Optimizing Naval Equipment Placement based on Antenna Field Strengths, Dimensional Constraints and Surrounding Equipment Constraints using SolidWorks.

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Executive Summary

Lockheed Martin Canada (LMC) is Canada's leading defense company and contracts to various Naval/Military organizations globally. LMC is an industry leader within the realm of naval engineering and integration of ship equipment onto and within pre-engineered naval ship structures. The most predominant project Lockheed Martin Canada has been contracted to conduct ship integration is the Canadian Surface Combatant project (CSC), in which LMC is responsible for integrating new advanced ship equipment into BAE's Type 26 (T26) ship structure. It is notable that the CSC (deemed the River Class) is being engineered to replace Canada's existing fleet of naval ships, the Halifax class. There are a multitude of teams contracted to ensure proper engineering and ship integration for the CSC, in which the team responsible for the mechanical design is named the modelling and arrangements (M+A) team, falling under the CSC Ship Integration team. A sub team of the M+A team at LMC is the Topside team, responsible for the physical layout and design of all equipment on the exterior, or the "Topside" of the ship. The Topside team must consider various equipment constraints when modelling and placing the equipment on the topside of the ship, such as antenna frequency keep out zones, the physical mechanical design of equipment, maintenance and keep out zones, blast radii and much more. Thus, the topside team plays a critical role in the design and integration of physical equipment on the CSC. The main modelling software used by the Topside team is SolidWorks, and using this software, physical design, checks and Line of Sign analyses (LOS analyses) can be conducted. LOS analyses is analyses conducted within SolidWorks in which the physical Line of Sight of each considerable piece of equipment is modelled and simulated, allowing LMC to see the physical POV of Topside equipment. Once these analyses are iteratively conducted until equipment compliancy is met, a technical feasibility study can be produced, illustrating equipment placement and design proposals for vendor and internal review.

Introduction and Purpose

Lockheed Martin Canada (LMC) is Canada's leading naval engineering contractor, and is the primary ship integrator within the Canadian Surface Combatant (CSC) project. The CSC, also know as the River Class fleet of ships, is set to replace the existing operating Naval fleet in the Royal Canadian Navy, the Halifax Class. There are various sub teams that fall under the Ship Integration aspect of the project at LMC, including the Modeling and Arrangements (M+A) team. More specifically, a sub team of the M+A team is the Topside team, responsible for the modelling and physical/mechanical design of the exterior equipment of the ship. To prove the validity of their work, the Topside M+A team must illustrate equipment compliancy through equipment feasibility studies. The purpose of these studies is to demonstrate equipment constraints, compliances and geometries in a 3-dimentional and digestible manner for both relevant internal and external teams. The facet in which these compliances are demonstrated are through various different sub-studies and physical checks in which the equipment geometry is iteratively modeled until a converged solution is agreed upon and shown within the study. These studies are the backbone of the Topside equipment, and play a crucial role in the CSC project. This memo walks through some of the technical theory and applied software to conduct these studies.

Theory and Analysis

An extremely important introductory analysis included in many Topside feasibility studies is the Quick-Look Line of Sight (LOS) analyses. These analyses are essentially studies in which an LOS point is modelled in physical space (X, Y and Z coordinates are defined) relative to the ship origin. This LOS point can be thought of as the eyeball, or first person POV point of where a physical piece of Topside equipment may reside. From here, a 360 degree render can be conducted within the SolidWorks model to create a visual snapshot of what the first person POV of the precisely located equipment can see. From here, a coordinate system can be set, with 360 degrees of rotation and a 0 degree up-and-down reference level. From this up and down reference level, 90 degrees vertically above and below the 0 degree level can be viewed. This can be seen geometrically illustrated on a spherical coordinate system, as per *(See Figure 1)*. Using this LOS render and coordinate system, measurements can be made at specific "slices" of elevation denoting the amount of azimuth (horizontal measurement) is unobstructed by other components on the Topside of the ship per "slice" or elevation (vertical measurement). This can be used to develop a 2-Dimentional plot for each elevation slice, in which triangle-shaped sliced can demonstrate which range of azimuths are unobstructed. This allows a physical representation denoting the LOS compliancy for each slice or section of elevation.

These LOS analyses play a crucial role for the Topside team and the CSC as a whole, as many pieces of Topside equipment have specific unobstructed requirements for specific elevations/azimuths, so the Quick-Look LOS analyses allow these compliances to be approximately calculated and show engineers if/if not equipment will need to be physically relocated. The relocation of Topside equipment can also depend on nearby antenna frequencies, as a RF signature exceeding the physical limit of Topside equipment means that the piece of equipment must be relocated, requiring another LOS analyses. The quick nature/method of these LOS analyses allow engineers working on the CSC to confirm equipment compliancy as per project defined requirements.

Using these 2-D LOS plots, one can construct a 3-dimentional spherical shape in which the centroid is located at the LOS reference point per piece of equipment. Using SolidWorks, one can create a 360 degree resolved shape denoting viewable and non-viewable azimuths per section of defined elevation. This allows visual representation in 3-dimentional space of what a piece of equipment can and cannot see (is obstructed by ship structure/equipment). This was a process the Topside team perfected, allowing each feasibility study to be digestible by higher management, allowing more streamlined equipment integration.

The process of mechanical design/modelling of specific pieces of Topside equipment was also conducted on a regular basis using SolidWorks. This meant that equipment design validation was to be conducted by the Topside team as well. The modeling and development of equipment assemblies using vendor supplied geometrical/engineering drawings allowed the team to develop intuitive 3D models, and lead to the discovery of various design flaws which was then reported back to the vendor. This workflow allowed the Topside team to not only place equipment on the Topside of the ship, but to allow a critical last line of defense in terms of equipment design and functionality.

Close work with the RF (radio frequencies) and Electromagnetic (EM) team was conducted to ensure topside equipment was not in any physical danger. This meant that in-depth

RF/EM compliances were demonstrated based on 3-D RF/EM analyses, allowing even more safety to topside equipment (Baron et al., 2002). It is notable that "Traditional ship designs have very large radar cross-sections. Asa result, modern designs must incorporate "clean" topside concepts" (Baron et al., 2002). This requirement of compliance raises large concerns with topside equipment placement, thus is a priority to be considered when locating equipment. A visualization of these radio frequencies can be seen in *figure 2.*, as this is a visualization of the type of RF simulations conducted and converted to a digestible way the RF patterns on the Topside of the ship can be distinguished, and hazardous Topside zones can be visualized.
All of these design considerations were iteratively considered for all analyses conducted within SolidWorks and allowed all feasibility studies to be carried out in a considerably detailed manner.

Results and Discussion

Throughout the term, over 9 topside equipment feasibility studies were developed and finalized. Within each study, extremely critical design/modelling lessons were learned and documented/discussed within the team, both improving efficiency and team communication. These studies included LOS (2D and 3D), RF, mechanical design and equipment compliancy considerations. It was determined that the relocation and implementation of the feasibility studies were compliant with contractual CSC standards, as this was an extremely iterative process that took up to 6 relocation options per study.

An extremely notable study that helped the Topside team refine their practices was a study completed most recently, in which the team worked closely with vendors and internal CSC engineers to deliver and iteratively converge to a new equipment design and solution. This piece of equipment contained multiple separate parts and had many overlooked design constraints. The team first modelled an original layout, and displayed this ideal layout to vendors and internal engineers. This layout was then iterated 3 times to acquaint to the topside layout and to improve equipment functionality/lifetime. This resulted in discovering design flaws from the model proposed by the vendor, and these errors were corrected in both SolidWorks design and layout. The final layout was then subject to an in-depth LOS study, in which both 2D and 3D plots were created showing equipment compliances and design considerations.

The equipment proposal and study was then presented to both internal and external teams, were a collaborative effort of various backgrounds converged to adjust the proposed equipment layout. This collaborative effort also lead to changes in the study logic itself, and allowed for not only an in-depth study to be finalized, but a digestible and presentable study ready for vendors, internal teams and higher management. With this successful finalization of the modelled study (using mainly SolidWorks), both high praise and utility was delivered to and from the study. This pattern continued into all other studies, and allowed extremely positive changes to be delivered to the topside of the ship.

Conclusion and Recommendations

As these studies conducted in SolidWorks were finalized, many invaluable software, communicative and mechanical design lessons were learnt throughout the M+A, and more specifically, Topside design teams. These extremely technical and thorough topside equipment feasibility studies lead to countless positive changes in ship design, equipment design, and team practices. These lessons were thoroughly documented and implemented throughout preceding studies, with improved practices throughout each and every feasibility study conducted and presented.

As many lessons were learned, it could be a very good idea to study the process of the feasibility study itself, as in investigating each and every process from a first-principles thinking standpoint. Conducting a study of the study process would allow flaws to be found and solved in a focused manner in one iteration, and would likely save time moving forward, instead of discovering logical flaws as the equipment studies are being conducted. Regardless, many invaluable process lessons were learned and are being practiced to this day, allowing continuous improvement and increased study accuracy with each iteration.

References

Baron, N. T., Bird, W. R., Potter, P., Rockway, J. W., & Stetson, N. K. (2002, February 26). Naval Topside Design: Learning from the Past, Shaping the Future. apps.dtic.mil. https://apps.dtic.mil/sti/tr/pdf/ADA399982.pdf

Center of Telecommunication Technologies. (2025). Antenna Pattern Editor 3.0. Wireless Planning. https://www.wireless-planning.com/antenna-pattern-editor-user-manual

Wall, A., Lee, R., Barber, H., & McTaggart, K. (2021, February 1). The NATO Generic Destroyer - a shared geometry for collaborative research into modelling and simulation of shipboard launch and recovery: source data posting on Open Science Canada. open.canada.ca. https://open.canada.ca/data/en/dataset/2c30e366-ef2b-400e-83630b13e4a7b6f4

Attachments

Figure 1. Example of spherical measurement tool used to visualize LOS analyses mapping, recreated in SolidWorks using the NATO Destroyer (open source data) placed inside the spherical LOS measurement tool (Wall et al., 2021). See ref #3.

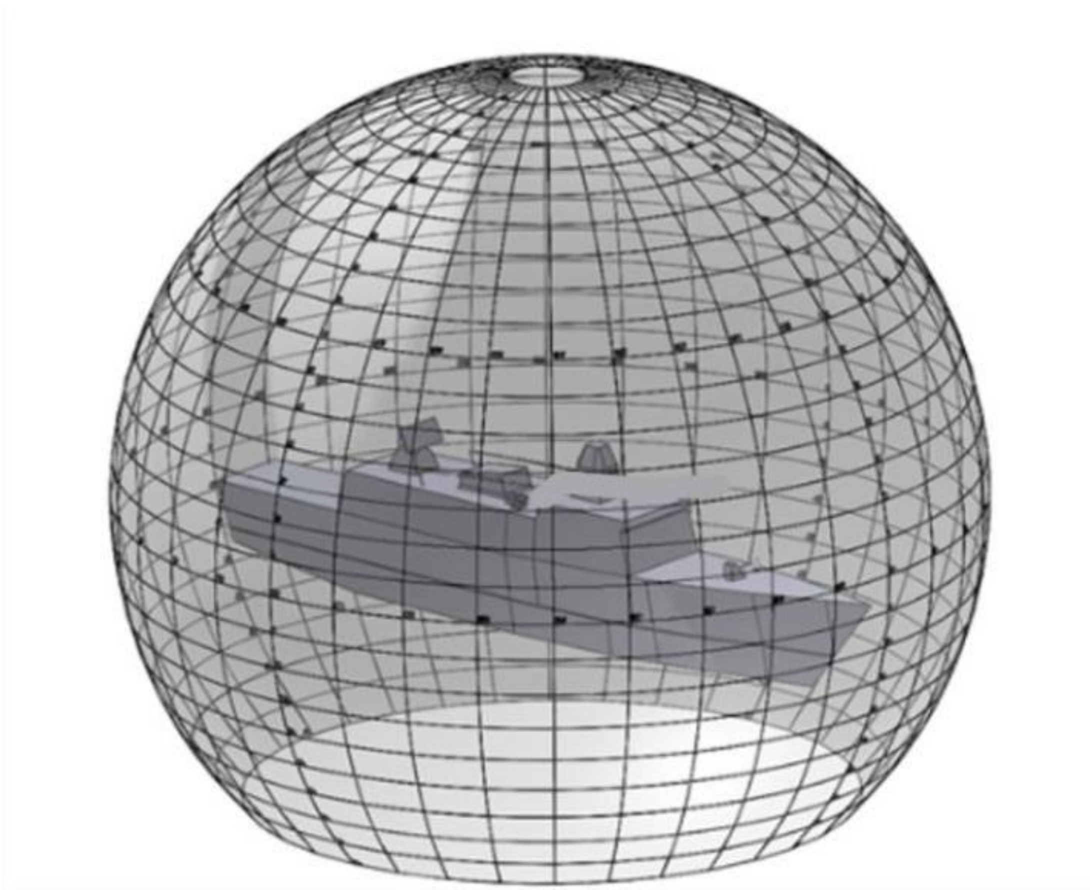
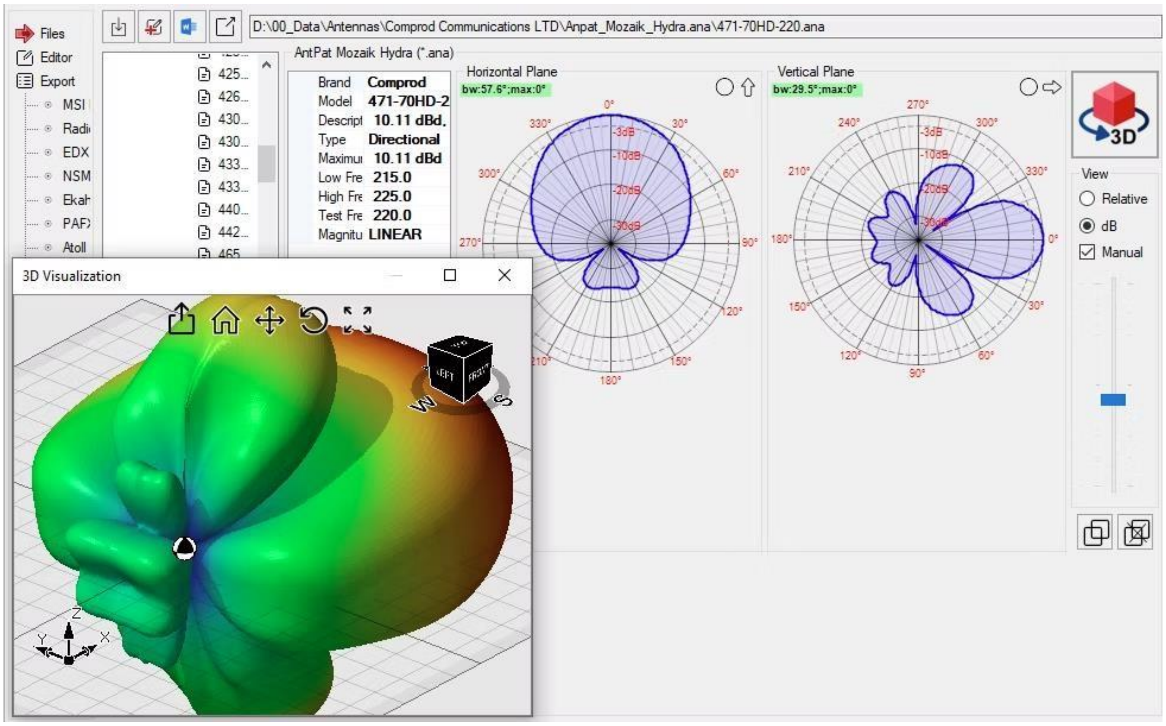


Figure 2. A visualization of the RF analyses conducted and converted to a legible manner, delivering crucial topside information for Topside equipment placement (Center of Telecommunication Technologies, 2025). See ref #2.



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