> bluetree700:
When you put it that way, it seems like any US SSN/SSGNs operating in the first island chain is very low probability. That makes me wonder what exactly would the role of US submarines be in the onset of a theoretical hot war between the US and China. If they can't immediately operate within the first island chain, and I assume engaging a CSG is equally suicidal, then what vulnerable Chinese military or civilian assets would they be able to hit in the onset of such a war? Or would they wait until PLA ASW capabilities were sufficiently degraded enough before acting in full force?

There are a few things that they can do. Firstly, they can be TLAM trucks. All 688 flight iis and 688is, and all Blk1-4 VAs have stores for 12 vertically launched TLAMs (CLS Mk45 Mod 1s, but converting to Mk45 Mod 2s) and, of course, the Ohio SSGN converts host enough space for 154 TLAMs in their CLS Mk45 Mod 2s (also called MACs, for Multiple All-Up-Round Canisters). They can also *theoretically* launch via torpedo tube (this is NOT typical, the TACTOM's F415-WR-400/402 engine caused a notable delay in development that led to them never sorting out some kinks in TACTOM's tube-launch capability - and thus it's for all intents and purposes they're not desirable for tube-launching unlike TLAM BlkIIIs - even in the TACTOM specific Capsule Mk3 Mod 0s for tube-launching), but this isn't really worth considering these days; *especially* not in higher maritime threat environments (A Mk48 ADCAP/CBASS is way more bang per buck to store even if TACTOMs were flawless in the tubes). You probably saw my post regarding TLAM quantities in theater (which, for those who might not know, usually hovers anywhere from 300-350 at any given time, but can get up to ~400 or as low as 250 barring exceptional circumstances), and the ~8ish SSNs + 1 SSGN we can keep IVO the PRC provide a respectable volume of fires in their own right (~250 TLAMs).

Before we go any further, it's really important to get into the nitty gritty about how the Tomahawk Weapons System actually works. To be candid, I don't meet too many people who know much about it beyond "it does the shoot missile then mr deadly telephone pole performs a NYOOM to target via the missile knows where it is and then when missile becomes missile ***at target*** it performs KILL KILL KILL KILL via explodey tip," which is a problem. Without an understanding of the system as a whole, it becomes pretty easy to underestimate the sheer complexity and sophistication of TLAM strike operations. Due to this propensity, many people overstate the effectiveness of the weapons system while also thoroughly understating/ underestimating how impressive it is to achieve even that lesser degree of effectiveness at all. In order to get any and all misunderstandings out of the way, and to ensure we're operating at a baseline level of TWS "system" knowledge... it appears it is time for a lengthy session of Patchwork_Chimera Academy! This time, we'll be doing an *abyssal-depth* deep dive into the Tomahawk Weapons System, including all of the nitty gritty overlooked bits. Make sure to go get a glass of water (right now!!!), since it's

important to stay hydrated while ingesting and processing new information, and plus it keeps you healthy!

The Tomahawk Weapons System (TWS) is a lot more than just the missile, contrary what most people seem to think (and what dogshit sim software like Command: Modern Operations would have you believe, but that's a rant for another time). Unfortunately PMA-280's Tomahawk Cruise Missile Technical Manual is Distribution D, otherwise I'd just throw it up on here so you folks could follow along (and it also means I can't cite anything from it that isn't also publicly available which blows, because it means I have to go look for a source for EVERYTHING to make sure I'm not posting anything that'll get me in trouble - which is harder than you might think as a TLAM Mission Systems SME :/). With that said though, I have been told Revision 15 is floating around out there if anyone is up for a ~40% outdated 300 pages of very boring reading.

TWS is comprised of the following major components:

- **TACTOM AUR (Tactical Tomahawk All Up Round)**- This is the physical component of the TWS, and is by far the most well known of the TWS subsystems - being the part that everyone sees when anything to do with a Tomahawk occurs. However, there's a lot more than meets the eye, and it's a pretty impressive piece of kit. The following are the major subassemblies which comprise the AUR:
    - **TCM (Tomahawk Cruise Missile)**- This is the "sharp-end" of the TWS stick, and is typically what people think of when they think of Tomahawks. Listed are the major subsystems of the TCM:
        - ***WDU-36/B Warhead*** - Fairly self explanatory, it's 1000lbs of PBXN-107 high explosive
        - **Forward Body Segment** - This is mostly structural, contains ~450lbs of JP-10, and hosts most of the retention apparatus for the warhead, as well as the cute chine-pilled nosecone
        - **Mid Body Segment**- This is a pretty important bit, hosting important bits of the guidance/navigation apparatus, the wings, and is the big beautiful "tube" part of the munition. Listed are the subcomponents within the Mid Body Segment:
            - 436lbs of JP-10 in three tanks of varying size
            - ***IMU (Inertial Monitoring Unit)*** - Pretty much what it sounds like, it's 3 accelerometers which generate the raw inertial data (linear accel, rotational angular rates) to be sent to the Navigation Processor for inertial guidance
            - ***DIU (DSMAC (Digital Scene Matching Area Correlator) Illuminator Unit)*** - Neat coverage-optimized flash illuminator that produces lighting for the DSMAC IV system during night strikes

        - ***Radar Altimeter Antennae*** - These are on the belly, and the fore antenna receives reflected radar pulses xmitted by the aft antenna, with which the altitude is computed and sent to the Mission Control Processor
- **Aft Body Segment** - I'm generally a butt > boob kinda guy, so this is my favorite on principle alone - but it also earns the #1 spot by being the neatest and spiciest portion of the missile. It hosts most of the essential mission systems and electronics, as well as (obviously) the powerplant and associated retention components. Listed are the major subcomponents of the Aft Body Segment:
    - Like 100 or so pounds of JP-10
    - ***Williams International F415-WR-400 Low-Bypass Turbofan Engine*** - This is a pretty neat engine actually, people really gloss over these sorts of things, and it's unfortunate. It puts out ~3.5kn (~750lbs) of thrust (on a good day) at a ~9-10:1 TWR (again, on a good day) and hosts a 4kw internal alternator as well as an AVCC (Alternating Voltage Control and Coordinator) system for power-delivery redundancy and as a source of engine-speed data. It's ignited through a pyrotechnic ignition cartridge, and hosts its own exhaust system as opposed to requiring a more complex integration with the rest of the TCM. Interesting fact, in 2003/4 AEDC worked with Williams to develop a UCC (Ultra-Compact Combustor) to replace the Annular Folded Combustor in the baseline F415, which achieved an *89%* improvement to LBO (Lean Blow-Out) resistance, and occupies almost 70% less volume. This allows for a significantly wider stable-thrust envelope, and without specifying: ***if*** something like this were incorporated (:P) it may be beneficial in, say, a munition that sports loitering capabilities as a core selling point.
    - ***Fins*** - Not super exciting, but there are 3 (unlike the Blk 1-3 Tomahawk's 4) foam-core fins that deploy over about a quarter of a second during TLAM launch. These, like the rest of the TCM, are engineered with RCS in mind; and thus are unlikely to generate an overly-significant return.
    - ***GEU (Guidance Electronics Unit)*** - This is the (highly spicy) cluster of sensors and electronics that are responsible for generating, processing, and applying targeting and TCM situ-data to generate control surface steering outcomes and get the TCM going where it needs to go. Listed are the (many) subsystems in this cluster:
        - ***ADM (Air Data Module)*** - Analogue sensor responsible for determining ambient air temperature

and current altitude (kinda like a pitot) which sends digitized

- ***Anti-Jam GPS Antenna*** - This is a 5-slot frequency-discriminating UHF antenna that receives Military GPS data on 1227 and 1575 MHz (these are the L1 and L2 GPS signal frequencies). Notably, this antenna is being replaced as part of the TACTOM recertification process's NAV/COMM (previously A2/AD) upgrade package for TACTOMS transitioning to Blk V standard. Without getting into specifics, it notably increases GNSS viability within EW-saturated environments, though it's still *highly* debatable whether it would remain operational a WESTPAC transit (I and the majority of OR/SAbros I respect believe it would not, as EW is a core strength of the PLA and their counter-space apparatus is pretty spooky), and it is basically a given that a platform-level EA effort would make it utterly untenable with the current GPS IIR-M and even with the newer Block III GPS satellites (which will only reach full operational capability for the military in ~2023) and their directional xmit capability - there's a vanishingly small chance that we'll be able to leverage GNSS at will. The Block IIIF lineup will be better for sure, but the first payload (SV-11) is only expected to be ready for a launch vehicle (which is just the point at which it *can* be launched, not when it will launch) in ~2026.
- ***AGR (Anti-Jam GPS Receiver)*** - This takes the previously mentioned GPS Antenna's input and performs the actual "backend" handling of that data. It's a single channel sequencing, dual-freq (the aforementioned 1227/1575MHz) receiver for P(Y) code transmissions (aka it can parse encrypted signals generated by taking normal, publicly available P-code, and applying a super-duper secret W code to that signal (you can find publicly that this is an XOR applied at ~500khz), producing an encrypted, more spoof-resistant P(Y) code). Of note, as I mentioned before, the AGR and Antenna are being replaced/improved as part of the NAV/COMM upgrade package, and one of the aspects of this change is the ability to receive the much superior M-code that GPS Blk III satellites transmit with their directional antennae. OCX (next generation Operational Control system software) and M-code are slated to reach full operational capability late this

year, which is a big deal. It'll provide a much larger bandwidth, much less significant lobes, up to a *~20db* in signal strength (~100x the power), and some other neat benefits. While, as I said, this is unlikely enough to ensure GNSS reliability in a contested environment, it's a step in the right direction and SORELY needed given how incredibly fragile the Blk II+ P(Y) system is in comparison.

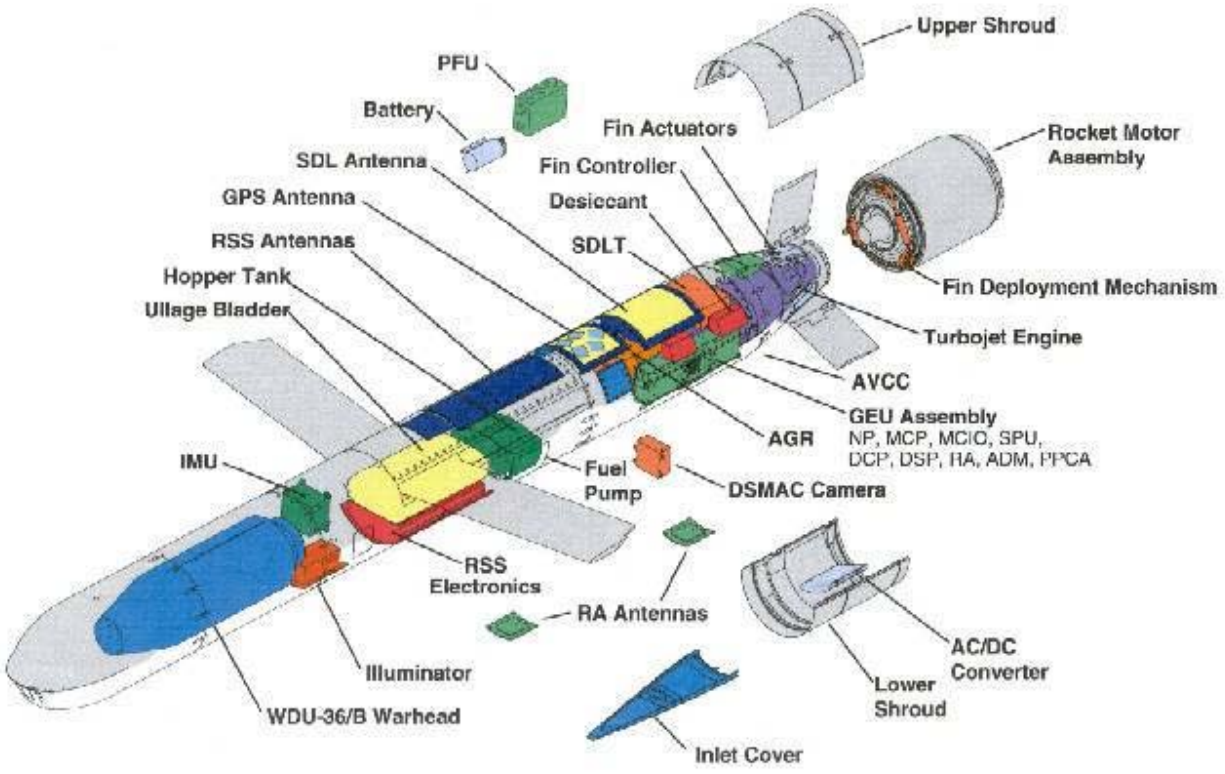
- ***DSMAC (Digital Scene Matching Area Correlation) Processor Subsystem*** - This is the logic apparatus for the DSMAC IV system, consisting of the DCP (DSMAC Control Processor) and DSP (DSMAC Signal Processor). The DCP is responsible for communicating with the DSMAC illuminator, sensor, and telemetry to communicate meaningful aimpoint error and subsequent corrective control outcome data from the information it has been given by the DSP, which is responsible for handling DSMAC sensor data, parsing it, comparing it to onboard-stored scenery data, and relaying the measured degree and nature of dissonance to the DCP. Of note, the stored target imagery can be either loaded onto the TCM through TTWCS's (Tactical Tomahawk Weapon Control System) mission planning/targeting/whatever systems, or it can be transmitted while in flight through the satellite datalink used for sending missile health, position, and other updates. Of course, this is true so long as the satellite datalink remains functional, and it is "structurally" possible - i.e. the launch platform or TSC (Tomahawk Strike Controller) as part of a broader strike operation both *has* that imagery, and is capable of transmitting that imagery to underway TACTOMS.
- ***DSMAC Sensor Assembly*** - The "Input" portion of the DSMAC scene-matching system (which, succinctly, is a similar system to TERCOM, but is used for terminal guidance onto a target which the TCM has an onboard set of images of (including surrounding scenery), and which are compared to images gathered by the TCM in its terminal phase to generate course/elevation corrections for lower CEPs), which is an optical greyscale camera (as of DSMAC IV). This sensor can also be used in conjunction with the Tomahawk's satellite datalink to transmit BDA imagery of previous TLAM impacts prior to its own impact.

        - ***MCIO (Mission Control Input/Output)*** - This is essentially a connectivity manager that handles the interface between the MCP (Mission Control Processor) and various air-data, guidance, and communications subsystems such as the FCS, TVC System, Air Data Module, Satellite Data Link Terminal, Radar Altimeter assembly, etc. This card has actually been upgraded pretty recently, I think it was in like 2014 or so.
        - ***MCP (Mission Control Processor)*** - This is kinda the "brain" of the TCM, and handles all "high level" functions throughout the munition. It manages the other subsystems, monitors their activity and data to dynamically optimize other subsystems' operation, handles all the autonomous launching activity, controls the Satellite Data Link Terminal, and is where the operational flight software is hosted (responsible for the "thinking" involved in controlling its flight)
        - ***NP (Navigation Processor)*** - Pretty neat ASIC (Application Specific Integrated Circuit, basically a chip built and optimized to do one thing really really well) that takes all the air, control surface, engine, guidance (tercom/dsmac), altimeter, etc. data and parses it into an executable navigation/guidance solution for the MCP to execute
        - ***PPCA (Pyro and Power Control Assembly)*** - Super boring bit that basically just handles the missile's pyrotechnics (motor ignition, engine startup, warhead kablam)
        - ***RAPU (Radar Altimeter Processing Unit)*** - This takes the returns from the Radar Altimeter Antennae we talked about in the Mid Body Section, parses that data into a meaningful altitude, and sends the data to the MCP via the MCIO for use in the NP
        - ***SPU (Secondary Power Unit)*** - Yet again, another "duh" subsystem. It's responsible for receiving power from the PFU (Power Filtration Unit) and distributing it to the individual components of the GEU cluster
    - ***CMA (Cruise Missile Airframe) Battery*** - Nothing super special here. It's a pretty standard pyro-Li thermal battery that outputs DC to the PFU (Power Filtration Unit) for distribution to mission systems
    - ***FCS (Fin Control System) + Fin Actuators*** - It's pretty much what it says on the tin. The MCP (Mission Control Processor) generates commands for the FCS, which

executes those commands and actuates the Fin Actuators to achieve a desired aerodynamic configuration.
        - ***PFU (Power Filter Unit)*** - Another "no kidding" subsystem. This one handles input power - be it from the Mk.41/45s pre-launch, or from the alternator/avcc post-launch - and isolates, then distributes that power to subsystems appropriately such that they're protected from any power generation peculiarities.
        - ***SDLA (Satellite Data Link Antenna)*** - This is what it sounds like, a single cross-slot conformal antenna with a frequency selective coating that operates at 256MHz and 296MHz to use the 5 and 25kHz SATCOM channels.
        - ***SDLT (Satellite Data Link Terminal)*** - This is the "processor" bit of the satellite datalink, and it operates in the traditional DAMA (Demand Assigned Multiple Access) UHF channels within GIG's (Global Information Grid - the DOD's system of nodes and relays in space, on/underwater, overland, etc. that facilitate information transfer and communications) MUOS (Multiple User Objective System) constellation, which are the narrowband UHF satcom component of the GIG, and which are replacing the older, much less capable UFO (UHF Follow On) constellation of '90s vintage
    - **Mk 135 RMA (Rocket Motor Assembly)** - Sorta technically part of the TCM, but I usually hold it as a slightly separate component personally. It's pretty much much what it sounds like. Mk.135s are about 600lbs, have jet-jab actuated TVC (Thrust Vector Control), are loaded with ~320lbs of Arcadene 360B HTPB for the burn, and sport connections to the Mk14mod2 canister to receive ignition, azimuth, etc. commands)
    - **Mk 14 Mod 2 Canister** - This is what the TCM + Mk 135 RMA assembly is contained in when loaded (it's encanistered within Mk 10 Canisters at depots, and loaded into Mk14s when it comes time to stick one in a ship or submarine) - and is the component responsible for interfacing with the Mk.41mod0/2's or Mk45mod1/2's launch control unit during launch operations. The Mk14 Mod 2 also has a bunch of neat electronics which can report TCM health, immediately declare ignition/launch failures, and communicates other stuff to the Mk.41mod0/2's mk211mod0/1 LCU (Launch Control Unit); and it handles/communicates to the TCM all of the commands given to it by the Mk 211 during targeting and launch operations

      NOTE: You'll hear more about those Mk 211 LCUs in future so keep them in the back of your mind

Anyhow, here's a nice image that shows what all this looks like put together

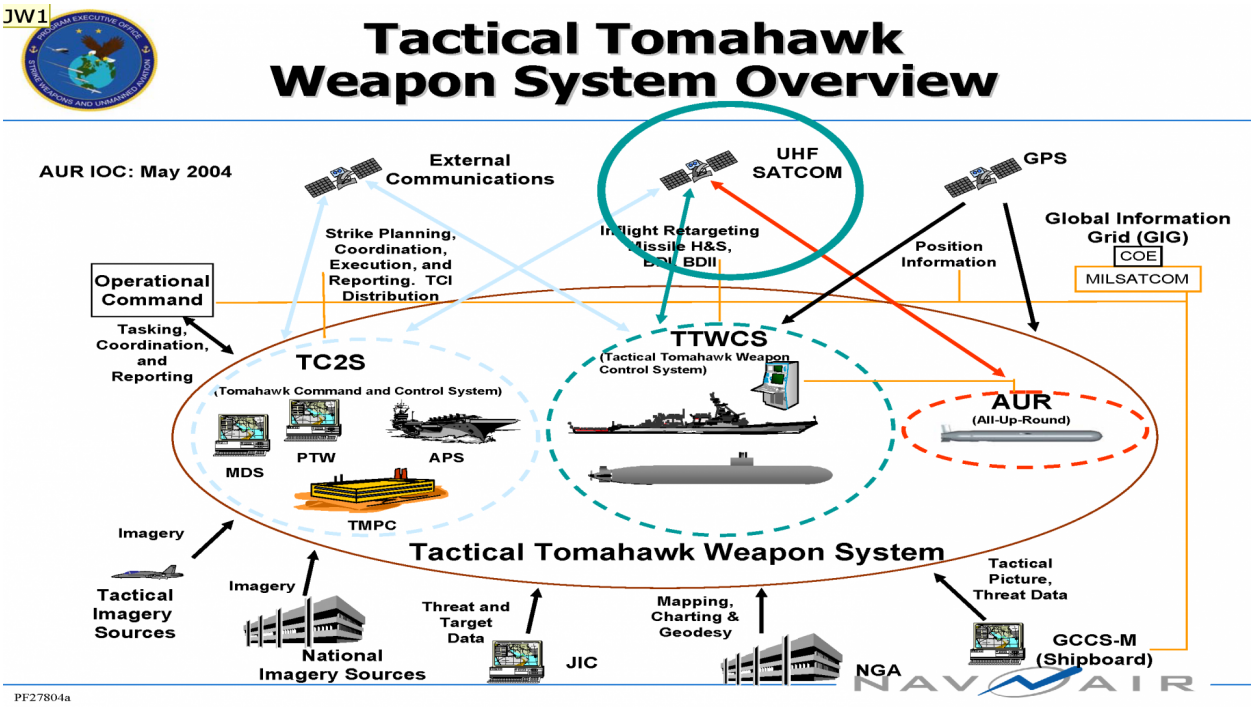


- **AN/SWG-5(V)6 TTWCS (Tactical Tomahawk Weapon Control System)** - TTWCS is the suite of systems aboard TACTOM launch platforms which facilitates the "execution" phase of TLAM strike missions. It what TWS operators interact with, how physical munitions aboard firing units are assigned to targets, which targets are assigned as primaries and which are designated as alternates (TACTOMs are capable of launching with up to 15 alternate "flex" targets), how transit-phase C2 is conducted, how terminal BDA imagery is received, and interacts directly with AEGIS - or AN/BYG-1 CCS (Combat Control System) in the case of Submarines - to coordinate and execute TCM launch operations. With newer iterations of TTWCS (another new version actually just got rolled out in 2017, but it's not aboard all vessels quite yet) there is a limited (but definite!) ability to plan TLAM launches aboard any given firing unit, as opposed to requiring either pre-planned strike plans or relying on TC2S's TAPS (Tomahawk Afloat Planning System) aboard CVNs for dynamic strike planning. Of note though, non TAPS/TMPC/SMPC (Tomahawk Afloat Planning System/Mission Planning Center/Mission Planning Cell) missions are unable to use TERCOM and DSMAC, and cannot be assigned flex targets (GPS only!!). Through TTWCS, Strike Controllers (at a centralized facility) or Missile Controllers (aboard individual launch units) are able to send aimpoint coordinate updates, and (for Missile Controllers, these have to be TLAMs launched by their vessel) can switch to one of the 15 alternate outcomes planned for the mission (basically,

changing around the targets and munition assignments mid-salvo).

- **TMPC (Theater Mission Planning Center)** - Previously referred to as TC2S (Tomahawk Command and Control System), TMPCs are responsible for operational level Tomahawk strike organization. This side of TWS ops conducts targeting, weaponeering, target allocation, salvo command and control, and handles distribution of the strike missions that are generated. TMPC architecture is principally designed around being able to handle high-volume strike mission generation in dynamic threat environments, and is a *very*scalable system employed at a multitude of echelons and aboard a variety of platforms. Listed are the various TMPC implementations and their differentiations from one another:
    - CMSAs (Cruise Missile Support Activities) - The two CMSA facilities (CMSA-Pacific, headquartered in Pearl, and CMSA-Atlantic, headquartered in Norfolk) are large, land based mission planning centers with all the software and hardware bells and whistles. Large planning volumes, large planning "scope," and the ability to rapidly distribute strike missions to fire units in their AOR (previously done via MDS (Mission Distribution System) as a part of TC2S)
    - TSMPCs (Tomahawk Strike Mission Planning Cells) - TSMPCs are a numbered-fleet level planning body (5th, 6th, and 7th Fleet have them iirc) with their own spicy TMPC configuration, and largely fill a similar tole to CMSA facilities, though not always at the same scale.
    - CSGs (Carrier Strike Groups) - Formerly(sorta? the nomenclature is still used to distinguish a CVN's TMPC facilities from like, crudes tmpc facilities) TAPS (Tomahawk Afloat Planning System) as part of TC2S, Carrier Strike Group level TMPCs are highly versatile, though scaled down, TMPC facilities. They're responsible for generating and distributing TLAM strike mission information to their subordinate employment platforms. This is pretty much the lowest-level planning suite to leverage all of TACTOM's capabilities
    - Launch Units (CG/DDG/SSN/etc.) - Per-launch-unit TMPC planning suites are integrated into TTWCS to provide a degree of autonomous planning capability to vessels operating disaggregated from a major strike mission data provider, but who still need to conduct dynamic strike ops. Missions planned aboard these platforms are restricted to GPS navigation, no flex targets, and other restraints which I've mentioned before.

At a high level, here is what the Tomahawk Weapons System looks like as a whole system-of-systems (courtesy of a terribad old NAVAIR powerpoint slide, which I should note - TC2S is, as previously mentioned, what we now just call TMPS):



The Tomahawk Weapons System is *seriously* complex, and places a non-insignificant logistical burden on the overall force structure. This is a ***major major*** factor when it comes to how we model TLAM employment. To get an understanding of how strike missions are actually *executed* with the TWS, I'll run you through the general order of events aboard a launch unit when generating a TLAM salvo.

TLAM strike missions are split up into 6 major phases:

- Pre-Launch
- Launch
- Boost
- Transition
- Cruise
- Terminal

These phases vary in nature between launch platforms (surface vs subsurface), mission types (dynamic vs deliberate), and target traits (can't hardly run a lo-lo profile when launching at the edge of the munition's range). As such, we'll go over a deliberately planned strike mission, and will briefly touch on how a dynamic mission would differ afterwards.

Pre-Launch+Launch:

Aboard the launch unit, TACTOM strike mission data is either received or retrieved from a disk aboard the launch unit. This strike mission data will be comprised of trajectory data, TERCOM and DSMAC reference imagery, mission definition metadata, BDAI capture points, etc. There may also be pre-planned midcourse health and status update checkpoints, at which the TCM will attempt to xmit information about itself via Tomahawk Strike Network (that aforementioned UHF Satcom Datalink) to the launch unit for TTWCS operators to work with.

- ***SSN/SSGN***
  - Power is applied to the TACTOM from the Submarine, which initiates the TACTOM's pre-launch operations
  - TACTOM AUR begins performing BITs (Built-In-Tests) to validate the AUR is in operational condition and that there are no anomalies inhibiting launch
  - AN/BYG-1 uses the Mk 45 CLS to interrogate the AUR for munition metadata and verifies the AUR's authenticity and operability
  - AN/BYG-1 loads the TCM with its LFS (Launch-Capable Flight Software) through the Mk 45
  - DSMAC, TERCOM, SATCOM, and other GNC (Guidance, Navigation, and Control) subsystems are energized and subjected to further BITs to verify they are operational
  - TVC and FCS systems are energized and subjected to BITs
  - IMU is energized and begins alignment. TACTOM alignment takes between 8 and 10 minutes, which is much better than the Blk III's 24-38 minutes.
  - TCM mission data is loaded via the Mk45, including the over-water segment which is planned by the launch unit through TTWCS
  - GPS W keys are loaded onto the TCM to enable P(Y) signal decryption
  - When the TACTOM enters IMU Mode 3 (meaning it's been satisfactorily aligned), the AUR is ready to launch
  - BOOSTER ARM, rapidly fired by INTENT TO LAUNCH (this is also referred to as the "Firing Command," as it's essentially the "lets do this" trigger) commands are sent by AN/BYG-1 to the Mk45, which commands the AUR to set the TCM's MCP to NAVIGATE rather than it continuing to align the IMU
  - Rapidly following the MCP to NAVIGATE toggle, the Mk 135, TVC, and Fin Control System are activated and the CMA Battery is enabled, and takes over power delivery
  - the MISSILE ENABLE command is sent to the Mk45 CLS, and a deadface (basically a "nothing else is going to happen here on our end, so any commands you receive are lies and you should ignore them") command is issued to prevent any anomalous weirdness

        - The gas generator responsible for “yeeting” the TCM out of the water is activated, and the TCM is sent hurtling upwards
    - ***CG/DDG:***
        - Power is applied to the TACTOM from the CRUDES’s Mk 41 Cells
        - TTWCS, or the Mk41s (via AEGIS) depending on mission and launch unit situ-specifics, select a cell (or cells in a Salvo mission) to satisfy the number of TCM launches required by the strike mission.
        - **HUGE NOTE:** People seem not to know this, but the Mk 41 VLS is only capable of launching 1 TLAM per half-module at a time. Remember how I said we’d revisit those Mk 211 Launch Control Units again? Well, again is *right now!* Each 8 cell Mk 41 module is divided into two 4-cell half-modules; each with their own Launch Control Unit. Due to power constraints, each 8 cell module is only able to energize one missile per half module, and cannot energize a missile in both half modules at the same time. As a result, we have what is known as the “Half-Module Constraint” that limits TLAM single-salvo sizes to 1/4 the number of Mk.41 cells aboard the vessel in any given strike mission. On Burkes, this is a maximum of 24 TLAMs, on Ticos it’s a maximum of 32. This actually has some pretty big ramifications on how we configure our vessel loadouts, and which missile goes where in the magazine.
        - Once the launch cell is selected, the half-module’s LCU is sent a MISSILE SELECT command, and the LCU verifies the availability of that cell before interrogating the munition for its metadata and sending it to TTWCS through AEGIS
        - The LSEQ (Launch Sequencer) performs a status check of the munition and cell before applying the OPERATE POWER command and continues to monitor the cell and AUR's responsiveness throughout the pre-launch/launch sequence
        - The Mission Data disc is retrieved, and is mounted for TTWCS to use.
        - TTWCS transmits mission data to the AUR via the MK41 as well as beginning the TCM IMU alignment process
        - Once TACTOM reaches IMU MODE 3 (IMU aligned), it is subjected to BITs and, assuming it passes, TTWCS sends the BOOSTER ARM command to the LCU, which passes it to the LSEQ
        - LCU commits the cell and half-module to a launch, energizes TCM GNC subsystems, opens the cell hatch and closes the plenum cover (dont wanna burn down the whole module lol)
        - When the LCU issues a satisfactory "everything's good to go bro, send it" signal to TTWCS, the rocket motor is armed and the MISSILE FIRE command is issued by TTWCS
        - Upon receiving MISSILE FIRE, the LCU issues a BATTERY ACTIVATE command to begin operating the CMA Battery and hand off power delivery to the AUR

- Once all systems have activated and the AUR reports no errors to the LCU, the LCU reports MISSILE ENABLED to TTWCS
- TTWCS sends the BOOSTER IGNITION order to the LCU, which is handed off to the LSEQ, which ignites the Mk 135, then blows the retention bolts holding the TCM in the Mk14 canister.

The major difference you'd see during this phase for a TTWCS/Firing Unit planned mission would be the mission-planning precursor step, which requires a non-insignificant amount of time to conduct prior to the steps listed above, but is not directly related to launch operations

Boost/Transition:
During this phase, things are mostly the same across platforms and mission types. The Mk 135 propels the TCM upwards and along its mission-specified flyout azimuth. The 3 fins deploy and begin contributing as control surfaces, and once the TCM achieves a specified velocity, the engine intake and wings are extended. After ~10-15 seconds, the Mk 135 exhausts its dV and is jettisoned. The turbofan engine is ignited and operates at maximum throttle setting until the TCM achieves its designated cruise altitude. It is also during this phase that connection is established with visible GPS satellites for guidance.

Cruise:
Once the TCM is within its planned cruise parameters, the GNSS/INS over-water guidance takes hold. When it reaches land, the onboard TERCOM data can be used to further supplement guidance. It is during this period that the TACTOM can be retargeted to one of the 15 flex targets assigned per mission, It will also send missile health and status updates to the either the TTWCS operator, or the Strike Commander at a higher echelon of operational authority, either at pre-planned checkpoints or on demand.

This phase is notably different in dynamically planned missions. Because launch-unit planned missions are only able to utilize GPS/INS guidance, it is much more susceptible to deviating significantly from the planned course. INS drift is still a (significant) thing, and in a GPS-denied or contested environment, the ability of a dynamic-mission TLAM to maintain an accurate pathing is pretty dubious. Without TERCOM as a secondary, non-GPS reliant means of navigation, it will be VERY difficult to employ launch-unit planned TLAMs in the WESTPAC.

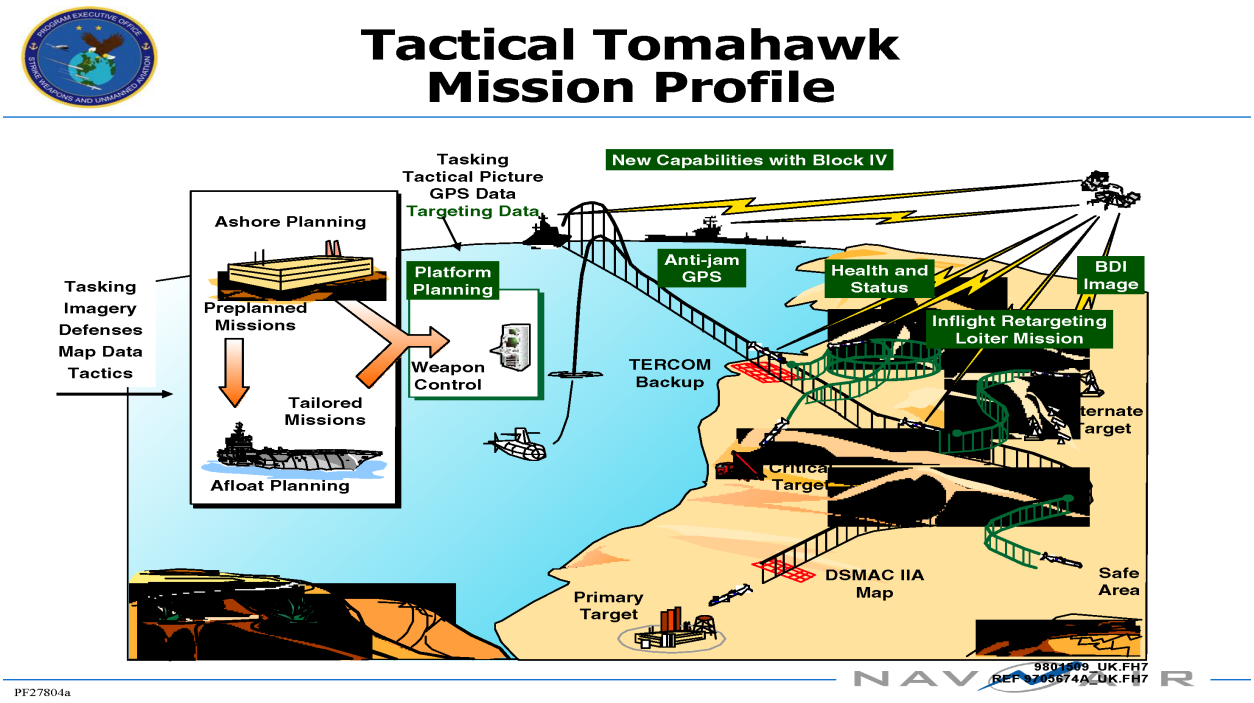
Another notable factor is EMCON. There's a *reason* why the PRC has built such a significant SIGINT apparatus, and TLAMs are vulnerable to having their (known frequency, known direction) Tomahawk Strike Network datalink transmissions localized, granting a warning to the PLA that there are TLAMs inbound from [X] direction, from which, defensive actions can be taken with the benefit of reaction time.

As such, there are some serious employment challenges present in both dynamic and deliberately planned TLAM strikes, and that fact may degrade Pa (Probability of Arrival)

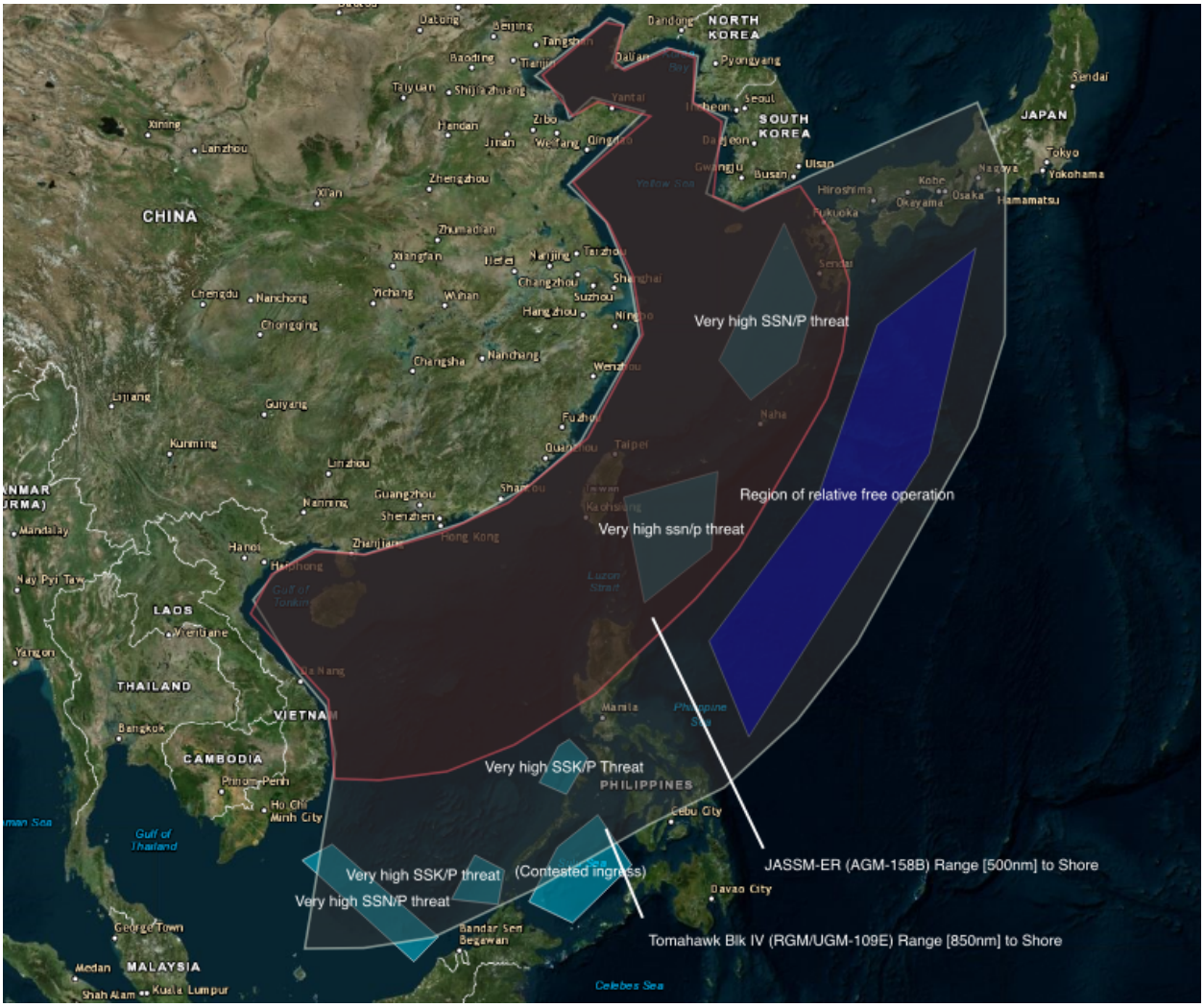
figures during weaponeering, which (in addition to the true attrition) introduces a virtual attrition by requiring larger numbers of TACTOMs to be dedicated to any given target.

Terminal Attack:
TACTOMs enter their terminal phase when they snap a BDAI image for use by the launch unit and higher levels of command and control. From this point, the TACTOM will utilize GNSS/INS and its DSMAC guidance to "home in" on the intended aimpoint. If the mission is fire-unit planned, or if the TACTOM was rerouted to an aimpoint only entered while the missile was in flight (as opposed to being a part of a broader strike mission), the TACTOM does not have access to DSMAC and will only be able to use GPS/INS guidance. During this terminal phase, the TACTOM executes either a pushover or a pop-up to ensure its final "glideslope" is an elliptical shape until the desired impact point is reached. This ellipse can be configured to enable impact at anywhere from -5 degrees to -85 degrees, so there's a good deal of flexibility.

As you can see, the actual execution of these missions is a *very* involved pro cess, and there are significant "pain points" in their employment concept that can be attacked which will hurt TLAM effectiveness by no small margin. To help with visualization, here's another awful powerpoint slide depicting a typical TACTOM mission profile:



Now, with that *finally* all out of the way, let's take a look at a VERY quick-and-dirty qGIS recreation of a (small) part of something me and @Tempest are working on:

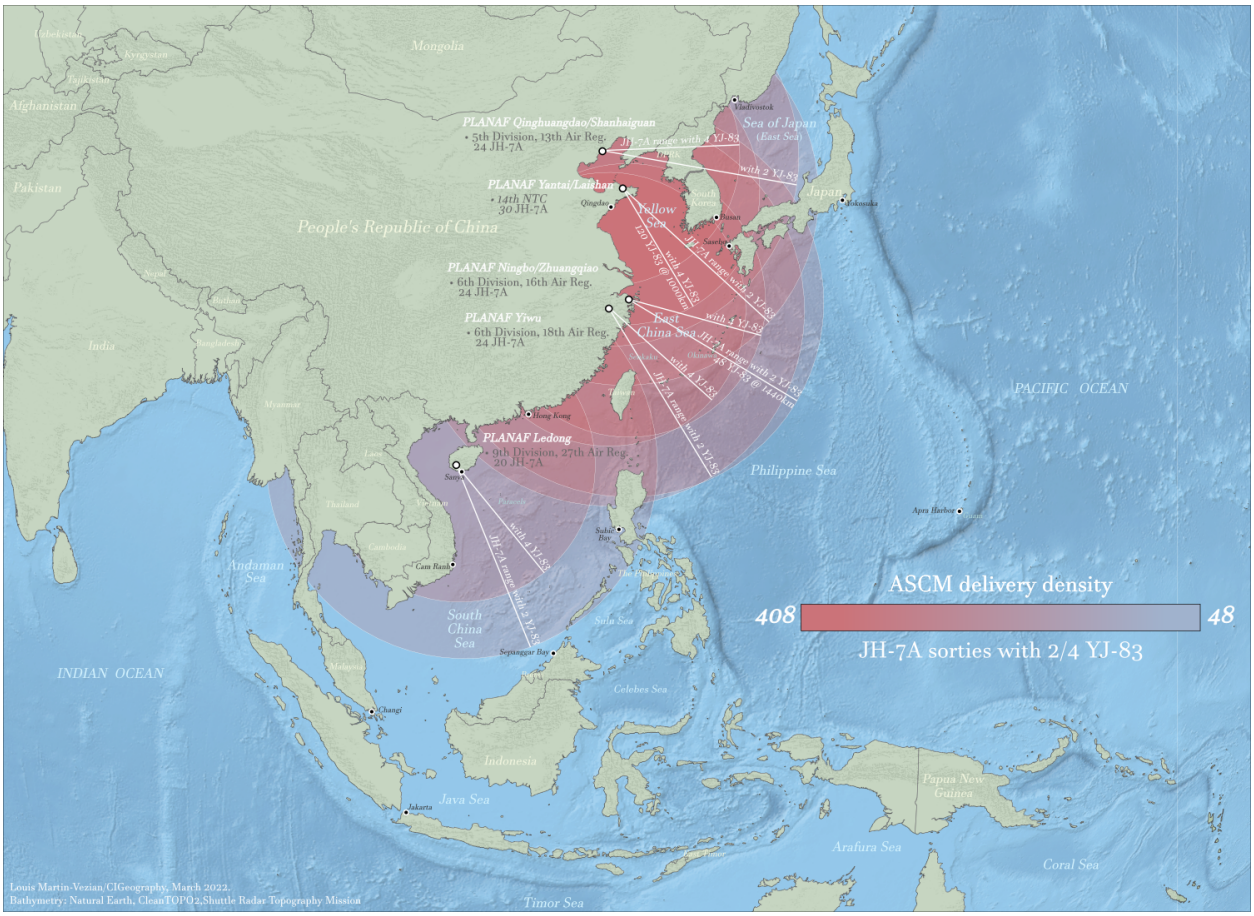


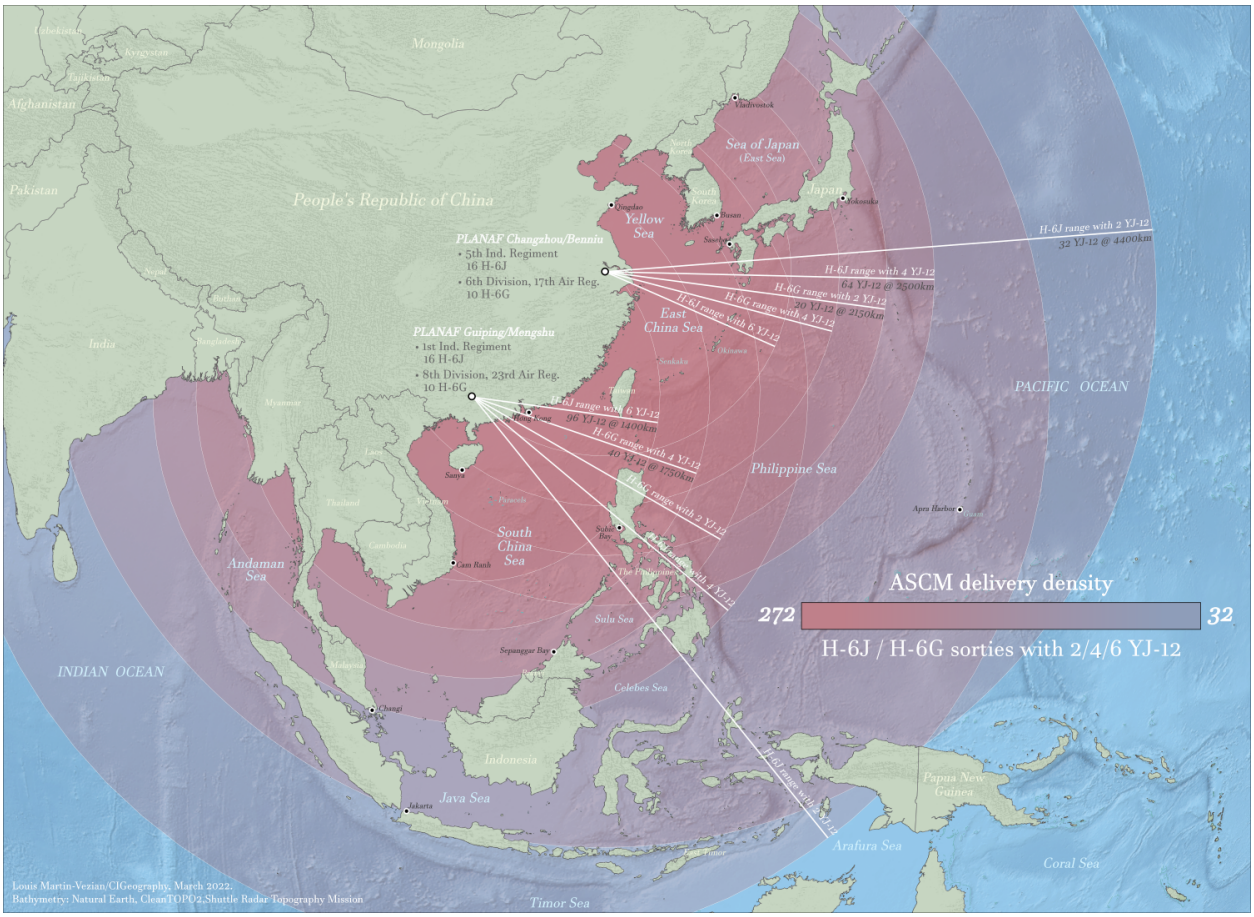
Fairly yucky rendering, but the gist is still there. The grey buffer (from China's coast) represents the region within which you can effectively employ TACTOMs against coastal targets (while using a hi-lo profile, which is significantly more vulnerable to detection and interception). Strictly, TACTOMs run ~900-950nm range figures, but due to mission constraints, you will never ever ever see them launched at that 950nm range. The farthest any TLAM will launch is generally ~50-100nm less than that. This is to accommodate dog-legged flyouts, lo-lo attack profiles (less efficient), course/target adjustments, enable a degree of loitering capability, and to compensate for the fact that terrain masking requires a longer route than a "straight-in" approach. Thus, surface launch units will be forced to operate within an ~850-900nm radius at farthest in order to employ TLAMs, which coincidentally is around the same distance CSGs can reach out to with JASSM-ERs following a 300nm fly-out aboard CVW Rhinos (JASSM-ER range is depicted as the red buffer).

From this, we can determine that the region marked in blue is the "sweet spot" for USN operations while still being able to employ TLAMs. From my own work, the CVN would be best served by operating on the outer edge of that Grey-zone, and "darting" (people love to talk about how "CSGs are really fast! people don't realize how fast they are! 700nm a day!" despite not realizing how slow 30kts truly is in a tactical sense. Sortie generation is conducted in single digit hours-sized timeframes, not in day-sized timeframes. CSGs really can't make any more than high double digit nm transits in the

timescale we see air ops occurring at) deeper into it when generating and recovering sorties. High-preference positions include the region east of Osaka + south of Nagoya, and the region Northeast of Catarman (Philippines) due to the added buffer of land based counter-air and BMD forces, adding another layer to the CVN's defensive apparatus. CRUDES would be operating farther west to generate their own counter-air and BMD screen for the CVN (as well as being able to employ TLAMs themselves). The SSNs would likely be operating as the farthest west force (while still east of the first island chain and high threat chokepoints), screening for PLAN subsurface threats, and providing a threat to PLAN surface forces attempting to break out towards the second island chain (in an effort to participate in an ASuW salvo for instance). They would also be capable of employing their TLAMs in the initial phase of operations.

While this is about as good as the USN can hope for, there's still a lot of pain-points. Firstly, take a look at these two images (courtesy of a past project by @Tempest).





As you can see, the PLANAF alone is capable of generating some pretty eye watering AShM salvos even out to these ranges. As a result of the initial operational fires (courtesy of the PLAAF and PLARF), US TACAIR presence in the region would be practically wiped out at the outset of a WESTPAC fight. ROCAF, JASDF, and Japanese based PACAF forces would be unable to meaningfully contest the skies immediately following the initial salvo. Airpower generated from Guam would also be degraded or disabled for a time. Thus, the skies would be all but clear for the PLANAF to sortie their own anti-shipping air assets. The CVWs would be able to participate, but would be immediately subject to prompt fires from DF-21Ds and DF-26s (inhibiting air operations due to the need to maneuver, as well as attritting magazines), and would not likely be capable of consequentially degrading the oncoming AShCM salvo. The CRUDES themselves would also be subject to this initial attack, which in addition to likely outright destroying/disabling a number of vessels - would also inhibit them from being able to employ their TLAMs. As we went over, the actual mission assignment and launch process takes a *bare theoretical minimum* of ~10 minutes, and if God himself were manning the Weapon Control Console, could *maybe* be conducted in ~15 minutes. However, when defending incoming munitions, AEGIS (when in auto-special) interrupts the Tomahawk strike mission execution in order to employ SM-2/6/ESSMs safely.

Thus, assuming the USN magically knew the exact second the PLA "launched" their first wave of strikes, and began the TLAM Mission coordination/execution

process *immediately*, it would still take a solid ~15+ minutes to begin launching TLAMs (without adding in any reaction and decision making time, and with a hyper-competent manning, while the vessel is also already at general quarters - so to put it succinctly, this is an *enormously optimistic* timeline) without including salvo-defense interruptions. In this timeframe, AShBMs would likely disable or destroy multiple surface vessels, and there would be a relatively small window before the rest of the PLAN/PLANAF salvo makes its appearance, during which the remaining vessels could *potentially* execute a partial strike mission. Of the ~~~~100-150ishhhhhh steady-state TLAMs you can count on having IVO the PRC aboard surface vessels, it's likely that anywhere from 33-50% of the TLAMs could realistically be employed in the face of the PLA's bandwidth anti shipping effort. I would expect the entirety of the forward deployed presence in 7th fleet to be de-facto out of action following the initial "fever-pitch" anti shipping effort.

If there were a single 1+3to5 strength CSG in theater within that TLAM employment envelope, I would expect it to be completely sent to Davy Jone's locker. If there were two CSGs in theater in 1+3 to 5 configurations, I would expect the majority of the CRUDES and at least one CVN to be at the very least mission killed. In return, the USN may be able to generate ~50-75 TLAMs, but with their host TTWCS stations destroyed, and comprised of incomplete mission salvos, they would be very poorly weaponeered/ coordinated fires.

To that end, people seriously underestimate how many TLAMs it takes to disable or destroy a major piece of infrastructure. Ports alone have potentially dozens of aimpoints, and even a relatively modest (but still competent) CMD effort can reduce Pa metrics enough to require multiple munitions per aimpoint to achieve an acceptable salvo Pe (Probability of Effect). Unfortunately for the USN, the PRC has notably more than just a "modest" CMD apparatus. The extensive AEW, shipborne, tacair, GBEWR, and GBAA platform sensors are a fairly daunting system to penetrate. If employed in a hi-hi mission profile (assuming the launch units were keeping nearer the far edge of their WEZ), their Pa figures can easily plunge down to sub 0.5 depending on the specifics of the salvo, which helps illustrate that 50-75 munitions is a drop in the bucket compared with what is needed to comprehensively degrade the PLA’s warfighting capability.

Additionally, because the missions were likely only partially fulfilled, TLAM per-target distribution may be shallow enough to prevent any single target effect from being successfully achieved. Think “10 missiles can kill 1 target, but if you have two targets and you launch 5 at each, you kill none.”

FWIW, I’m speaking in fairly probabilistic terms here, but that aforementioned project with @Tempest will be a bit more quantitative/concrete in nature - and it even comes with a video series, so i don't wanna just copypaste all of our unfinished work into a sdf post lol.

Anyhow, SS(G)Ns are likely to be better off than their surface force counterparts vis-a-vis TLAM employment capabilities. The SSGN in theater would likely be loaded with

multiple pre-planned strike missions; and would be operating in a safe enough bastion to reasonably expect to complete a magazine-depth salvo. While, again, the threat environment is HIGHLY non-conducive to TLAMs (Pa figures are *not* hot; and the sheer *number* of targets - which all have many many aimpoints - is absolutely eye watering), the ability to fulfill a coordinated strike mission of 154 munitions is nothing to scoff at, no matter how degraded their effectiveness may be. The SSNs in theater are more of a wildcard, and are difficult to really talk about without getting myself black holed lol. Without getting *too* much into it (again, there's gonna be more crap about this in that project), the 96 TLAMs aboard SSNs are unlikely to all be effectively weaponeered to produce effects (dispersed, not-in-contact platforms with not enough TLAMs to - on their own - destroy a single significant target results in redundancies, insufficient launch volumes, and other crap), and - while they're on Tomahawk Strike Network - risk being localized and thus providing the PLA with launch platform *very rough* locations. Once the SSGN exhausts its TLAM supply, it would likely return to Pearl to hoover up as many Mk10 stored AURs as it could carry back out; and once the SSNs exhaust their TLAM supplies, they would focus all their attention on acting as that "forward screen" and occasional penetrating "hunter" force.

And thus, we conclude. Hopefully that answered your question and gave some insight into why the answer is what it is.