Sea-launched TacSats for Responsive Space (STaRS)

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Lt Col Robert Carneal (SMC/XRDP) & Mr. RayMing Chang (SMC/CDE)
robert.carneal@losangeles.af.mil & rayming.chang@losangeles.af.mil

U.S. Air Force

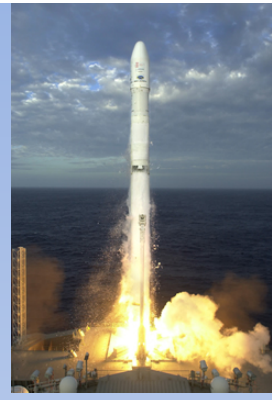
Definition

- DoD defines Operationally Responsive Space (ORS) broadly as assured space power focused on timely satisfaction of Joint Force Commanders' (JFC) needs
- The ORS Plan categorizes space assets into three tiers:
  - Tier-1: On-orbit (current assets leveraged and prioritized for warfighter)
  - Tier-2: ORS assets in ready reserve; ready for launch or deployment
  - Tier-3: New assets rapidly acquired to meet specific COCOM/User need
- A STaRS system would launch Tier-2 assets

Premise

- Space Operations planners from the commercial sector to military applications desire responsive satellite systems that are multi-mission capable, easily and inexpensively produced, smoothly integrated, and rapidly launched
  - This emphasis demands shifting the launch paradigm to one that truly enables access to space
    - Provide tactical deployment on demand
    - Provide capability to put current payload technology into orbit, versus several years by today's standards
- Today’s launch paradigm overly constricts the opportunity window to meet commercial sector needs and military demands
  - STaRS system would address many of the problems associated with limited launch pads at fixed sites, including issues with “possible” launch pad availability due to competing program priorities as opposed to having a definite launch date

A Beginning. . .



Equatorial Launch by Sea Launch
(source: fcc.gov)

- Sea Launch has already shown the feasibility of sea-based launches
  - Converted oil rig and associated command ship process only one launch vehicle at a time
  - Suffers from some of the same latencies associated with land launches
- Sea-based launch can take advantage of positioning to optimize mission profile
  - Equatorial launch takes advantage of Earth's angular momentum in order to launch larger payloads than possible at other latitudes

Another Step. . .

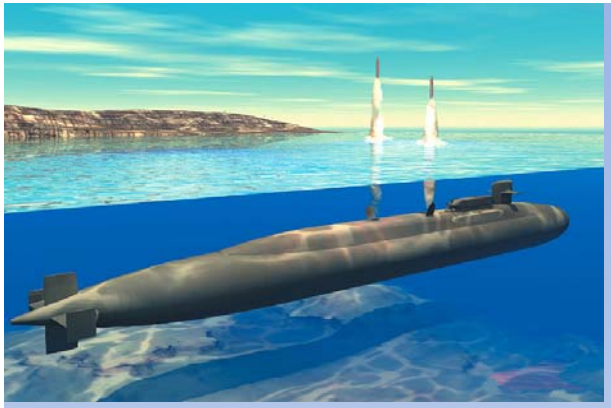
- Russia began pioneering sea-based launch for commercial practices
  - May 2006 successfully launched Compass-2 micro-satellite from Yekaterinburg submarine positioned in Barents Sea using a Shtil booster rocket
    - Russian launches from Barents sea because of range issues
  - Conceivably, Russians could probably perform an equatorial submarine launch of a 100kg satellite using a Shtil
- If submarine launch is just as expensive as the historical average of $10k / lb of payload placed in orbit, then there's no need for further consideration
  - Novomoskovsk K-407, submarine of Russian Northern Fleet's 3rd Flotilla, launched two German satellites into orbits ranging from 250 to 500 miles above the Earth
    - Both were nanosatellites, one weighing 18 lbs and the other 7 lbs
  - Northern fleet reportedly paid $111,000
    - Equates to $4,440 / lb

Refinement

- Russia has continued refining its submarine launched satellite concept
  - Volna, a liquid two-stage rocket, is 46 feet long with a diameter of 6 feet
  - Delta III or IV class submarines are used as the platform
  - Volna has capability to place 115 kg into LEO from an equatorial launch site with a maximum volume of 1.3 cubic meters

The Next Step

- Most commercial and military payloads would require satellites of considerably larger size than Category 1 (10 to 100 kg)
- Payload size on a single sea-based launch vehicle would not likely achieve the heavy class [Category 3 (500kg plus)] in modern satellites
- Small to medium payloads [Categories 1 and 2 (100-500kg)] will likely be ideal for sea launches



Artist Conception of a SSGN Tactical Trident outfitted to launch Tomahawks, UUVs, UAVs (U.S. Navy Image)

Submarine Launch

- Borrowing from existing submarine missile launch technology and adapting it to STaRS is plausible
  - Trident II used in Navy's boomers is 44 feet tall with a diameter of 6 feet and 2 inches
  - For comparison, Delta II, used to launch GPS satellites, is 125 feet 9 inches in height with a core diameter of 8 feet, and a fairing diameter of 9.5 feet
  - Tridents could be retrofitted to lift payloads of less than 100kg

Ship Launch

Artist Conception of a cargo ship performing a small vehicle launch (Image credit: Christopher Doray)

- Converted oil tanker (or equivalent class) could be used for sea-based launch by blending concept of submarine lift with payload sizing consideration
  - Mid-size oil tanker can measure 967 feet long and 166 feet wide
  - Ballistic missile submarine can measure 560 feet long (about 60 % length of a mid-size oil tanker)
- Borrowing from existing submarine technology, a converted ship would have the capacity to use a silo approach on a larger scale than a submarine
  - Silos would provide a shield against the environment, and could even extend above the top deck, presuming proper ballast exists below the water line for stability
  - Silos could be sized larger than possible on a submarine, allowing for larger boosters

Options

- In order to balance real estate with payload lift capacity on a mid-size oil tanker class (or larger) for STaRS, then a new launch vehicle could be sized between Trident II and Delta II dimensions
- Another approach would be to use existing Delta II launch vehicles, and position the STaRS launch tubes down the center line of the ship

Applications (1 of 2)

- Launching to LEO would not be a limiting factor if satellite missions require another orbit
  - By first inserting a payload to LEO, coupled with near simultaneous launch of a payload assist module—docking on orbit of this follow on module could provide the taxi ride to final insertion
  - Payload assist module technology already exists, and was designed to transfer payloads to geosynchronous orbit
    - Successful use of this concept has been done for both Space Shuttle missions and Delta class launches

Applications (2 of 2)

- Tactical sea-based launch capability could provide a niche to augment military applications
  - Communications and intelligence gathering as demands surge during conflicts
    - These dynamic, real world events will not wait for traditional launch processing cycles
- Short lived satellites with a mean mission duration of six months to a year could quickly augment space-based resources
- In the near future, sea-based launch could also handle routine, smaller payloads to include launch profiles that are otherwise too restricted on land due to the need for avoiding dropping expended stages on the population
- A payload assist module could be launched separately in order to boost a given payload to its final insertion point—sea-based launch could provide these complementary launches within a short time
- Sea-based launch could help free up precious land-based pads for medium to heavy class launches

Mission Implications (1 of 2)

- Possible that the ability to rapidly replenish a satellite constellation may provide deterrence to the use of Anti-Satellite (ASAT) systems by adversaries
  - Ohio-class submarine with 24 GPS-like small satellites could ensure the U.S. continues to have essential space-based navigation capabilities over very limited latitudes
  - Since 24 satellites is the minimum goal for an operational GPS constellation, then STaRS could posture for rapid replenishment, effectively countering ASAT denial
  - Normal replenishment could occur periodically from STaRS in order to maintain mission proficiency, make use of the existing GPS-like payloads, then reload with upgraded GPS-like satellites

Mission Implications (2 of 2)

- Rapid replenishment of a communications satellite constellation is also feasible
  - Orbcomm satellites are 142kg and a constellation of 29 Orbcomm satellites covers most of the earth
  - Theoretically, a submarine with 24 silos that has the capability of launching 150kg payloads to orbits of approximately 900km could possibly repopulate most of an Orbcomm-like communications constellation if ASATs were to destroy them

Challenges

- Unique challenges compared to land-based launches
  - Home port must be established to provide logistical transfer of rocket bodies and their payloads
  - Security must be maintained at the appropriate level for the payloads
  - Transit time to and from port is a consideration for launch cycles, and would therefore drive a recommendation for a minimum of two sea-launched TacSats for Responsive Space (STaRS) platforms
    - While one STaRS ship is in port either for maintenance or receiving new launch vehicles and accompanying payloads, the other STaRS ship can be at sea
- STaRS systems would require a down-range ship or platform to provide for mission control and range safety
  - Significantly, the U.S. could leverage the use of Unmanned Aerial Vehicles to provide range services
  - Another consideration will be developing appropriate flight termination systems, which could be developed from current systems for missiles

Future Potential

- Satellites could be designed as modules, similar to plug-and-play devices already produced with computers
  - Master module containing some fuel, thrusters, docking sensors, universal docking, and on-board computing could be launched along with modules necessary to assemble and play on orbit
  - Master module would maneuver to dock with its other modules, to include items such as a fuel module, sensor suite, communications package, on-board mission processors, and solar arrays
  - Master module would boot up the on orbit assembled payload package and run through diagnostics
    - If a module did not pass, then that module would be disconnected and allowed to be disposed of through burn up on reentry—master module would await a replacement piece and STaRS could provide the responsive replacement launch
    - Once the new piece is inserted into orbit with the master module, the new piece can be assembled for play on orbit—payload assist module(s) could be used for insertion to final orbit
- Note that assemble and play on orbit opens up the possibilities of payload sizes even larger than today's heavy class satellites
  - Final on orbit assembled designs would not be limited to faring sizes—the construction itself need only survive the space environment

Questions?