A Con-Ops Enabler: Scalable USVs in a Nesting Doll Approach

By Jack Rowley

While the Navy will buy substantial numbers of large, medium and small USVs, it has yet to evolve detailed plans of how these platforms might be used together to accomplish a variety of naval missions. Additionally, the Navy would be well-served of moving away from "one-of" USVs for singular missions and explore the utility of investing in families of similar USVs to capitalize on putting together mutually compatible hull, mechanical and electrical (HME) attributes and systems.

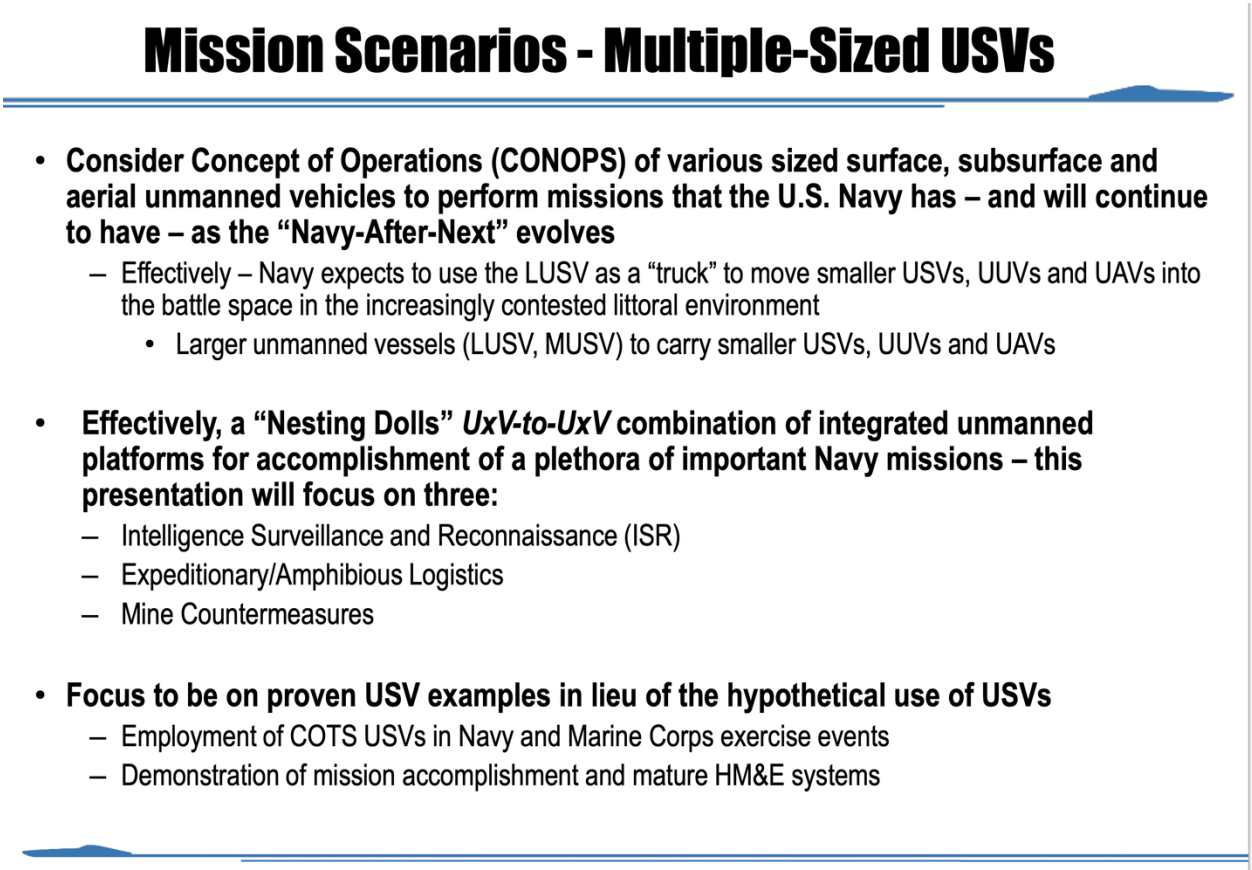
I argue that a concept of operations (CONOPS) can be developed today with regard to leveraging a scalable fleet of USVs and combing these into combined operations. WE can deploy large, medium, and small unmanned surface vehicles (USVs) together in a "nesting dolls" taxonomy where the larger USVs carry smaller USVs, UUVs and/or UAVs into contested areas in order to perform a wide array of fully unmanned missions ranging from intelligence surveillance and reconnaissance, to intelligence preparation of the battlefield, to mine countermeasures, to logistics resupply, to others.

"Nesting the Dolls" Into an Integrated UxV-UxV Solution

I would like to sketch out a "Nesting the Dolls," into a UxV-UxV con-ops solution. This provides a significant capability important to the evolving combat environment. If the U.S. Navy wants to keep its multi-billion-dollar capital ships out of harm's way, it will need to surge unmanned maritime vehicles into the contested battlespace while its manned ships stay out of range of adversary A2/AD systems, sensors and weapons. Small and medium expeditionary USVs such as the MANTAS need a "truck" to deliver them to an area near the battlespace. This is where it is proposed to leverage the Navy's planned investment in the large, unmanned surface vehicles (LUSVs). This is how an October 2020 Congressional Research Service report describes this vessel:

"The Navy envisions LUSVs as being 200 feet to 300 feet in length and having full load displacements of 1,000 tons to 2,000 tons. The Navy wants LUSVs to be low-cost, high-endurance, reconfigurable ships based on commercial ship designs, with ample capacity for carrying various modular payloads—particularly anti-surface warfare (ASuW) and strike payloads, meaning principally anti-ship and land-attack missiles. Although referred to as UVs, LUSVs might be more accurately described as optionally or lightly manned ships, because they

might sometimes have a few onboard crew members, particularly in the nearer term as the Navy works out LUSV enabling technologies and operational concepts."[1]



Depending on the size that is ultimately procured, the LUSV can carry a number of T38 MANTAS unmanned surface vehicles and deliver them, largely covertly, to a point near the intended area of operations. The T38 can then be sent independently to do a number of the missions described in this paper such as expeditionary logistics, or alternatively, can launch one, or more, twelve-foot (T12) MANTAS to perform the ISR and IPB missions as described above. Building on work conducted by the Navy laboratory community, the T38 or T12 will have the ability to launch multiple unmanned aerial vehicles to conduct overhead ISR and IPB.[2]

For the MCM mission, the LUSV can deliver several T38s equipped as described above. These vessels can then undertake the "dull, dirty and dangerous" work previously conducted by Sailors who had to operate in the minefield. Given the large mine inventory of peer and near-peer adversaries, this methodology may well be the only way to clear mines safely.

---

[1] Ronald O'Rourke, *Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress* – CRS Report 45757

[2] See Vladimir Djapic et al, "Heterogeneous Autonomous Mobile Maritime Expeditionary Robots and Maritime Information Dominance," *Naval Engineers Journal*, December 2014 for a description of how an unmanned surface vehicle can launch unmanned underwater vehicles and unmanned aerial vehicles.

"Nesting the Dolls" CONOPS

Most people with any Surface Navy experience can think of a multitude of potential "Unmanned-Unmanned" missions that could be performed by multiple USV, UAV and UUV platforms working together, autonomously, in an integrated support environment. The mission considerations can span surface, anti-surface, anti-air, mine, anti-submarine, amphibious and expeditionary warfare areas. The scenario presented below is evolutionary in nature in that it builds on existing unmanned surface vehicle work and is well within the ability of a team of naval engineers and designers to adapt a family of USVs to meet the requirements of these scenarios. Given the recent strides in USV development, including craft already in design and fabrication, USVs designed to meet the scenario requirements presented below can be realized within the next few years.

Related Facts & Assumptions:

1) Operation Overlord is already in work and two prototype workboat-type LUSVs are operational in an autonomous scenario for technology, payload and CONOPS testing.
2) Six contracts have been awarded to a number of companies for detailed LUSV studies with the assumption that the best of these design criteria will result in a contract to build the first of the next generation of LUSVs. These are expected to meet or exceed the requirements as earlier stated.
3) A contract has been awarded to L3Harris for the design and fabrication of the first MUSVs, to be delivered by 2023, which are also expected to meet or exceed, the Navy requirements.
4) Eight contracts have been awarded by DARPA related to the development of "No Manning Required Ships" or NOMARS, designed from the keel up to take the human completely out of the onboard calculations.
5) The Sea Hunter trimaran MDUSV (formerly DARPA ACTUV) is being tested at Surface Development Squadron One in San Diego, and the next Sea Hunter class, the Sea Hawk, is currently in final process of final delivery
6) A number of other small to intermediate sized USVs are in operation both commercially and militarily within the international community. For the U.S. Navy, these include the Textron CUSV which is now a program of record as the MCM-USV for operations within the LCS MCM Module.
7) MARTAC has already proven the small USV, the MANTAS T12 craft, as a TRL9 craft with participation in multiple Army, Navy, USMC exercises and deliveries of quantity of five T12 to the United Kingdom Strategic Command, one to the U.S. Army Corps of Engineers in Portland, Oregon and one to the U.S. Navy CNMOC/NRL at Stennis Space Center, Mississippi. Additional craft are under lease to commercial industry.
8) MARTAC is in the process of completing its first next generation MANTAS DEVIL RAY Expeditionary Catamaran craft. This first-of-class prototype is a converted manned craft with a length of forty-four feet. Dubbed the T38E, it has already operated in excess of eighty knots in the July 2020 Trident Warrior exercise where it demonstrated its capability as an MCM mine detection/neutralization platform. It is currently scheduled to participate in the IBP-21 exercise in April 2021 where it will further demonstrate autonomous ISR, mine-laying and high-speed intercept evolutions.

9) MARTAC is in process of completing the final designs for the DEVIL RAY Expeditionary series of T24 (24 foot), T38 (38 foot) and T50 (50 foot) craft. Production on these vessels is expected to begin later this calendar year.

Setting the Stage:

This scenario is built around an Expeditionary Strike Group that is underway in the Western Pacific. This Strike Group includes three LUSV under supervisory control from a large amphibious ship. Supervisory control of these three LUSVs during normal underway operations is provided from a single control station on a single ship. The supervisory control station includes seating for a single operator who controls multiple USVs in addition to an adjoining sensor/payload operator for monitoring and controlling the mission sensors/payloads onboard each of the craft. A single supervisory operator station will be required for each LUSV during active Strike Group operations. Each LUSV is further configured with onboard multiple smaller USVs, UUVs and UAVs.

Each of the three LUSVs are carrying three or more, T38 DEVIL RAY craft configured with small USVs, UAVs, and UUVs for specific missions. Technical characteristics and configurations of the T38s for this specific sample mission are:

- *T38-ISR* outfitted with
    - Radar, EO/IR gyro-stabilized cameras and EW sensors.
    - Multi-beam echosounder/sonar lowered through the moon pool located just forward of the craft center of gravity (CG). The moon pool door opens on command and the sonar is lowered when on station for the ISR evolution. The doors stay open when sonar is lowered.
        - Moon pool doors remain closed during high-speed transit.
    - Two MANTAS T12 - each configured with thermal camera, passive EW Sensors and single-beam or side-scan sonar.
        - Autonomous launch and recovery design of the T12 from the T38 uses two twin rails on the aft lower deck of the T38. When commanded by the supervisory controller, the T38 performs an angular ballast-down-aft evolution to place the stern into the water and when commanded, allows the T12 craft to slide into the water. Recovery uses the same rails and a hook at the bow of the T12 to catch the recovery crossbeam which is attached to each set of the rails.
        - The MANTAS T12 is powered up autonomously when it is released. It is then monitored and controlled from a strike group supervisory controller. Communications relay may be required via the T38 to the LUSV to the command ship, depending on distance from the strike group.
    - Two to four UAVs (depending on UAV type/size). Preference will be given to UAV gyrocopters. due to the fact that while fixed wing UAVs can be launched from these vessels, they will not be recoverable on this size platform.
        - UAVs are mounted in the bow area rigidly attached to a launch/recovery point for the gyrocopters. They will be protected from wind and spray via shields and/or cover.

        - Launch and recovery is started on command from the supervisory controller.
            - Cover is removed autonomously.
            - The gyrocopter is started. Confirmed start is sent to the supervisory controller and to onboard command/control. Mounts are released autonomously, and gyrocopter launches itself
            - The gyrocopter is under supervisory control via comms relay to the strike group via the T38.
- *T38-MCM* outfitted with:
    - Radar, EO/IR gyro-stabilized cameras
    - High resolution multi-beam echosounder/sonar lowered through the moon pool. Moon pool door opens on command and sonar is lowered when on station for mine-detection evolution.
    - Aft mounted twin rails on the lower deck of the T38 which allows for an angular ballast-down-aft evolution to place the stern into the water and, when commanded, allows the T38 to stream and then recover one of the two tows mounted on the rails:
        - Sea Scout (or equivalent) mine-hunting UUV with high-res side-scan sonar
        - Mine neutralization system ROV
    - Streaming, including launch and recovery, is initialized by the supervisory controller. The mine-hunting and neutralization evolution is closely monitored in real time by an explosive ordnance operator onboard the strike group control ship. The operator will be seated on same console as the USV craft supervisory controller to ensure that the preset autonomous track inserted by the controller is followed by the craft and to make decisions, as required, regarding any mine-like objects that are detected by either the sonar or the streamed UUV/ROV.
- NOTE: Other configurations for the T38 could be added to the mix of T38s installed on the LUSVs. Differing sensor configuration that can be developed for the multitude of mission scenarios envisioned for a UxV-UxV evolution will be limited only by the imagination of Fleet operators.

Launching and Recovering of the T24/T38/T50 from the LUSV

This will be a technical challenge in itself and must be considered during the development of the Requests for Proposal for the design of the LUSVs.

Should the "Nesting Dolls" UxV-UxV approach as introduced in this paper be considered for use by the Navy, the final length and beam of the LUSV will determine how many smaller MUSVs, Expeditionary USVs and small USVs it can carry and where they should be placed on the deck. The configurations for each of the USV variants, as designed for the LUSV, will establish the best, and most efficient, autonomous launch and recovery technical approach. Considerations could be as follows:

- Modified A-frame aft
- Modified traditional 7m/11m cradle and over-the-side davit on multiple stations port and starboard
- Angled slides port and starboard over the side or aft over the stern

- Ballast system within LUSV to ballast it down to USV deck level for a direct drive-on/drive-off solution. Similar to the methodology as employed by Expeditionary Sea Base USNS Lewis B. Puller.

In considering the above options, it is apparent that the fourth option with the ballast down system may be the most effective for allowing the LUSV to autonomously carry, launch and recover USVs such as the Sea Devil T24, T38 or T50. The Expeditionary Sea Bases already are capable of carrying the LCAC hovercraft effectively because of the LCAC flat lower hull and hover skirts. As such, the T24, T38 and T50 catamaran, shallow draft, hulls would be ideal for autonomous launch and recovery from a flooded deck.

These are just some of the primary design implications that must be considered, specified and included in the final configuration for the LUSV.

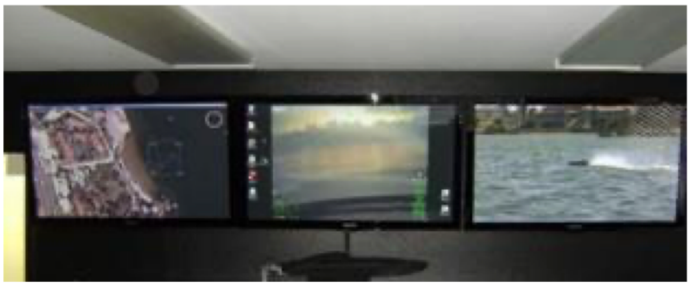
Operational Scenario for "Nesting Dolls" Mission

The Expeditionary Strike Group in the Western Pacific is on routine patrol about five hundred nautical miles from the nearest landfall. An incident occurs in their operating area and the strike group is requested to (1) obtain reconnaissance of a near-shore littoral area, associated bays and river accesses and (2) determine if the entrance to a specific bay has been mined to prevent ingress. The littoral coastline covers two hundred nautical miles. This area must be reconnoitered within twenty-four hours without the use of air assets.

Command staff decides to dispatch the three LUSVs for the mission. Two LUSVs are each configured with quantity of four T38-ISR craft and the third LUSV is configured with quantity of four T38-MCM vessels.

Operational Scenario CONOPS - *"Nesting Dolls"* Mission

- **Unmanned Transit under supervisory control of Strike Group**
  - Initially single supervisory controller for all three craft
- **LUSVs proceed at 25kts to a "launch waypoint" within 250Nm of shoreline (10hrs)**
  - Autonomous independent mission scenarios for T38-ISR and T38-MCM preloaded by controllers during transit
- **Two LUSVs each launch 2 of the 4 T38-ISR craft**
  - T38-ISR craft missions independently take each to locations nearshore about 50Nm apart from each other
  - Waypoint for ISR/EW scan starting location along shoreline
- **Third LUSV launches 2 of the 4 T38-MCM craft**
  - T38-MCM craft proceed independently along different routes to location for mine-presence evaluation
- **USVs proceed to initial start waypoints at speeds of 70-80kts – all set to arrive at same time**
  - On station within 4-5hrs of LUSV launch



The single supervisory control station for the three LUSVs remains manned in the mothership for the initial transit to the MUSV departure point, at which time, two others will be manned to provide further supervisory control.

The three LUSV depart the strike group steaming together, in a preset autonomous pattern for two hundred and fifty nautical miles to a waypoint that is central to the two hundred nautical mile ISR scan area, two hundred and fifty nautical miles from the shore. At this waypoint, the LUSV will stop and dispatch the smaller T38 craft and then loiter at this location for their return. Steaming at a cruise speed of twenty-five knots, the waypoint is reached in about ten hours.

At the dispatch waypoint, the two additional supervisory control stations are manned (now one per LUSV) and command is given by the supervisory controllers as follows:

- Two T38-ISR craft to be launched from each of the two LUSVs carrying the ISR craft. The autonomous mission previously downloaded specifies a waypoint location along the coast for each of the four craft. These waypoints are fifty nautical miles apart from each other, indicating that each of the four T38 craft will have an ISR mission of fifty nautical miles to cover.
- Two T38-MCM craft to be launched from the third LUSV. The autonomous mission previously downloaded has them transit independently along different routes to two independent waypoints just offshore of the suspected mine presence area where they will commence mine-like object detection operations.

- In this manner, each of the six craft will be transiting independently and autonomously to their next waypoint which will be the mission execution start point.
- Transit from the LUSV launch point, depending on route, will be about two hundred and fifty to three hundred nautical miles to their near-shore waypoints. Transit will be at seventy to eighty knots to their mission start waypoint near the coast. Transit time is between four and five hours..
- The plan is for each of the T38-ISR craft to complete their ISR scan in four to five hours each and for the two T38-MCM craft to jointly scan the bottom and the water column for the presence of mine-like objects in four to five hours at a scan speed of six to eight knots..

T38-ISR Mission

Operational Scenario CONOPS - *"Nesting Dolls"* T38-ISR

- **Second T38-ISR launches UAVs on Added Mission**
  - Supervisory payload controller sees in-shore situation that is suspect
    - Controller quickly makes up autonomous mission and downloads to two UAVs
  - Commands launch of two Gyrocopters configured with Cameras and EW equipment
  - T38 remains at location loitering in "ballast down" low signature configuration transferring real time visual/sonar data from UAVs to Strike Group – via LUSV if comms require it
  - UAVs complete mission, returns to T38-MCM location for autonomous recovery and latching to deck
- **ISR Mission Complete – T12 and UAVs Recovered**
  - T38-ISR craft both return to LUSV at high speed for autonomous recovery on deck of LUSV

Four craft fifty nautical miles apart proceeding in the same general direction to cover all sections of the ISR mission:

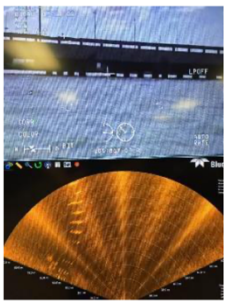
- ISR mission of each T38-ISR craft is at twelve to fifteen knots cruise speed.
- The supervisory payload controller/monitor sees all data (radar, camera, sonar) from the T38s under their supervisory control in real-time as the craft sees it. Depending on communications paths used, this data may be sent directly to the strike group from the T38 or may be relayed from the T38 to the LUSV, and then on to the strike group controllers.
- During the ISR scan, the payload controller sees a shallow water bay and river access area that he/she wants additional data on. The controller commands "stop" to one of the T38-ISR craft when it is adjacent to the shallow water area that needs scanning. The controller

commands autonomous launch of one of the two MANTAS T12 craft on that T38 which has already been preloaded with its autonomous mission. The T38 remains on station in loiter while the T12 performs its shallow water ISR scan. When complete, the T12 returns to the T38 where it is autonomously recovered. The T38 is then commanded to continue its mission and the supervisory controller adjusts ISR speed for the rest of mission to accommodate time lost with the T12 scan.

- During the ISR scan, a second payload controller for a different T38-ISR craft sees an area inshore that is suspect and wants to obtain more information on that area. When passing the suspect area, the controller commands "stop" to the T38 and further commands autonomous launch of two of gyrocopters that have already been preprogrammed for their mission. The UAVs are unlatched and launched autonomously and the T38 loiters on station awaiting their return. The UAVs send real-time video of the suspect area back to the payload controller on the ship via relay to the T38, then to the LUSV, and on to the ship. When the UAV mission is complete, the gyrocopters return to the T38 and, under laser guidance, are autonomously recovered and latched down on the craft.
- Upon completion of each of the four separate fifty nautical mile T38 ISR missions at their respective "mission complete waypoints," the craft are released by the controller to return to their LUSVs for recovery onboard.

Operational Scenario CONOPS - *"Nesting Dolls"* T38-ISR

- **Four T38-ISR are 50Nm apart proceeding in same direction at 12-15kts speed**
  - Plan to cover ISR coastal scan mission in 4-5 hours
  - Supervisory controllers view all radar, camera and sonar data in real time at Strike Group
- **T38-ISR launches T12 USV on Added Mission**
  - Payload mission controller sees shallow water bay and river access for further exploration
    - Controller quickly makes up autonomous mission and downloads to MANTAS T12 craft
  - Commands launch of MANTAS T12 configured with EO/IR Cameras and Side Scan Sonar
  - T38 remains at location loitering in "ballast down" low signature configuration transferring real time visual/sonar data from T12 to Battle Group – via LUSV if comms require it
  - T12 completes mission, returns to T38 location and is autonomously recovered.



T38-MCM Mission

Two craft arrive at waypoints near the underwater scan area

- The craft supervisory controller and the EOD operator work together to ensure that the area is adequately scanned. The craft controller sends a command to deploy the onboard sonar.
- Both craft open moon pool doors and deploy their respective high resolution multi-beam sonars.
- Upon further command from the supervisory controller, each craft deploys its SeaScout UUV tow for side-scan survey of the area
- Each craft has been programmed for the autonomous "lawn mowing" mine detection mission where the overall scan area has been split equally between the two craft.
- The EOD operator sees scan results of both onboard sonar and SeaScout tow-sonar in real time and has the ability to work with the supervisory craft controller to interrupt the autonomous scan to take a second or third pass at any detected mine-like object for further classification or identification.
- Upon completion of the underwater mine detection scanning, the SeaScout UUV tow is autonomously recovered, the onboard sonar is retrieved within the moon pool and the moon pool cover is closed.
- The two T38-MCM craft are released, by command, to return to their LUSV for recovery onboard.

Upon recovery of the six T38 on their respective LUSVs, the LUSVs are commanded to return to the strike group at twenty-five knots cruise speed.

The estimated time to return is ten hours .

The timeline for entire mission is as follows:

- LUSV detach strike group to T38 Launch point and launch six T38: – 10-12 hours
- T38 transit from launch point to mission ISR/MCM start waypoints: – 4-5 hours
- ISR Mission and MCM Mission time from start to complete: – 4-5 hours
- T38 transit from Mission completion point back to T38 for recover: – 4-5 hours
- LUSV recover T38s and return to strike group formation – 10-12 hours
- Mission complete

Effectively, even with the Expeditionary Strike Group five hundred nautical miles from shore, the strike group commander had the results of the ISR and MCM scan of the shoreline littoral area within twenty to twenty-two hours after the departure of the LUSVs from the strike group. The LUSVs were back on station in the strike group in less than forty hours, ready for the next mission scenario.

Shaping a Way Ahead

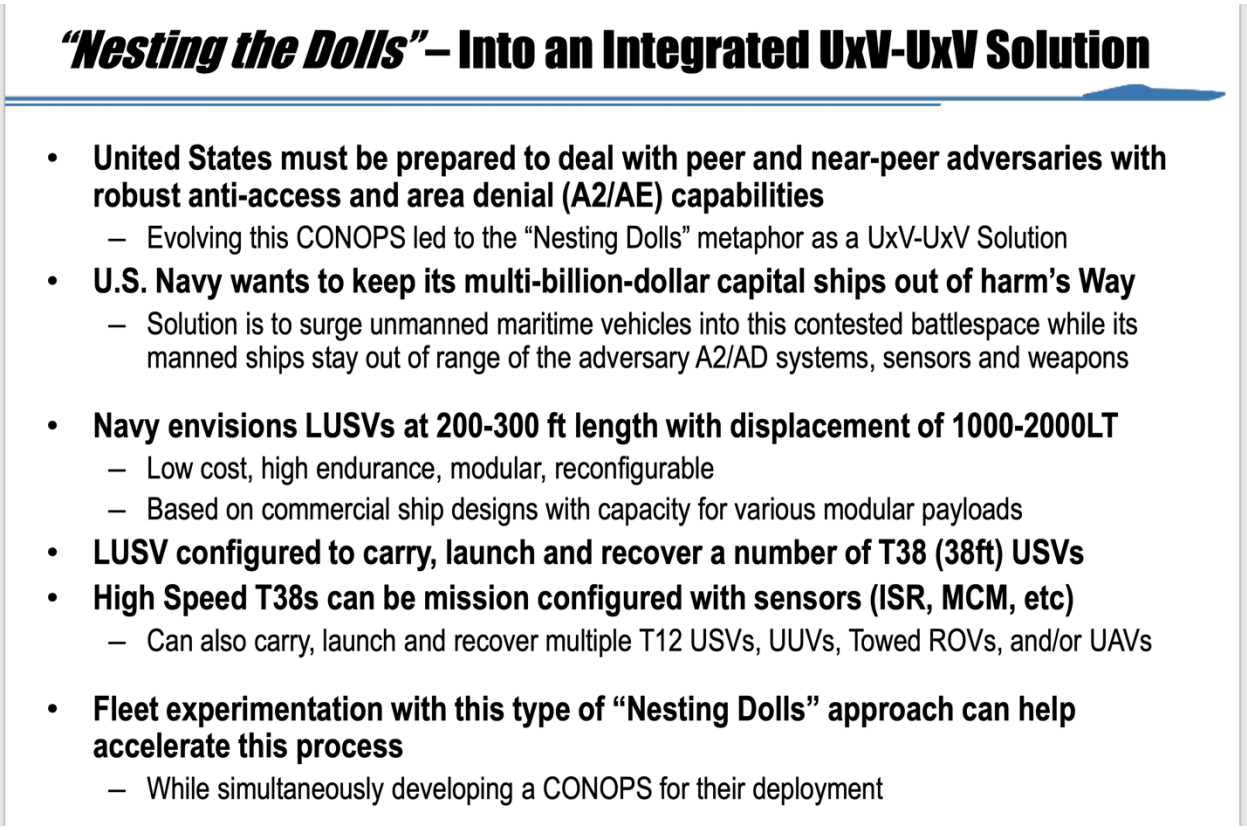
An effective mission that demonstrated the capability of a true multi-craft UxV-UxV "Nesting Dolls" approach that involved the following different class and size of UxVs:

- Three (3) LUSV
- Six (6) Devil Ray T38 Expeditionary USVs (4 ISR and 2 MCM)
- One (1) MANTAS T12 USV

- Two (2) gyrocopter UAVs
- One (1) SeaScout towed UUV

Each of the above UxVs, as depicted in the scenario, are already either:

1) Operational and in use
    a. MANTAS T12
    b. Gyrocopter UAV
    c. SeaScout towed UUV
2) Under contract for final design and fabrication
    a. LUSV
3) In final design and development by a commercial company with prototype nearly complete
    a. Devil Ray T38 Expeditionary USV (The T38E prototype is already in use in Navy exercises)



The con-ops is clearly conceivable; the technology is here to execute the con-ops.

Experimenting with this Nesting Dolls approach can help accelerate this process while simultaneously developing a concept of operations for their employment.

"Nesting Dolls" Mission Timeline & Summary

- **Expeditionary Strike Group Mission Timeline Completed**
  - LUSV detach Strike Group to T38 Launch point and launch six T38 → 10-12hrs (250Nm)
  - T38 transit from Launch point to mission ISR/MCM start waypoint → 4-5hrs (250+Nm)
  - ISR Mission and MCM Mission time from start to complete → 4-5hrs
  - **Data sent back to Strike Group in Real Time – all data received within <u>18-22hrs</u>**
    - 24hr mission timeline for data collection and delivery to Strike Group was met

- **Sample CONOPS "*Nested Dolls*" Unmanned Systems are available today**
  - Operational and in-use today at TRL8 and above
    - MANTAS 12
    - Gyrocopter UAVs
    - Sea Scout towed UUV
  - Under contract for final configuration with design and fabrication contract to follow
    - LUSV
      - Operation Overlord in progress could serve interim LUSV solution
  - In final design and development by commercial company – prototype nearly complete
    - DEVIL RAY T38 Expeditionary Class USV
      - T38E prototype is showing good potential within scheduled Navy exercises