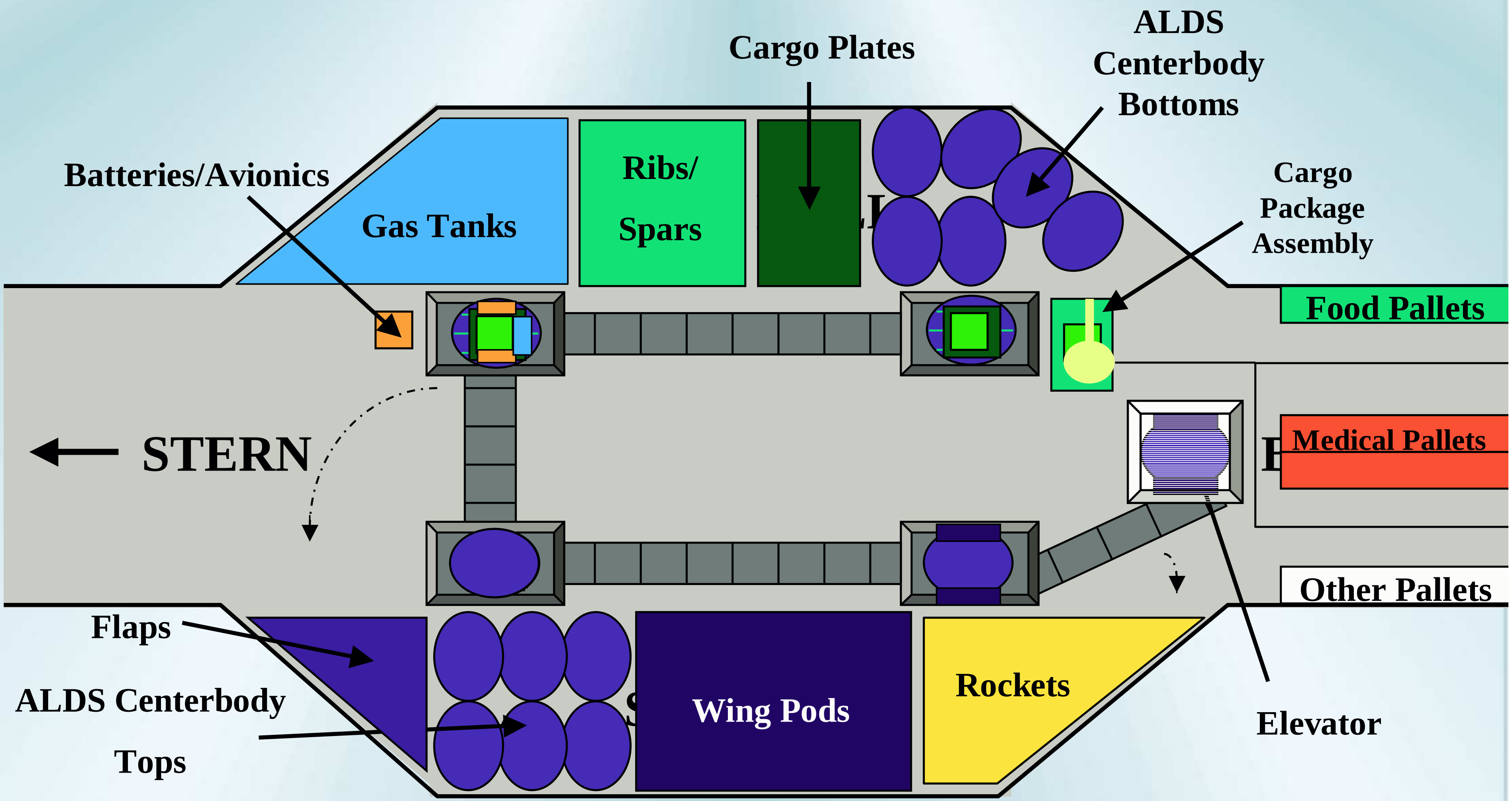
Stamping



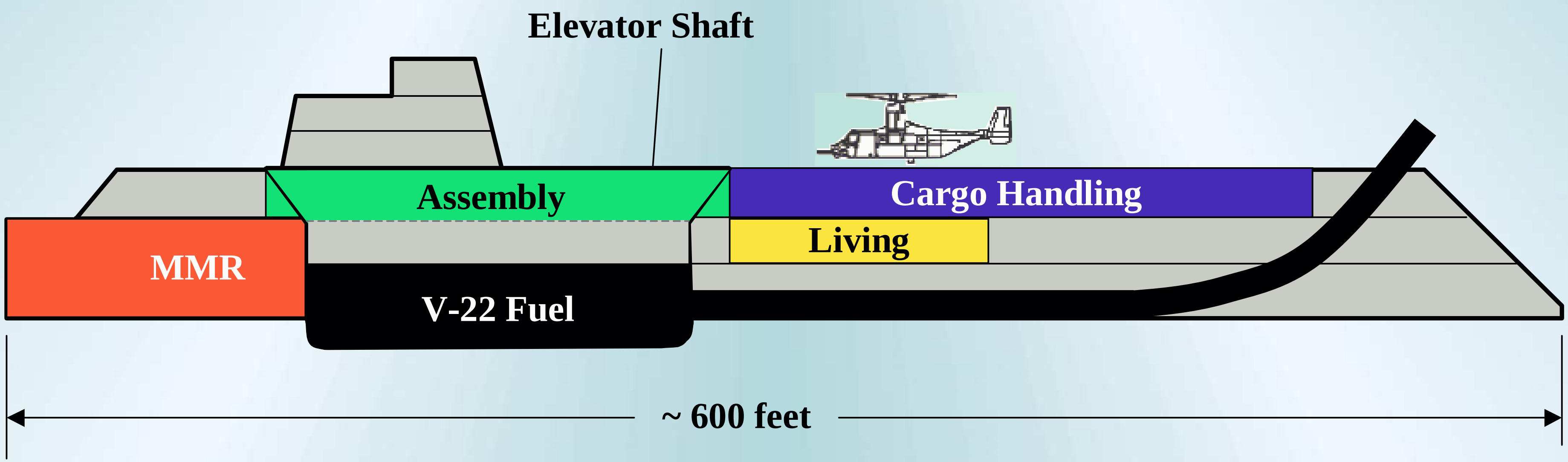
Four Day Manufacturing Volume Analysis



NEAR-TERM SOLUTION: STACKING


Cargo Plates
ALDS Centerbody Bottoms
Batteries/Avionics
Gas Tanks
Ribs/ Spars
Cargo Package Assembly
Food Pallets
STERN
Medical Pallets
Other Pallets
Flaps
ALDS Centerbody Tops
Wing Pods
Rockets
Elevator

Conceptual Profile View of ALDS Launch Trimaran



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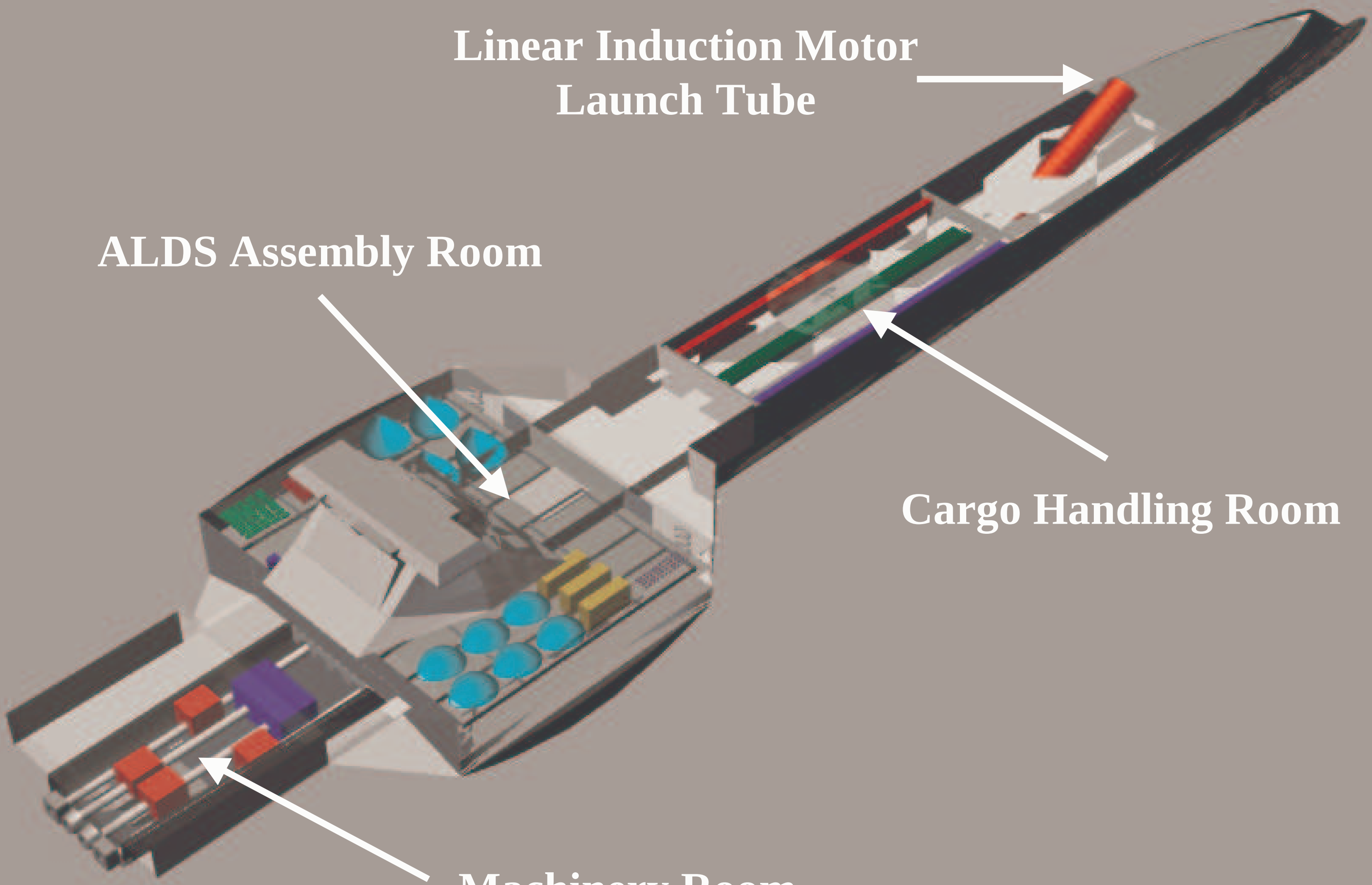
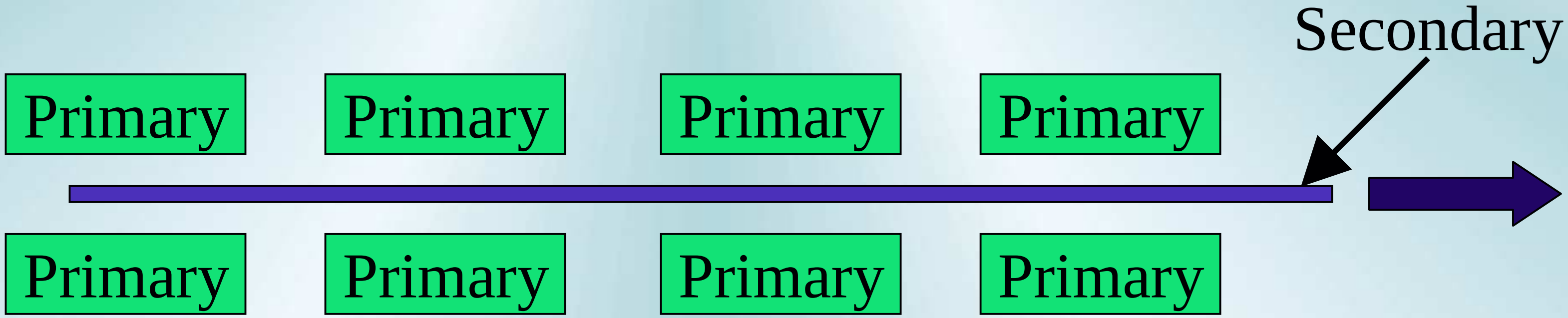


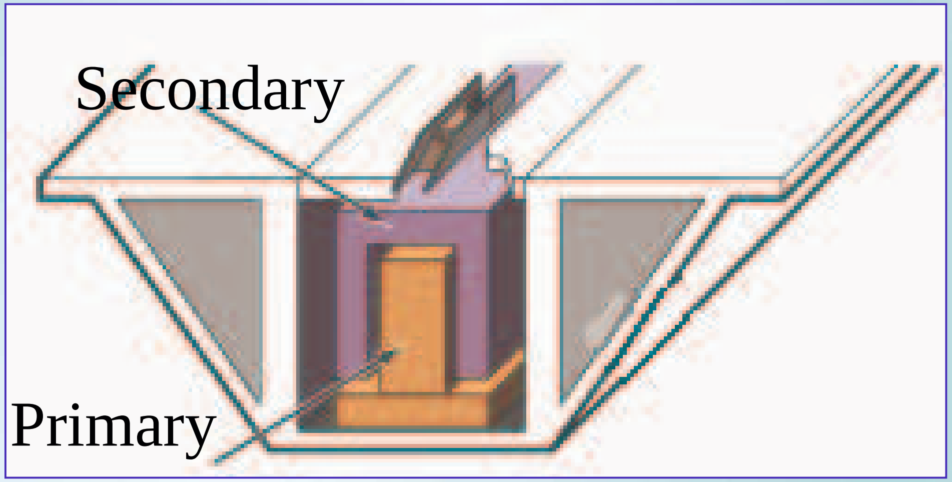
Ship Design - Related S&T Issues

- Further develop cargo handling technology to increase automation.
- Develop manufacturing/assembly process onboard ship & investigate Plastic Injection Molding as a possible future solution.

Part III
Linear Induction Motors

Linear Induction Motors





Electromagnetic Aircraft Launch System (EMALS)

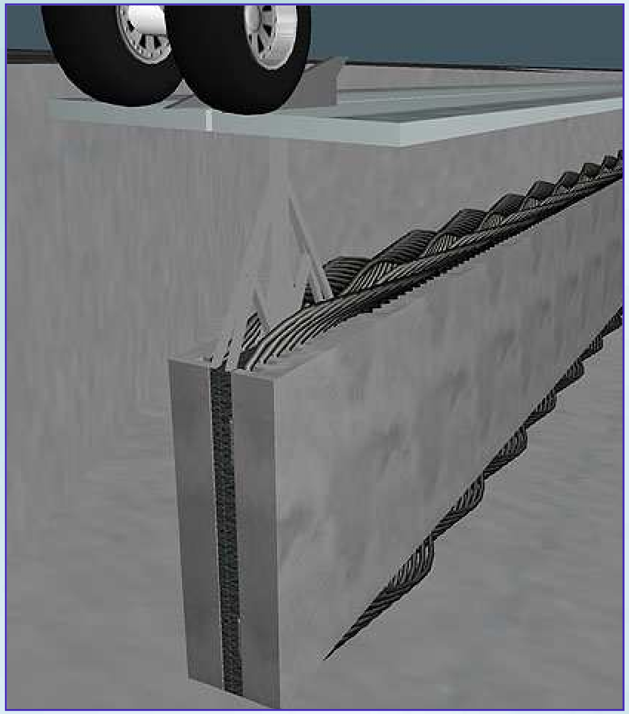
- Aircraft Mass : 10,000 to 100,000 lbs
- Speeds: 50 to 200 knots
- Min time 2s, max accn: 5g

ALDS Launcher Requirements

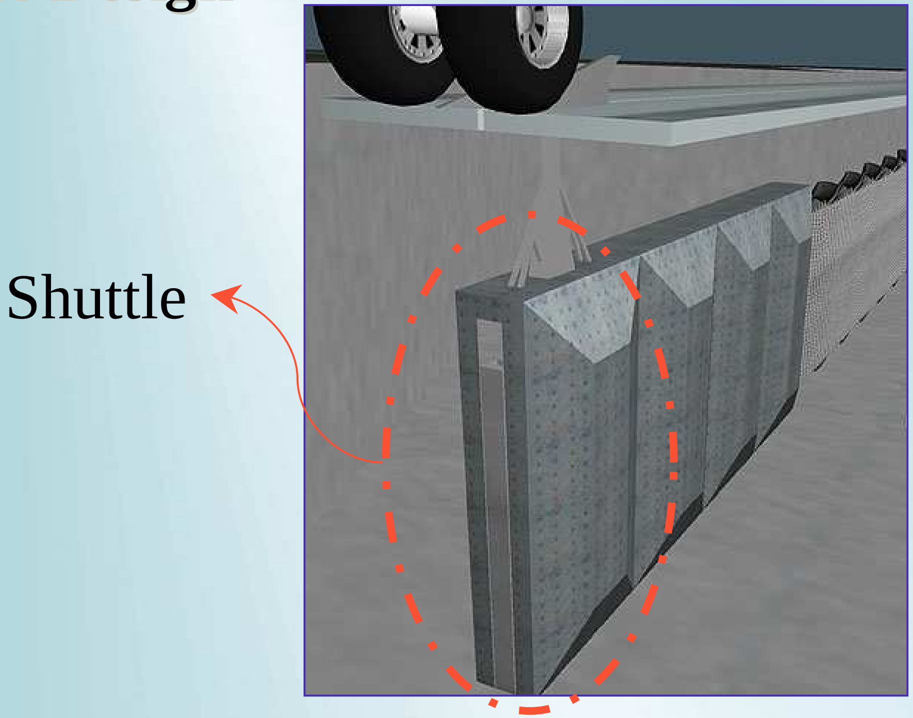
- ALDS Mass : 1,500lbs
- Speed : 500 knots
- Acceleration : 30g's
- Reusable shuttle design
- Curved track

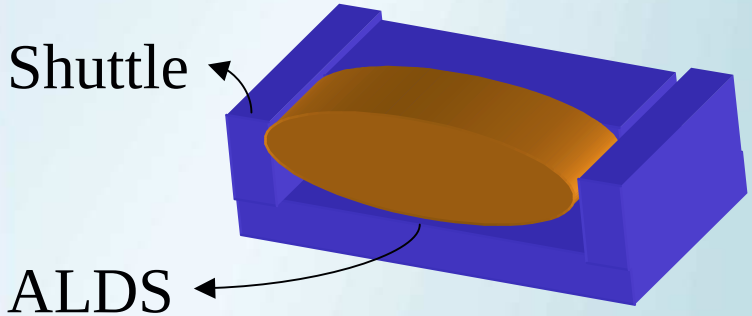
Shuttle Design

Blade Design

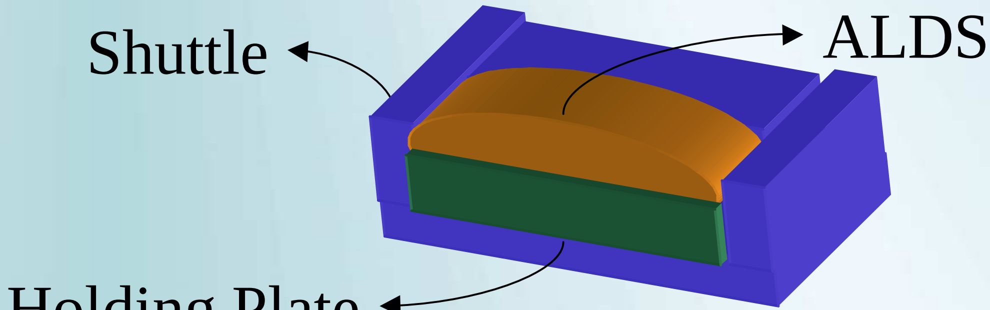


Inverted U



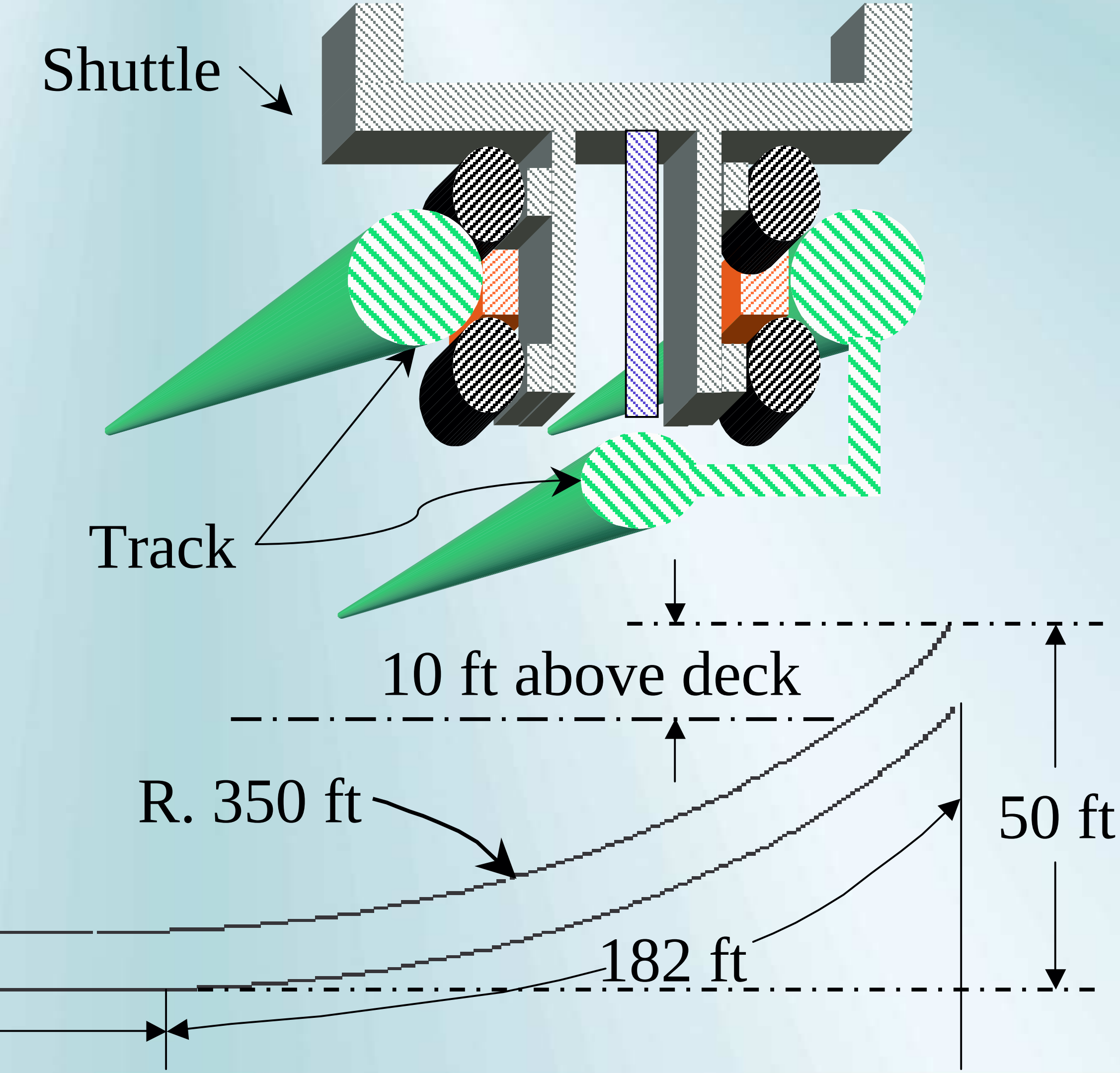


Design I



Design II

Track Design



Linear Induction Motor S&T Issues

Thermal Considerations

- Heating of the primary, secondary and track
- Cooling systems

Electromagnetic Interference

- Magnetic Interference
- Magnetic shielding around track

Power Requirements

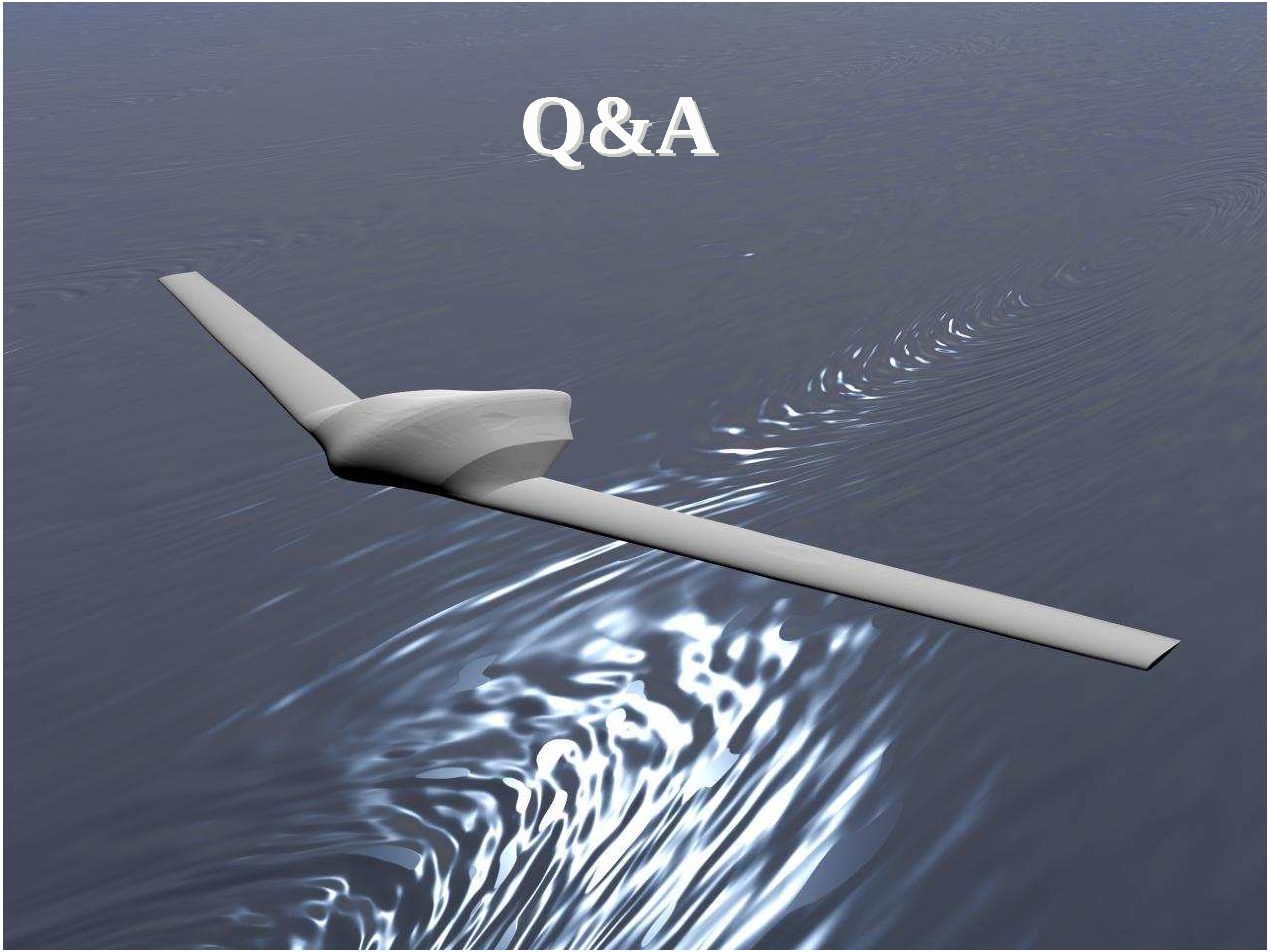
Vibrations

Summary

- Logistics requirement
- Advanced Logistics Delivery System concept
    - i. Unmanned Glider/Inflatable Wings
    - ii. Launch Ship
    - iii. Linear Induction Motors
- S&T requirements
    - i. Inflatable Wing Technology
    - ii. Linear Induction Motors
    - iii. On Board Assembly / Cargo Handling

Conclusion

- ALDS can be an asset to sea base logistics
- Funding is required to bridge the technology gap
- Identified near term and far term solutions
- Conceptual design work is complete
- Preliminary Design to Follow


Q&A

Is ALDS expendable?

ALDS is designed primarily to be an expendable vehicle. Having no engine or pilot the vehicle cost is relatively low when compared to other logistics delivery systems. The cargo that ALDS is designed to transport (i.e. supplies, ammo, etc) is also relatively inexpensive. Expendability offers two advantages, firstly if an ALDS vehicle is lost due to malfunction or enemy attack, another body can be launched and the impact on the overall mission is negligible. Secondly, the small man receiving team does not have the logistical issue of returning the glider. With small systems such as the avionics and GPS, it may be possible to retain these to be returned to the sea base at a convenient time. The aluminum shell may be of use to local civilians. Options of burning the ALDS vehicle for energy have also been considered, depending on the material of manufacture.

How do Helicopters compare to the role of ALDS?

The ALDS mission is based on re-supplying small dispersed teams. A helicopter therefore would have to go from point-to-point to make relatively small drops. The payload capability of a V-22 is around 20,000lbs. This equates to 20 ALDS drops. The V-22 would therefore have to maneuver to up to twenty different locations compared with twenty launches from the ALDS ship direct to the target. The time to deliver would therefore be considerable less with ALDS than one V-22. Additionally, Seabasing concepts do not necessarily include the securing of the beach. Therefore, sending a manned, expensive aircraft into a hostile zone is less desirable when compared to the small, inexpensive, unmanned ALDS vehicle. ALDS also offers low delectability compared to a helicopter. It has no IR signature and it’s radar cross section is extremely small.

How do fixed wing airdrops compare with the role of ALDS?

Fixed wing airdrops again face the problem of flying a manned aircraft into what is considered to be a hostile environment. However, cargo planes can fly at a much greater altitude to make drops and the Army currently demonstrate techniques of hitting targets within 20m. There are three main problems airdrops face:

1. A base is required for the aircraft to refuel and stock up. With Seabasing not necessarily being able to handle the C-type aircraft, this means the aircraft would have to be refueled and re-stocked from a source outside of the Seabase. Seabasing is attempting to remove the constraint of being dependent on a land base. Also, there is the logistical problem of keeping the land base stocked up (and manned) with the required cargo.
2. An aircraft can only drop as much payload as it can carry. In the case of a C-130 this is around 42,000lbs. This equates to 42 ALDS drops. With an estimated 250 drops a day this would require six C-130 sorties.
3. Airdrops usually employ a parafoil design. Current parafoils have moderate to poor glide performance and not enough airspeed to glide into winds.

On launch, how does the LIM shuttle traveling at 500kts slow down?
Upon launch it is envisaged that the track will level and descend again forming a 'hill' profile. At the same time an electromagnet braking force will be applied. The length of additional track required depends on the deceleration ability of the LIM (currently unknown). Additionally, at the end of the track (rubber) bumpers could be used to absorb any remaining kinetic energy.

How is the heat of the LIM dissipated?
EMALS has a cycle time of 45 seconds. As a result liquid cooling is required to dissipate the heat generated. After discussions with General Atomics and Carderock (Philadelphia) it is expected that a two-minute cycle time, as with ALDS, is sufficient to dissipate the heat between launches. Liquid cooling adds a large complexity to the system and therefore avoidance is desirable. Embedding the launcher within the ship could create problems for heat dissipation. Between launches air will be blown down the tube due the physical movement of the 'dolly'. An additional measure is to embed the ALDS launcher tube within another tube of a greater diameter. Air could then be blown down this external tube to aid in heat dissipation.

What difficulties are faced with regards to inflatable wings for use on the ALDS vehicle?
Inflatable structures have existed for many years. In fact, the 1957 Goodyear Inflatoplane was an entirely inflatable aircraft. In recent times NASA has demonstrated the use of inflatable wings and Vertigo (an aerospace inflatable structure company) are developing the inflatable wing for the Army's Extended Range Aerial Drop System (ERADS). ERADS is a 12,000lbs airdropped logistic delivery vehicle. A 1,000lb demonstrator was built and flown. The wingspan of this demonstrator is 29ft, compared to ALDS 70ft wing span. Inflatable wings suffer 'crimping' problems beyond a certain length. This hurdle must be overcome to successfully employ inflatable wings on ALDS. Recent developments show the possibility of hardening the wings using UV light as a drying agent. ALDS 70ft wingspan is the 'ideal' to achieve the fifty-mile range. However, if 70ft cannot be reasonably achieved, ALDS is still a feasible concept with a reduction in basic range.

Given the sensitivity of flying wings to sweep and twist (for stability and trim reasons) rigid wings are required. Are inflatable wings able to provide this rigidity?
Inflatable wings being used today operate at extremely high pressures making the structure very rigid. Recent advances in materials technology have allowed the wing to withstand a high pressure. Compared to the Goodyear Inflatoplane which operated at 25psi, inflatable wings in use today have pressures up to 130psi. This higher pressure though requires stronger structures, more complex inflation systems and a greater mass of gas. Inflation pressure can be reduced through the use of struts. However, due to ALDS flying wing glider's relatively planar design, struts are not an option.

How accurate is ALDS?

Vertigo have demonstrated an ability to land their air drop packages within 20m. It is expected in the next ten to fifteen years within 10m will be possible. Simple GPS combined with a fly-by-wire system will allow ALDS to meet similar accuracies. Guided missiles are much more accurate. This may be due to parafoil drops becoming less controllable near the ground. However, ALDS is a fully controllable vehicle and a high accuracy is believed to be feasible.

Why is high accuracy required?

High accuracy is required because ALDS may deployed to a zone with high foliage coverage. This means there maybe only be a very small clear area to land ALDS. There may also be large deviations in the local terrain and ALDS needs a relatively flat area to land.

How does ALDS land?

ALDS lands as a conventional aircraft does but instead of a wheeled-undercarriage, it skids on the base. The vehicle is reinforced such that the cargo survives and remains in tact. As the vehicle is expendable ALDS does not need to be designed against permanent damage, as long the cargo and vehicle remain in tact. Compared to airdrop systems, it may be seen as an disadvantage that ALDS requires a ‘runway’ to land instead of just floating down to earth. However, the advantage of ALDS over parafoil delivery systems much out way the disadvantage of requiring a landing area. If a clear area is simply not possible (which is unlikely), there is no reason that ALDS could not contain a parachute that would simply deploy near the ground to the vehicle float to the ground.

How reliable is the ALDS system?

The main sources of possible ALDS failure are:

1. Failed launch.
2. Failure to inflate wings.
3. Failure of avionics.

The linear induction motor is designed to offer high availability but not necessarily extremely high reliability. If EMALS fails it could result in a loss of an aircraft. If an ALDS glider is lost in the ocean another body can be launched, with little impact to the overall mission. However, if the launcher itself fails and ALDS is unable to launch this is a problem. Linear induction motors generally have a high availability and it is not expected that reliability problems will exist in this area.

If the wings fail to inflate this will result in an ALDS body falling (uncontrolled) into the sea. Again, with a relative inexpensive vehicle this can be tolerated say every one in one hundred launches. However, if one compares ALDS wing inflation to that of a car air bag, very high reliability can be achieved.

A failure in the avionics in the climb phase will result in an uncontrolled descent to earth. A failure in the glide phase will result in a stable descent in the direction of flight. Chances of hitting the target would be very slim and the vehicle will probably be lost.

Reliability is a question of acceptable losses. A linear induction motor can be made very reliable but would cost more than accepting say a 1% failure rate. A similar argument applies to the other failure modes. As ALDS is expendable and relatively inexpensive, the cost of accepting higher losses (as compared to military aircraft) will be much less than creating a system with zero losses.

How is ALDS affected by weather conditions?

The ALDS ship will have a sea state six survivability, as it will be deployed from the continental US and will have travel over the open oceans. However, operationally, survivability at such a high sea state appears unrealistic. The assembly process on board involves moving cargo around this may suffer problems at sea state six. An estimate has been made that the ALDS ship would be fully operational at sea state five.

The ALDS glider can be affected by all weather conditions such as wind, rain and air sinks. Performance results will be very similar to that of sailplanes. With regards to wind, the extreme performance degradation will be experienced with a strong headwind, resulting in reduced range. At the other end of the scale, a strong tail wind will increase the range of ALDS. The ALDS ship cruises up and down the coast and appropriate points should be chosen to launch, to take best advantage of the wind. Using weather-monitoring systems on board the ALDS ship, the glider can be programmed to avoid severe weather conditions. However, this means height is wasted, as the glider will not fly directly to the target in line of sight. Heavy rain will still allow ALDS operations but will increase the stall speed of the glider. This means cruise speed may have to be increased which means the glider will not fly at optimum L/D hence decreasing range. Additionally, steep turns should be avoided as stall speed increases in the turn. Local sinks will cause ALDS to vertically descend at a higher rate. However, sinks are usually associated with thermals. This means over a fifty-mile glide the sinks should be effectively cancelled out by the thermals.

Is the ALDS ship equipped with weapons for defense?

The ALDS ship contains no defensive weapons. It is envisaged that appropriate vehicles would escort it. Cruising twenty miles from the coast means the ship is outside of the standard gun range. However, missiles will remain a problem and this is one purpose of the escort. Before operations commence it may be that aircraft will have already destroyed major equipment ashore posing a threat.

How are the ALDS wings inflated?

The ALDS wings are inflated by using compressed gas. A currently available solution is through the use of gas bottles. However, gas bladders are more suited to the ship environment as they occupy less volume when stowed uninflected. Materials already exist that offer high strength that would be suitable for use as gas bladders. An inflation system controls the inflation and adds air when ALDS descends due to atmospheric pressure variation with altitude. The inflation system is a large contribution to the overall weight. On ERADS it weighs as much as the wing itself. On ALDS it is estimated it will make up 7% of the overall weight.

Why does ALDS have a payload of 1,000lbs?

It has been estimated (by the previous ALDS cell) that a ten-man team requires 1,000lbs of dry cargo to supply the team for three days. This was how ALDS 1,000lbs payload was chosen. It seems however that this is not strictly true, for one reason, that no-one really knows what the logistics requirements will be. Current efforts have taken the 1,000lbs payload as a basic design figure – but nothing concrete. For lack of better estimates, 1,000lbs seems to offer a good balance between supply and aircraft range (as increased payload results in decreased range).

Why does ALDS have a basic range of fifty miles?

The fifty-mile range is results from a set of basic design values that fit well together. It is envisaged that ALDS can launch at 500kts. This velocity will allow ALDS to achieve maximum height without suffering supersonic effects. A glide angle of around thirty was chosen as being on par with mid-range sailplanes. It offers high performance but not unrealistic. High performance gliders have the capability of a glide angle of forty plus. These two things combined give a basic range of fifty miles. With the ALDS ship cruising twenty miles from the coast this offers logistic delivery thirty miles inshore, which is a reasonable figure. Range can easily be augmented through the addition of disposable rockets. In the ALDS ship design it was estimated that 10% of launches will be rocket augmented.

Why a 30g acceleration?

Again, no one design figure is concrete. All the figures together make an acceptable ‘package’. Recent studies have shown that in the right conditions, the human body can survive 45g accelerations. Therefore, 30g acceleration for cargo seems reasonable. None of the cargo is susceptible to high accelerations therefore this is not a consideration. High acceleration means the launch distance is reduced. However, the ALDS vehicle must be stronger to withstand the resulting forces. The current figures give a fair tradeoff between launch distance and ALDS structural requirements. The important thing to remember about all the design figures is that none of them are set in stone. It is easy to be of the mind that ALDS MUST achieve a fifty-mile range and it MUST launch with a 30g acceleration. At such an early conceptual design phase, it is not possible to say whether such figures are achievable. If, for example, studies show ALDS can only launch at 450kts with a 25g acceleration, this is not a failure of the concept.

Why 30ft^3 of cargo space?

This is the result of a packing study that was performed, to see the most efficient way of packing cargo. The volume is also the result of a 1,000lbs of mixed cargo. Additional cargo space is available towards the rear of the body for oddly shaped items.

Why inflatable wings as opposed to a fixed wing?
With an aspect ratio of twenty, the aerodynamic loads on launch would be too great for a fixed wing aircraft to survive without excessive structural design. This extra structure would add extra weight, which is undesirable in glider design. A secondary reason is storage. With approximately 250 launches per day, on a four-day cycle, the storage space on board the ship for fixed wings would be too large.

Why is ALDS a flying wing design?
Flying wings offer up to a 25% reduction in parasitic drag. However, there is also a reduction in lift. A good design however will reduce the drag by a greater amount than the lift, resulting in a higher lift to drag ratio. In terms of ALDS this means a greater glide ration resulting in a larger range. As a rough approximation, an equivalent fixed wing design would only achieve half the range of the flying wing design. Flying wings are also simpler and cheaper to construct, which is advantageous for an expendable glider that has to be assembled ready for launch every two minutes.

How is ALDS assembled on the ship?
Storing complete ALDS bodies on board ship is not an option, as they would occupy too much space. For a near term solution, manufacturing processes on board the ship need to be avoided due to the complex integration and operational issues on-board a ship. Therefore, ALDS will be a snap together design. This does add a weakness to the design over say riveting, but ALDS is expendable therefore a loss in strength can be tolerated. Also, the benefits to be gained of ease of integration overcome the slight loss in strength of an equivalent riveted structure. A future design would feature a manufacturing process on board. Plastic injection molding is an ideal solution to minimize on board space and create a strong, accurate ALDS shape. The operation of a plastic injection-molding machine on board a ship is a capability gap which funding could bridge.

What level of automation is expected with ALDS?
With a system that launches every two minutes, a high degree of automation is desirable. The ALDS glider is fire and forget, i.e. once launched, it will fly to it’s target unaided. On board the ALDS ship, a high level of automation is designed for. The cargo loading and assembly phases will be fully automated using a combination of COTS. The main human effort is required in the loading of the cargo on-board the ALDS ship and the placement into the appropriate spaces.

How is the cargo unloaded from ALDS?

ALDS is a snap together design. The body would include a quick release mechanism which would release the cargo. The future option of a plastic injected molding design would include a flap to release the cargo. The main point here is that the cargo survives and remains in tact for the landing.

How is ALDS controlled?

Controls are located on the rear of the ALDS centerbody. The flaps occupy ~20% of the chord. They act as the primary controls in the climb, but secondary in the cruise due to efficiency reasons. The main method for control in the glide phase is through the use of wing warping or morphing.

The centerbody is launched at 500kts, at an angle of around 30 degrees. How confident is the team that the body will launch correctly and not become unstable?

There are two ways to look at this question. Firstly, you can consider the centerbody as a projectile, which is propelled off the deck of a ship and climbs to attitude through the expenditure of kinetic energy. However, the centerbody is an aerodynamic shape capable of generating lift (and drag). The body is controllable through the use of the flaps, and at high speeds only small flap deflections would be required. Aerodynamically the body is unstable. A fly-by-wire system with a feedback control system (autopilot) will control the centerbody. Military aircraft, such as the F-15 are naturally unstable yet are fully controllable through avionics. The unstable nature of ALDS in the climb is even desirable as it results in rapid maneuvers, i.e. the controls are extremely responsive.

ALDS needs a specialized ship design.

YES -you do, but currently there is no way of providing this capability from Sea based supplies. This is not something that you would backfit onto a aircraft carrier as you are never going to send a high value asset into the littorals. Backfitting onto other ships is likely to lead to signigicant inefficiencies & impact in their primary and secondary roles given the space requirements imposed by ALDS logistics.

other supporting justification might include;

1. the ALDS ship has lots on unused upper deck space where three helo pads could be placed enabling a leapfrog refueling facility for helos going ashore extending their range
2. the ALDS ship could act as a support vessel for special forces (launch and recovery)
3. the ALDS ship frees up air assets for other more important warfighting duties rather than logistics delivery

What does the team see as the next steps in the ALDS program?

The Advanced Logistics Delivery System (ALDS) is an advanced sea-based concept capable of providing rapid sustainment of goods and supply to dispersed military forces maneuvering ashore. The system consists of a shipboard mechanical launcher and an autonomous, unmanned glider designed to transport cargo such as food, ammo, fuel, and water. The glider has inflatable wings, which deploy at apogee. An initial conceptual design has been performed and several follow-on projects have been identified.

The centerbody was designed using basic conceptual methods and preliminary studies are now required. Computational Fluid Dynamics (CFD) would allow the centerbody to be aerodynamically optimized to reduce the size and drag, while maintaining the required lift. A detailed structural design also needs to be performed such that the body can withstand all associate loads experienced at launch, cruise and landing. Finite Element Analysis (FEA) would allow aid in the optimization to reduce structural weight while maintaining integrity.

The ALDS glider is naturally stable, and basic stability analysis has been performed. However, flying wings tend to have greater stability issues than tailed aircraft and a detailed analysis needs to be performed.

Flying wings, unlike tailed aircraft, do not have a wealth of design tools and experimental data available, due to the small number built. This means the design of a successful flying wing is strongly experimental. There is therefore a desire to build ALDS glider models. Wind tunnel tests would provide basic aerodynamic characteristics. It is also desired to test the launch by catapulting a working centerbody model. A model of the glide body with moving flaps is also desired to prove the concept and aid in the preliminary design. An investigation into inflatable wing deployment, and the effect upon the glider is also of interest.

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Technology roadmaps need to be ascertained with regards to inflatable wings and the other S&T issues.

The ship design needs to undergo a similar preliminary study.