Toward an Interactive Future for Explosives Safety Siting in Master Planning

Kyle Root, PE[1]; Kevin Mueller, PhD, PE, PSP[2]; Fred Jorgensen, PE, PSP[2]
[1]Thornton Tomasetti, 1700 Market, Suite 1750, Philadelphia, Pennsylvania, USA.
[2]Thornton Tomasetti, 600 W Fulton, Suite 705, Chicago, Illinois, USA.

Abstract

Department of Defense community master planners are continually tasked with assessing the future needs of United States military installations across the world. Master planning sessions are typically conducted over the course of a single week with all parties on site, allowing for full engagement with project stakeholders and base personnel. Proper placement of the munition storage area is an important aspect of the installation's master plan. Explosives quantity distance arcs must be calculated for each potential explosive site; existing and new. The work of the explosives safety consultant requires a complex spreadsheet tracking distances for every potential explosive site and reporting those values back to the team to coordinate safety requirements within the master plan. This process, while valid and acceptable, separates the explosives safety consultant from the team during what should be a collaborative multi-day workshop. Thornton Tomasetti has developed a novel approach for interactive explosive safety siting. The Blast Optimization and Operations Mapper (BOOM) tool began as an internal research effort to bring the calculation and plotting of explosive quantity distances into a single, interactive environment. BOOM moves the explosive safety engineer to the table for collaboration by dynamically performing calculations of quantity distance arcs and plotting them near instantaneously as the master plan comes together. Built in Grasshopper and interfacing with Rhino geometry, site plans can be imported, referenced, modified and added to the master plan as it is developed, all while BOOM calculates and plots the requisite information in real time. BOOM represents a paradigm shift for military master planning in which quantity distance calculations become an integrated and efficient part of the planning process.

Introduction

The role of explosives safety consultants during military master planning involves repeatable calculations tied to the dynamic geometry of an evolving site plan. Master planning charettes are intended, and expected, to be a collaborative effort to rapidly assess and plan for the future of the base and mission. Common workflows are segregating calculation from planning as a function of the available tools. Coupled workflows involving site planning and calculations are commonplace across numerous other industries. Military master planning can be improved by borrowing from the workflows set in place across industries like architecture, engineering and construction.

Master Planning

Every United States military base (CONUS and OCONUS) is required by the Department of Defense (DoD) to update the base master plan at least every five years [1, 2]. Master planning sessions are traditionally conducted in person on base with all stakeholders present. The master planning session is typically conducted over the course of a single week, five working days. During the master planning session, base personnel representing every interest of the installation collaboratively plan out future programming and capacity design to ensure the needs of its missions will be met.

One aspect of the base master planning is the layout of its munition storage areas (MSA). The layout of each MSA is a collaborative effort involving numerous base personnel representing the various interests of the base. Over the course of five days, the in-person planning team will take an existing site plan of the base and collectively develop a new master plan of the base. The role of the explosives safety consultant during the master planning session is to ensure each MSA meets the required setbacks to every asset on base.

Current Methodologies

The role of the explosives safety consultant during military master planning is often associated with verification because of current tools and methodologies. As new or expanded MSAs are proposed, a new Beddown arrives, or a new road is planned through the base, the explosives safety consultant must calculate the interaction between every moving asset on base and every potential explosion site (PES). These calculations, as performed by the explosives safety consultant, take little time but occur many times over the course of five days, removing stakeholders from the master planning discussion following each variation significantly impacts the overall collaboration efforts.

Calculation of the required explosives quantity distance (QD) arcs is commonly performed using complex spreadsheets tracking hundreds of ES and PES locations in a single file. As the number of munition locations grow, the spreadsheet may quickly approach thousands of cells of information. And while many professionals may not think twice about a spreadsheet this size, in the context of multi-day, in-person collaboration, continual updates becomes increasingly difficult.

Complex spreadsheets and reduced potential for collaboration are motivation for seeking new workflows. However, the most prominent driver of innovation in explosives safety siting master planning is the disjointed process in which QD arcs are drafted. By the end of the weeklong master planning session, the team produces a preliminary site plan visually depicting each calculated QD arc for every PES. Current methodologies rely on two distinct steps to go from PES to QD arc; first calculate all distances in a spreadsheet, then draft arcs based on those distances in another software like AutoCAD [3]. This workflow separates the calculations from the site and moves the explosives safety consultant into a position of verification, as opposed to collaboration (Figure 1).

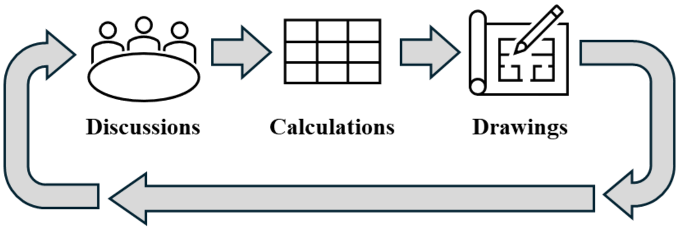

Figure 1. Typical workflow for explosives safety consultant during master planning charette. Discussions take place, the explosives safety consultant performs calculations to determine explosive quantity distances, distances are compared to the site plan, and the cycle repeats itself as additional discussions take place.

Thornton Tomasetti has developed a solution that moves the explosives safety consultant back to the table for collaboration through efficient and consolidated geometric calculations. The Blast Optimization and Operations Mapper (BOOM) has been developed out of years of exploring the benefits behind computational design.

Computational Design

Computational design has been widely adopted by the architecture, engineering, and construction (AEC) industry for years. Across AEC, computational design methods allow designers to define the guiding rules of the digital built environment and explore results. Early stage, this may be a definition or algorithm that defines the twist of a high-rise tower as a function of the building's height and footprint. Later in a project, this may be an algorithm for calculating individual façade panel dimensions across a building and grouping similar sizes to optimize fabrication.

Thornton Tomasetti has been a leader in computational design and parametric modeling, due largely in part to the firm's dedicated computational research group, CORE studio [4]. Since 2011, CORE studio has applied parametric modeling tools to realize designs, manage drawing production and facilitate fabrication, Figure 2.

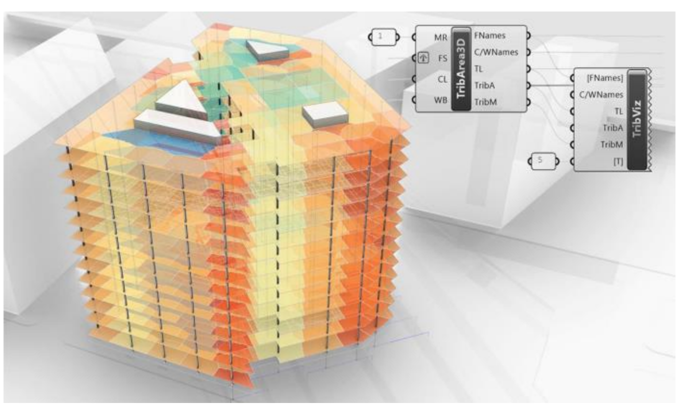

Figure 2. Example of computational design solution from Thornton Tomasetti CORE studio in which column tributary areas are automatically calculated from a simple 3D massing model.

Designers across AEC have solved some of the built environment's most challenging problems with computational design. At its core, computational design allows practitioners to merge calculation with geometry, a problem not unique to the AEC industry.

Platform

One of the most widely used platform solutions across industries in the world of computational design is Rhino and Grasshopper [5, 6]. Rhino is a versatile 3D modeling platform found commonly in architecture, engineering, landscape, product, and marine design. Grasshopper is a visual programming environment integrated with Rhino.

Thornton Tomasetti has developed BOOM in Grasshopper (Figure 3), to interface with Rhino geometry. The solution provides the ability to reference and modify site geometry within Rhino, while BOOM dynamically calculates and creates QD arcs (Figure 4).

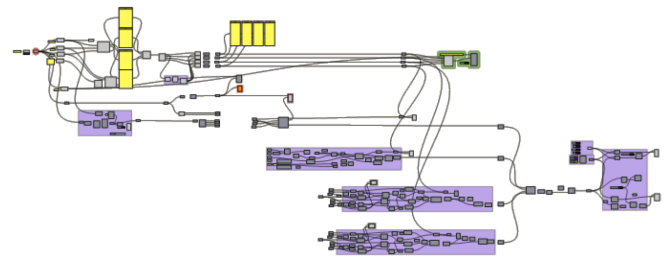

Figure 3. Snapshot of the Grasshopper script developed for BOOM. Grasshopper is a parametric modeling plugin for Rhino that allows calculations to interface directly with geometry in the model space.

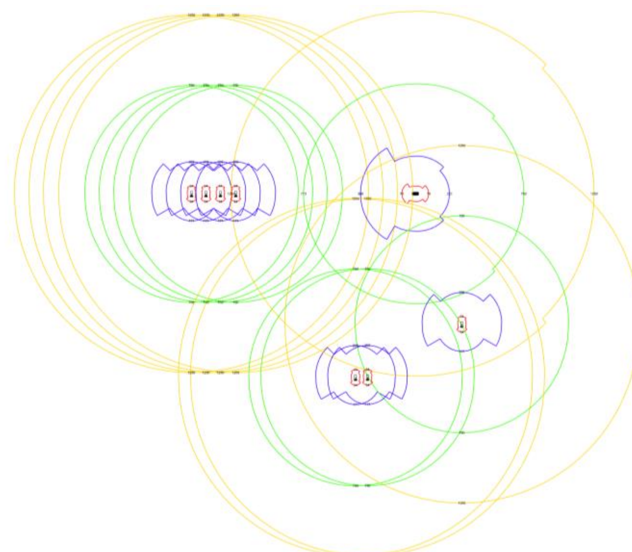

Figure 4. Example BOOM output showing the automatic calculation and plotting of multiple QD arcs.

BOOM Development

BOOM is an active Thornton Tomasetti development. In its current state, the tool supports HD1.1 quantity distance calculations as specified in the Defense Explosives Safety Regulations 6055.09 [7]. The procedures in place can accommodate alternative standards, such as UK or NATO, depending on what the project requires.

BOOM Workflow

Rhino, as a computer aided design (CAD) platform, allows for various file type imports. In advance of the master planning charrette, an existing site plan file is typically distributed to the team. Once imported to Rhino, the explosives safety consultant will have access to interactively assign the required properties to all geometry representing the PESs across the site. The required properties are those related for calculation of the QD arcs; net explosive weight (NEW), magazine type, barricading, and identifying marks such as the base-assigned building number. With BOOM, the assigned curve metadata is dynamically pulled into the calculation, QD arcs are calculated and plotted near instantaneously (Figure 5).

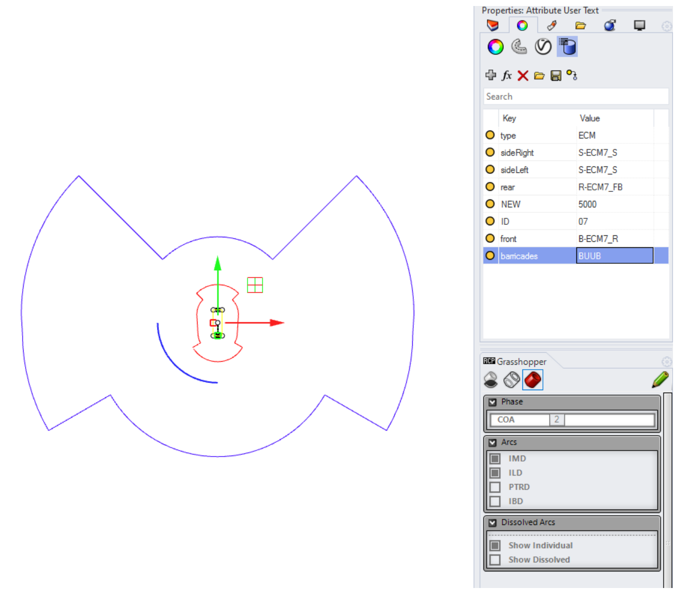

Figure 5. Example BOOM interface. Metadata attached to the Rhino curve geometry is populated to define each magazine's parameters. Metadata is pulled into the calculation engine in real time, solved, and QD arcs are instantly displayed.

BOOM can also rapidly generate dissolved QD arcs from individual QD arcs in real time (Figure 6). Through custom-scripted solutions defining the equations found in the DESR, to conventional components for drawing arcs, curves, and solving filled regions, the adaptability of the Grasshopper environment is delivering explosives safety siting for master planning in a truly interactive platform; an environment that supports the format in which other members of the master planning team are working within.

Summary/Conclusions

BOOM moves the explosive safety engineer to the table for collaboration, unincumbered with segregated spreadsheets. Rhino and Grasshopper are industry standard solutions for computer aided design and have numerous means of interfacing with site plans of all file types. Calculations of quantity distances at each PES are performed instantaneously in the context of the site.

Computational design has changed the way practitioners work across architecture, engineering and construction. BOOM represents a shift toward the future of military master planning where explosives safety siting is no longer a separated 'check' but instead an interactive component of the process.

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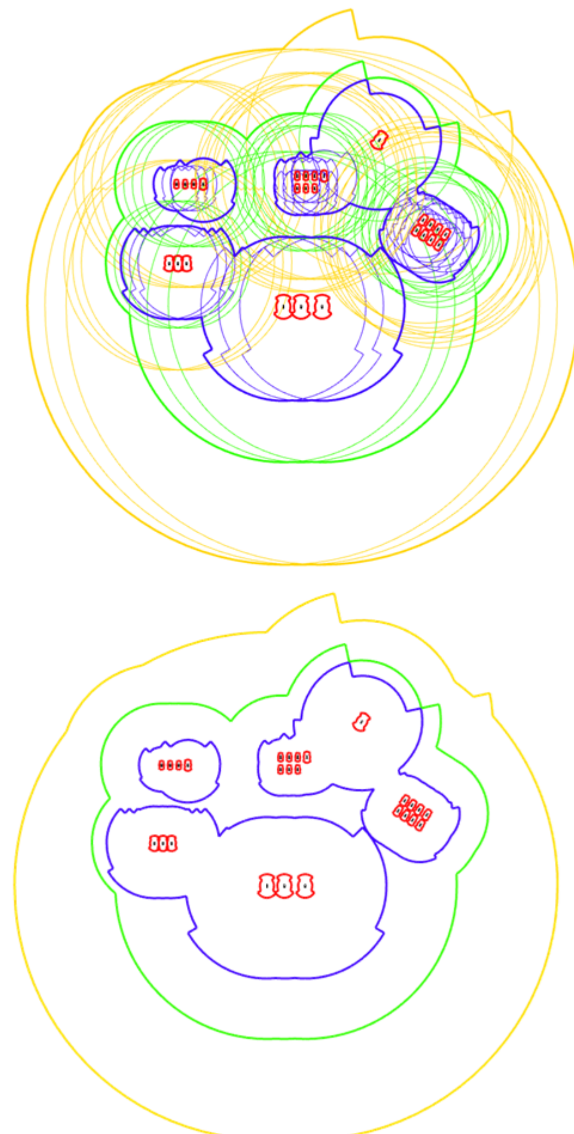

Figure 6. Example output from BOOM. Dissolved QD arcs are instantly solved from individual QD arcs.

Contact Information

Kyle Root, PE
+1-267-238-4016
kroot@email.tt

Fred Jorgensen, PE, PSP
+1-312-788-7032
fjorgensen@email.tt

Kevin Mueller, PhD, PE, PSP
+1-312-788-7032
kmueller@email.tt

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