QDArc / EXPLOSIVE SAFETY

WHITE PAPER · 2026

A site-planning application for Explosive Safety Site Planners across DoW, DoE, NATO, and contractor communities.

A regulation-anchored, deterministic siting environment for Site Planners who lack practical access to the existing DoW-sponsored automated site-planning tool — DoW contractors, DoE laboratories, NATO partner-nation installations, and contractors with DoW flow-down obligations.

REGULATORY BASIS

- DESR 6055.09
- DAFMAN 91-201
- DOE-STD-1212-2025
- AASTP-1 / 1.1
- DDESB TP-15 / 21 / 23 / 26
- UFC 4-420-01
- MIL-STD-882E

PREPARED AS A NON-PROPRIETARY DESCRIPTION
OF PURPOSE, REGULATORY BASIS, AND WORKFLOW.

QDARC.COM
CONTACT@QDARC.COM

CONTENTS

What's inside.

§ 01 · EXECUTIVE SUMMARY

A site-planning application, anchored to the regulation.

QDArc is a software application that supports an Explosive Safety Site Planner end to end in producing the explosives site plan for an installation. It computes the regulatory protection distances — Quantity-Distance, or QD — around every place that stores or handles explosives, renders those distances as arcs on the installation map, identifies the Exposed Sites those arcs cross, decides whether the resulting layout is compliant per the applicable regulation, and assembles the submittal package the Site Planner gives to the approval authority.

At the heart of QDArc is the **QD Engine** — the component that takes hazard division, net explosive weight, and configuration data for every place that stores or handles explosives and computes the required protection distance to every site that needs to be protected.

The function of explosive safety site planning is the same wherever explosives are stored, even when the role title, broader scope, and reporting chain differ — a U.S. service base under Department of War (DoW, formerly Department of Defense / DoD) regulation, a Department of Energy (DoE) national laboratory, a NATO partner-nation depot, or a contractor facility operating under DoW flow-down requirements.

> CLEAN-ROOM BUILD
>
> QDArc is built clean-room — developed using only publicly released regulations, public technical papers, and public training materials, with no use of non-public, restricted, or proprietary documentation from any existing tool. Every requirement traces back to a public source or to the founder's documented professional knowledge. Section 11 describes the methodology in detail.

QDArc serves Site Planners who lack practical access to the existing DoW-sponsored automated site-planning tool or to its current web-based modernization — DoW contractors and government personnel without licensed access, DoE laboratories, NATO partner-nation installations, and contractors with DoW flow-down obligations. QDArc v1.0 implements the DoW regulatory baseline (DESR 6055.09 and the DESR 6055.09_DAFMAN 91-201 Department of the Air Force supplement) because that is the regulation set the founder knows cold. Sites whose work follows the DESR base rules — including Army, Navy, Marine Corps, and DoE laboratories whose practice aligns

with DESR base — can use QDArc v1.0 today. Service-specific additions (Navy NAVSEA OP-5, DoE-specific supplemental requirements per DOE-STD-1212-2025) and NATO AASTP-1 with its companion site-plan manual AASTP-1.1 ship in later releases.

QDArc does not pursue official DoW adoption as a production replacement for the existing automated site-planning tool. It exists to serve users that tool does not reach.

QDArc is in the design phase as of 2026; this paper describes the V1.0 product as designed and the V2+ roadmap as committed. Project status detail is in Section 13.

§ 02 · ORIGIN

Why this tool exists.

The founder spent ten years in U.S. Air Force explosive safety, most recently at the Major Command (MAJCOM) headquarters level, where site planning under DoW regulation was a principal area of work. A subsequent role at a DoE national laboratory exposed the gap that motivated this project: the DoW-sponsored automated site-planning tool, while present at the site, was not operationally usable. The tool depends on a commercial geographic information system (GIS) license whose access path had been phased out by the vendor. Months of effort — engagement with a specialist consultancy, exploration of every available workaround — confirmed no off-the-shelf product fills the gap for a Site Planner who needs deterministic QD output traceable to the regulation.

> QDArc is the answer the founder wishes had existed at the DoE laboratory.

Outside of installations with current licensed access to the DoW-sponsored automated site-planning tool, deterministic QD work is performed today with whatever combination of regulation, spreadsheets, GIS, and subject-matter judgment the Site Planner can assemble. Site Planners without that access — DoW contractors, DoE laboratories, NATO partner-nation depots, contractors with DoW flow-down obligations — face the same gap. The DoW-sponsored current web-based modernization of the automated site-planning tool, while a meaningful advance for users who will have access to it, runs on DoW network and identity infrastructure and does not by itself reach users outside that infrastructure.

QDArc exists to serve users that tool does not reach.

§ 03 · FUNCTION & SCOPE

The Site Planner's function and what QDArc covers.

The Explosive Safety Site Planner is the installation's focal point for explosives safety risk. The role title varies: the U.S. Air Force has historically used "Weapons Safety Manager"; other services and the joint community use "Explosives Safety Manager"; DoE laboratory practice varies by site. The work, where it intersects explosive site planning, is consistent. The role covers:

- Identifying every place that stores or handles explosives (the **Potential Explosion Site**, or PES).
- Identifying every Inhabited Building (IB), structure, aircraft, road, and asset that could be affected (the **Exposed Site**, or ES).
- Determining the regulatory protection distance for every PES to ES relationship (the **Quantity-Distance**, or QD).
- Identifying where the required QD is not met, according to the applicable regulation.
- Documenting the mitigation that covers each non-conformance, with the residual risk characterized for the approval authority's acceptance decision.
- Assembling the **Explosive Safety Site Plan** (ESSP) submittal package and submitting it through the approval chain.
- Supporting inspections, leadership briefings, and external reviews against the regulation.

Any installation that stores explosives — a DoW service base, a DoE laboratory, a NATO host-nation depot — must hold a current, approved site plan for every PES. The site plan shows that the explosives at that location are far enough from Inhabited Buildings, aircraft, roads, and other explosives to meet the separation distances required by regulation — or, where a shortfall exists, that the shortfall is covered by an approved mitigation.

The Site Planner produces the technical basis on which an approval authority — an installation commander, a laboratory director, a host-nation safety authority, depending on the community — accepts or refuses the residual risk. **The Site Planner does not accept risk.**

QDArc covers the Site Planner's end-to-end workflow for this task:

- Lay out the installation on a map.
- Designate which features are PESs and which are ESs.
- Capture the explosive content (hazard division, net explosive weight, configuration) at each PES.
- Compute the required QD for every PES to ES relationship.
- Render the resulting arcs on the installation map for review.

- Identify and characterize any non-conformance per the applicable regulation.
- Track the mitigation that covers each non-conformance.
- Assemble the ESSP submittal package — drawings, tables, narrative, references — as a single submittable artifact.

WHAT QDARC DOES NOT DO

QDArc produces the technical basis for site planning. It does not approve site plans — the approval chain in each community, with thresholds set in regulation, is unchanged. It does not pursue official DoW adoption as a production replacement for the DoW-sponsored automated site-planning tool; it exists to serve users that tool does not reach. QDArc's risk analysis is deterministic, anchored to the regulation's published K-factor tables and formulas; where a separate quantitative risk assessment is needed, **SAFER** (Safety Assessment for Explosives Risk) and **IMESAFR** (Institute of Makers of Explosives Safety Analysis for Risk) — both developed by **A-P-T Research, Inc.** — are the recognized tools, and their results can be carried alongside the deterministic QD as supporting documentation for a Risk Analysis mitigation. Section 10 enumerates the full set of analytical and operational exclusions.

§ 04 · REGULATORY BASIS

Regulatory foundation.

QDArc implements separation-distance and siting rules drawn from approved, publicly released explosive safety regulations of the communities it serves. QDArc v1.0 implements the DoW baseline; supplements for the other communities ship in later releases.

4.1 Implemented in QDArc v1.0

DESR 6055.09

The joint base explosives safety regulation.

DESR 6055.09_DAFMAN 91-201

The Department of the Air Force supplement to DESR.

A site operating under DoE, Navy, Marine Corps, or Army regulation will be able to use QDArc v1.0 when it ships for analyses that follow the DESR base rules. The base rules apply directly. Community-specific supplements are not invoked until later releases add them.

> **A PRACTICAL NOTE FOR DOE LABORATORIES**
>
> Some DoE laboratory practice already applies Air Force criteria in part. For those laboratories, QDArc v1.0's DESR + DAFMAN coverage will handle a substantial portion of the day-to-day work at v1.0 release, and the DoE-specific supplemental rules per DOE-STD-1212-2025 land in a later release on top of that base — additive rather than replacement.

4.2 Scheduled for later releases

- **DOE-STD-1212-2025** — DoE's explosives safety technical standard. Adds DoE-specific provisions on top of the DESR / DAFMAN base coverage already shipping in v1.0.
- **NAVSEA OP-5** — the Navy / Marine Corps supplement. QDArc's regulation selector accepts "Navy" as a value today; the OP-5 supplement tables are scheduled for a later release.
- **NATO AASTP-1 Edition D, Version 1** — the principal NATO standard for the storage of military ammunition and explosives. Bundles in **AASTP-1.1 Edition A, Version 1** — Manual for the Development of an Explosives Safety Site Plan Based on AASTP-1 — as the companion reference for site-plan format and content (the AASTP-1 analogue of DDESB Technical Paper 26). Scheduled for a later release; expected to be the principal foreign-market unlock.

4.3 Cross-cutting public references that inform QDArc behavior

DDESB Technical Papers TP-15 (Revision 4), TP-21 (Revision 2), TP-23 (Revision 2), and TP-26; UFC 4-420-01; MIL-STD-398A; and MIL-STD-882E with Change 1. Each is cited in full in Section 15.

The K-factor tables in DESR and the AF supplement, with their formula footnotes, drive most of the numerical work. The regulation uses a small set of mathematical forms across its tables. QDArc applies the right form to each row rather than assuming one formula fits everywhere — using the wrong form in the wrong place produces wrong distances, and the discipline to read each row's footnote and apply the correct math is part of what the QD Engine is for.

Review authority varies by community. At the DoW level, the **Explosives Safety Office** (ESO, formerly the Department of Defense Explosives Safety Board / DDESB) reviews explosives safety submittals at the federal level — site plans for new construction, facility modifications, or change of use per DESR §V1.E5.2.1; deviations per §V1.E3 (waivers, exemptions, Secretarial certifications); and risk-based site plans per §V6.E5, along with the periodic reviews these documents require. Service-component safety chains review at thresholds below ESO. DoE has its own review chain through the site office. NATO partner-nation work goes through the host-nation safety authority. QDArc produces the technical basis for the review; it does not change who reviews.

§ 05 · DOMAIN

Core concepts.

A Site Planner reading this section will recognize all of it. It is included so the rest of the paper reads without context-switching back to the regulation.

5.1 Potential Explosion Site (PES)

A PES is any location that holds an explosive item subject to QD controls — a magazine, an operating building, a holding yard, a loaded aircraft on the ramp, an Explosive Ordnance Disposal (EOD) operation. Each PES is characterized by its **hazard division** (HD, set by the explosive item's classification), its **Net Explosive Weight for Quantity-Distance** (NEWQD, the weight that drives the QD calculation), and its **configuration** (earth-covered magazine, above-ground magazine, open pad, aircraft, or another regulation-defined class). QDArc v1.0 covers the full hazard division set in current DoW regulation.

5.2 Exposed Site (ES)

An ES is anything that QD is supposed to protect. Each ES type carries a regulatory relationship to each PES — an Inhabited Building is protected to **Inhabited Building Distance** (IBD); a public traffic route to **Public Traffic Route Distance** (PTRD); an intra-line exposure to **Intraline Distance** (ILD); a sibling magazine to **Intermagazine Distance** (IMD).

Some real-world objects function as both PES and ES depending on context — a loaded aircraft is a PES to the buildings around it and an ES to the magazine across the ramp. QDArc evaluates the object in each role separately and carries both records.

5.3 Quantity-Distance Arcs

A QD arc is the radius, drawn around a PES, inside of which a given ES type is non-conforming. The four arcs most often shown are `IBD`, `PTRD`, `ILD`, and `IMD`. Each arc radius is computed from the PES's NEWQD using the regulation's K-factor table, selected by hazard division, PES configuration, and ES type.

5.4 Caps, Minimums, and Special Rules

Beyond the basic K-factor lookup, the regulation has additional rules — maximum allowable weights for certain magazine configurations, minimum distances for certain hazard divisions, and special-case provisions that override the default formulas in specific conditions. When one of these rules sets the final number, QDArc records which rule won, not just the K-factor calculation.

5.5 Hazardous Fragment Distance

For some HD 1.1 and HD 1.2 items, fragments thrown by an explosion can reach farther than the blast wave's protected distance. The **Hazardous Fragment Distance** (HFD) is the distance at which the density of fragments — the count per unit area — drops below the level the regulation considers dangerous. When HFD is greater than the QD blast distance, HFD governs the arc. QDArc compares both for every applicable pair and uses the greater. Declaring an exposure "safe" on the blast distance alone, when fragment distance is greater, is exactly the failure mode this comparison prevents.

5.6 Maximum Credible Event (MCE)

The **Maximum Credible Event** (MCE) is the largest quantity of explosives that could detonate in a single event at a PES. For most HDs, MCE equals total NEW. For HD 1.2.1, NEWQD is the MCE — the single largest detonating item — rather than total NEW. Certain configurations cap or reduce MCE below total NEW: the High Performance Magazine limits MCE to 60,000 lbs per DESR §V1.E7.3.1.3; DDESB-approved buffer configurations limit MCE to the largest stack plus the buffer material excluding HD 1.4; and separations by qualified barriers or by time per DESR §V1.E7.3.2 can reduce MCE to the largest single stack rather than the summed total. NEW (raw explosive weight), NEWQD (the weight that drives the QD calculation per the applicable HD's rules), and MCE (the credible single event) are three distinct concepts; QDArc carries each separately and records which one drove a given result.

§ 06 · WORKFLOW

How QDArc functions — workflow.

The application is organized around the Site Planner's actual workflow. A user opens QDArc, opens an installation, and proceeds through the workflow in order. Each stage produces a record that the next stage consumes.

6.1 Map and Installation Layout

QDArc opens to a map of the area, with an open-source basemap (such as OpenStreetMap or USGS) as the default. The Site Planner can import installation-specific GIS layers — building footprints, fence lines, taxiways, real-property feeds where available — and can draw additional features directly on the map for facilities not yet captured in a feed. The map is the substrate the rest of the workflow reads against; QDArc does not replace the underlying mapping data, it draws on top of it.

6.2 PES Designation and Configuration

Each PES is placed on the map, given an identifier, classified by hazard division and configuration, and assigned its NEWQD. A PES may carry multiple hazard divisions simultaneously, with NEW assigned per HD. Specialty PES classes — EOD operations, explosives burn and demolition areas, holding pads, munitions loading points, operating buildings — each get the fields regulation requires for that type and not the ones it doesn't.

> AIRCRAFT GROUP SITING
>
> The Air Force airfield workflow per DAFMAN §V3.E3.T17 Note 15 is included in QDArc v1.0's committed feature set. A flight line is rarely a single aircraft sitting alone; it is a group of aircraft on a ramp with explosives loaded, where the combined Net Explosive Weight of the group drives the external QD distance and aircraft within the group are suppressed from intermagazine-distance considerations to one another. QDArc models the aircraft group as an entity, computes combined NEW for the external arc, applies within-group suppression, carries per-platform aircraft templates (the standard footprint and configuration of common Air Force platforms), and supports the PEX / NEX dual-polygon model that distinguishes the populated extent from the no-explosives-clearance extent on the ramp. Operational state — the aircraft is parked, fueled, configured for combat, configured for cargo — adjusts the arc accordingly. The aircraft template catalog ships with the common Air Force platforms a Site Planner is most likely to place; a Site Planner can record installation-specific dimensions where the catalog default does not match the actual aircraft.

6.3 ES Designation and Configuration

Each ES is placed, classified by type (Inhabited Building, public traffic route, intra-line exposure, sibling magazine, utility, asset), and given the attributes regulation needs to apply the right protection level.

6.4 Relationships and Exposure Routing

For each PES, QDArc finds the relevant ESs and routes each pair to the correct regulatory section. The routing record keeps the PES side, the ES side, the regulation section, and any pair-specific overrides the Site Planner has applied (a sector assignment, a barricade declaration) on separate axes. This separation matters because the same physical pair can be governed by different regulation sections under different conditions.

6.5 Data Validation and Pre-Analysis Checks

Before any QD computation runs, QDArc performs a battery of data consistency checks. The checks find things like: two PESs sharing a name, a NEWQD that exceeds the configuration's regulation-defined maximum, an override applied where it doesn't belong, or a combination of fields that suggests a copy-paste error from another PES.

Findings come in two severities. **Errors** block further processing until resolved. **Warnings** require the Site Planner to acknowledge them with a written rationale before submission. The acknowledgment is durable — it persists with the site plan and is visible to the approval chain.

6.6 QD Determination — the QD Engine

For each PES to ES pair, the QD Engine:

01 **Selects the K-factor table row** from hazard division, PES type, ES type, and applicable conditions.

02 **Applies any conditional hazard-division rule** the regulation defines. For example, very small quantities of HD 1.2.1 (where NEWQD ≤ Maximum Credible Event ≤ 450 lb, per DESR §V3.E3.2.2) are evaluated under HD 1.1 rules instead of HD 1.2.1 rules. QDArc applies these conditions automatically and tags the result with the regulation citation, so a reviewer sees on screen exactly which rule changed the math.

03 **Computes the required separation distance** using the correct formula for that table row.

04 **Compares QD against HFD** for fragment-driven items; the greater governs.

05 **Applies any maximum or minimum** the regulation imposes, and rounds per regulation. Per DESR §V1.E7.5.2, when the decimal portion of the computed distance is 0.5 ft or more, round up to the next whole foot; less than 0.5 ft, round down. (Example: 87.4 ft rounds to 87 ft; 87.5 ft rounds to 88 ft.)

06 **Records the binding rule** — which K-factor row, which footnote, which limit governed — and the regulation citation that drove each step.

WORKING THE MATH IN REVERSE

Some calculations require QDArc to solve the problem the other direction: given a fixed actual separation distance between a PES and an ES, what is the maximum NEW that can be stored at that PES without exceeding QD? This answers the common Site Planner question: "I have X feet between this magazine and that road. How much can I put in the magazine?" The engine uses a controlled numerical method to find the answer, with explicit detection of any case that does not converge. It does not silently return a wrong value.

6.7 Spatial Assessment

Once required distances are computed, the spatial assessment turns each PES into one or more arcs on the map and finds the Exposed Sites that fall inside each arc.

Finding candidate exposures. For each PES, QDArc searches a zone around it for candidate ESs. To make sure no real exposure is missed — including ones a Site Planner might create later by uprating a PES — the search zone is sized using the largest NEW present anywhere on the installation with the broadest applicable K-factor, not just the NEW of the PES being evaluated. A search zone larger than the actual arc costs nothing; one too small can miss a real exposure.

Sector determination. For sector-aware PES types — earth-covered magazines (ECM), open storage modules (OSM), round earth-covered magazines (REM), and Hardened Aircraft Shelters (HAS) — QDArc computes the angular position of each candidate ES relative to the PES's front bearing and assigns it to the correct sector (Front, Right Side, Rear, or Left Side per DESR §V3.E3.T1 notes; HAS sub-sectors per DAFMAN §V4.E3). Each sector takes its own K-factor and produces its own arc.

Barricades. QDArc reads the barricading state for each PES-ES pair from the imported barricade GIS layer where one is available, and from explicit Site Planner declarations at the pair level otherwise. The engine consumes the barricading state as an input. Line-of-sight verification — whether a declared barricade actually blocks line of sight between the PES and ES — is out of engine scope in V1 and remains the Site Planner's responsibility.

6.8 Compliance Verdict and Arcs

For each PES to ES pair the spatial assessment flagged, QDArc issues a compliance verdict. The arc record carries enough information that a reviewer can see, for each exposure: which PES, which ES, which arc type, which required distance, which K-factor citation governed, and what mitigation (if any) covers it.

WHEN A SINGLE PES STORES MULTIPLE HAZARD DIVISIONS

A real PES often contains explosives in more than one hazard division — a magazine might hold both HD 1.1 munitions and HD 1.3 propellant, for instance. Per DESR §V1.E7.2.3, the regulation specifies how mixed-HD storage is evaluated. For HD 1.1 mixed with HD 1.3 or HD 1.6, §V1.E7.2.3.3 and §V1.E7.2.3.4 require summing the NEWQD and siting the entire mixture as HD 1.1. For HD 1.1 with HD 1.2, §V1.E7.2.3.2 requires computing both (summed-as-HD-1.1 and HD-1.2-subdivision-alone) and using whichever generates the larger QD. HD 1.4 is the exception per §V1.E7.2.3.1.1 — HD 1.4 weight is not additive, but HD 1.4 criteria must still be evaluated separately and the largest result used. QDArc applies these rules automatically in the engine and records which rule and which combined NEW drove each binding distance, so a reviewer sees the regulatory basis for the result.

Sectored PES. For PES types whose required distance depends on the sector an ES sits in — Front, Right Side, Rear, and Left Side of an earth-covered magazine, for example — the verdict is computed per sector. The arc rendered on the map is the composite of the per-sector arcs.

THE EVALUATION ZONE

Per DAFMAN §V1.E5.2.3.3.1.3.3 (Added)(DAF), the **Evaluation Zone** is an installation-level outer boundary used to bound the analysis envelope of an ESSP submission. By default it is 1.2 × the largest IBD computed on the installation; when an installation has geographically separated explosives areas, the EZ is computed per area. QDArc produces the EZ automatically and renders it on the submittal drawing.

6.9 Explosive Safety Site Plan Assembly

The final stage assembles the ESSP submittal package: the narrative description of each PES, the table of PES-to-ES exposures with arcs and verdicts, the drawings, the supporting mitigations, and the references. The package is structured to match what the approval chain in the user's community expects to receive, with the Evaluation Zone and supporting drawings attached.

§ 07 · MITIGATIONS

Mitigations and the Site Planner lane.

Where a PES to ES exposure does not meet the standard QD requirement, the deviation from the regulation requires a documented basis on which the approval authority accepts the residual risk.

In regulation, that basis is called a **deviation**. In QDArc, the record that documents the deviation is called a **mitigation** — it is the thing the Site Planner attaches, tracks, and submits.

The QDArc v1.0 Air Force mitigation set contains seven types, each anchored in a specific DESR 6055.09_DAFMAN 91-201 sub-paragraph:

- **Risk Analysis (RA)** — a risk-based analysis (such as DDESB TP-23 methodology, or a quantitative risk assessment performed with SAFER or IMESAFR, both developed by A-P-T Research, Inc.) demonstrates acceptable risk despite the QD shortfall.
- **Engineering Analysis (EA)** — an engineering basis (modeling, test data, expert analysis) demonstrates the actual hazard is less than the table-driven distance implies.
- **Waiver** — a written authority permits the deviation under documented conditions.
- **Exemption** — the pair is determined to be exempt from the QD requirement by an authority with that determination power.
- **Event Waiver (EW)** — short-term authorization (typically bounded at twelve months or less) for a specific event or limited-duration operation.
- **Secretarial Exemption / Certification (SecCert)** — Service Secretary or designated authority certifies the deviation per DESR provisions.
- **Compensatory Measure** — a specific operational or procedural measure (limited NEW, restricted access, monitoring, similar controls) implemented to reduce risk to acceptable levels.

Other service mitigation sets — for example, the Army Certificate of Risk Acceptance (CORA) and Navy / Marine Corps / NATO variants — ship in later releases as the corresponding service-variant supplements are built.

Every mitigation record carries the approving authority, the date of approval, the supporting documentation, any expiration date, and a status (active, expired, superseded). Only an active mitigation clears a violation for submittal. Active mitigations are displayed on the map alongside the PES, ES, and arcs they relate to, so a reviewer can see at a glance which exposures are covered.

> HIGH-SEVERITY RISK ASSESSMENT (HSRT)
>
> Risk Analysis mitigations carry the Air Force HSRT severity / probability matrix per DAFMAN §V1.E3. The matrix evaluates severity against probability to produce a risk level that the approval authority sees on the same surface as the deviation. QDArc surfaces the HSRT result on the mitigation record so the reviewer sees the deterministic QD shortfall, the supporting risk analysis, and the resulting risk characterization in one view.

THREE THINGS QDARC EXPLICITLY TREATS AS NOT-MITIGATIONS

- A **reduction of NEW** is a configuration change to the PES — the engine re-runs.
- A **change in the related code** between a PES and ES is a routing change — the engine re-runs.
- A **custom arc** drawn over the engine's computed arc is a drawing-layer override that requires a citation to an Engineering Analysis mitigation but is not itself a mitigation type.

LANE BOUNDARY

The mitigation set above governs site-plan shortfalls — the Site Planner lane. It does not govern compatibility-group or mixed-storage approvals, which run on a parallel approval chain owned by the local munitions or ammunition organization. QDArc displays compatibility-group information for reference (it helps the Site Planner read what is in a magazine) but does not own those records and does not route those approvals through the site-plan pipeline.

§ 08 · REFERENCE

Reference catalogs.

Several reference catalogs ride alongside the live working data:

- **Aircraft templates** — standard wingspan, length, footprint, and fuel-load defaults for the Air Force platforms a Site Planner is most likely to place as a PES or ES on the ramp. The shipping catalog covers fighter and attack aircraft (F-15, F-16, F-22, FA-18, FA-22, A-10), bombers (B-1, B-2, B-52), airlift (C-5, C-17, C-130), tankers (KC-46, KC-135), rotary-wing (HH-60G), and a Composite US CAPA entry for mixed parking areas.
- **Standard magazine designs** — the named DDESB Technical Paper 15 (Revision 4) protective-construction designs that qualify for built-in K-factor footnote treatment, with their associated default dimensions.
- **Compatibility-group letters** — display-only descriptions of HD / compatibility-group combinations for the thirteen recognized groups (A, B, C, D, E, F, G, H, J, K, L, N, S), drawn from DESR and DDESB Technical Paper 21 (Revision 2), so the Site Planner can read a magazine card without leaving QDArc.

These catalogs are versioned, sourced, and dated. Where an installation's actual data differs from the catalog default — for example, a specific aircraft's measured dimensions or a magazine's

surveyed footprint — the Site Planner can record an installation-specific value that takes precedence in the analysis for that installation. The catalog default remains visible alongside the installation-specific value, with a record of who entered the override and when.

§ 09 · OUTPUTS

Outputs.

The artifacts a Site Planner will produce from QDArc v1.0:

- The on-screen map with overlaid arcs, mitigations, and the Evaluation Zone — used in working reviews and walk-throughs.
- The exposure table per PES — used in briefings with approval authorities and reviewing offices.
- The full ESSP submittal package, structured to match the form and content the approval chain in the user's community expects to receive, with the siting drawing, attachments, and transmittal.
- Mitigation status reports — what is active, what is expiring, what is unsigned.
- Standard reports — the QD Calculation Detail report (per PES, per HD, showing the binding rule and citation chain), the Limiting ES report (which exposure is governing for each PES and why), the Weapons Safety report, the Batch Analysis report for installation-wide views, and the DQ Results table (maximum allowable NEW per PES per HD given current actual distances).
- Standard exports — DXF, KML, GeoJSON, and File Geodatabase formats for installation-GIS interoperability; CSV exports for tabular handoff; map graphic exports in PDF, JPEG, PNG, and EMF for briefings; and a full project backup that captures the complete project state for transfer, archive, or disaster recovery.
- The audit log — every change to a PES, ES, mitigation, or acknowledgment is recorded, dated, and attributable.

The audit log is not a software feature for its own sake. It is the record the Site Planner relies on when a finding three years later asks "when did this change, and who approved it?"

QDArc supports role-based access aligned with the explosives-safety review chain. The Site Planner who owns the project has full edit access; reviewers, inspectors, and approving authorities have read-scoped access to the package contents and the supporting analysis — matching the submission and approval chain in each community's regulation (DAFMAN §V1.E5.2.1.13–.14 for AF; equivalent provisions in the corresponding service / community regulation).

> REGULATION EDITION PINNING
>
> Every analysis record carries the regulation edition (DESR Edition and Change number; Department of the Air Force supplement edition where applicable) it was computed against. When the regulation changes, the math does not change behind your back. The Site Planner re-runs and confirms. A tool that quietly re-computes prior analyses against a new regulation is a tool that can produce a confidently wrong answer; QDArc does not do that.

§ 10 · BOUNDARIES

Boundaries — what QDArc does not do.

What QDArc does not do is as important as what it does:

- **Not a quantitative risk assessment tool.** QDArc does not implement DDESB TP-14, NATO AASTP-4, or any probabilistic risk methodology. Where quantitative risk assessment is needed, SAFER and IMESAFR — both developed by A-P-T Research, Inc. — are the recognized tools. QDArc's role is to produce the deterministic QD record that those tools consume as a baseline.
- **Not a UN Hazard Class / Division assigner.** Hazard division is set by the explosive item's classification, recorded in munitions data, and consumed by QDArc as input. QDArc does not assign HD; it applies the QD criteria for the HD that has been assigned upstream.
- **Not a Surface Danger Zone tool.** Surface Danger Zones (range safety, governed by references such as DA PAM 385-63 for the Army and AFMAN 91-224 for the Air Force) are out of scope. The disciplines overlap in vocabulary but the analyses are different.
- **Not a munitions-accountability or inventory system.** Mixed-storage approvals, magazine load records, and compatibility-group approvals live in munitions records and have their own approval chain.
- **Not a substitute for the approval chain.** QDArc produces the technical basis; the approval chain — installation-level, service-component, NATO host-nation, DoE site office — remains unchanged.

§ 11 · BUILD APPROACH

Build approach — clean-room methodology.

The clean-room principle defined in Section 1 governs every requirement in the project. To restate it from the perspective of the build: QDArc is developed using only publicly released regulations, publicly released DDESB Technical Papers, public conference proceedings, public training

materials, and the documented professional knowledge of the founder. The project does not use, paraphrase, or reproduce content from any non-public, restricted, or proprietary documentation of any existing automated site-planning tool.

Every requirement traces to one of:

- A publicly released regulation (DESR 6055.09, DESR 6055.09_DAFMAN 91-201, DOE-STD-1212-2025, NATO AASTP-1, NATO AASTP-1.1).
- A publicly released DDESB Technical Paper.
- A public conference proceeding or public training material.
- An explicit Subject-Matter-Expert (SME) contribution from the founder's career, recorded as such alongside any supporting regulatory citation.

The discipline is enforced in three ways. First, every requirement document carries the citation for every requirement on the line where the requirement appears. Second, the project's operating rules explicitly forbid citing any non-public material as the basis for any requirement; if a contributor tries to anchor a requirement to a non-public source, the requirement is rejected until a public source or a marked SME contribution can be found. Third, a routine reviewer pass re-runs the citation trace and verifies that each cited source still says what the requirement claims it says.

> DISCIPLINE IN PRACTICE
>
> The methodology has caught and corrected real errors during the build — including incorrect regulation citations that an outside reader might never have noticed. The point is not to avoid looking like other tools; when two tools are driven by the same regulation and the same operational problem, structural similarity is expected. The point is to make every line of QDArc defensible to a reviewer who asks the simple question: where did this come from? The answer must be a public source or a marked SME contribution. It cannot be "an existing tool does this."

§ 12 · VALIDATION

Validation approach.

QDArc's compliance verdict is only useful if the QD Engine is right. The validation approach has four parts.

12.1 Worked-example validation

The engine is validated against worked examples taken directly from regulation — worked examples in DESR Volume 3, DDESB Technical Papers (notably TP-15 Chapter 6 for protective-construction examples and TP-26 for site-plan format examples), and publicly released training materials — with the calculations transcribed from the source and cross-checked. Validation is against the regulation, not against any other tool. Agreement with another tool is not the standard; agreement with the regulation is.

12.2 Coverage

The validation set will exercise every K-factor table row, every formula form, every cap and minimum, and every combination of multiple hazard divisions in QDArc v1.0's scope. Coverage is enumerated explicitly rather than left to chance: every DESR Volume 3 table, every DAFMAN supplement table including the airfield matrices T17 / T18 / T19 and the HAS-specific tables in DAFMAN §V4.E3, and every formula form the regulation uses. Edge cases — rule transitions, mixed-HD combinations, sector-boundary cases, fragment-distance-governs cases — are enumerated explicitly. The number of worked examples scales with coverage; the working target is several hundred cases drawn from the regulation itself and the supporting public references, growing as AASTP-1 and DOE-STD-1212-2025 work lands.

12.3 Transcription discipline

Every K-factor table cell, every footnote, every formula in the engine cites the regulation cell it implements. A separate routine — read the regulation cell, look at the value the engine produced, log whether they match — runs after the original implementation work is done. This separates the act of writing the value from the act of verifying it.

12.4 Planned independent walk-through

> INDEPENDENT SME WALK-THROUGH
>
> Before any external user runs QDArc against production data, the validation set will be walked end-to-end by a second explosive-safety subject-matter expert who is not the founder. The walk-through validates the math, not the code; it asks "does this number match what the regulation says it should be?" of every binding result. This step has not yet been performed; it is the gate before any external use.

§ 13 · STATUS

Project status and deployment posture.

QDArc is currently in the design phase, before code. The project has produced thirteen Product Requirements Documents covering project conventions, map and installation layout, PES designation and configuration, ES designation and configuration, relationships and exposure routing, data validation, QD determination, spatial assessment, compliance verdict and arcs, ESSP package and reports, mitigations, storage-compatibility reference, and feedback and audit-log viewing. Additional PRDs covering the user interface shell, the access model, and the standalone QD calculator surface — along with a validation test corpus plan that grows alongside regulation coverage — are scheduled as scope-extension work. The V2 roadmap covers NAVSEA OP-5, DOE-STD-1212-2025, AASTP-1, deployment readiness, ecosystem integration, the reference-data layer, workflow extensions, user-experience and training, and lifecycle. Each requirement traces to a publicly released regulation, an SME contribution from the founder's career, or a public reference, consistent with the build approach in Section 11.

Implementation begins once the design is finalized. QDArc is meant to be complementary to, not in competition with, the DoW-sponsored current web-based modernization of the automated site-planning tool. Both efforts address different parts of the same problem: the DoW modernization helps users who are inside DoW infrastructure today; QDArc serves users who are outside it or whose access to it is limited.

DEPLOYMENT POSTURE

QDArc V1 targets web-first deployment with progressive-web-app patterns for intermittent connectivity, so a Site Planner working in a field office or on a network with variable latency can still operate. The deployment work — Common Access Card / Personal Identity Verification authentication for DoW networks, federated identity for DoE and NATO partners, on-premises deployment for environments without internet egress, and security baselines aligned with the federal NIST Risk Management Framework — is scheduled as a distinct workstream alongside the regulatory supplements. Section 508 conformance per 36 CFR Part 1194 is targeted as part of the V1 acceptance criteria; federal procurement eligibility depends on it, and accessibility matters operationally for every user community. Specific compliance authorizations (Authority To Operate, FedRAMP authorization, DoD Impact Level designation) will be pursued as each customer community's adoption requires; the architecture does not foreclose any of them. Details on a particular deployment posture are available on request as the design crystallizes.

REGULATION UPDATE HANDLING

A regulatory-update ingest workstream — automating the detection, diff, and audit of changes between regulation editions — will run alongside feature work to keep the rule tables and validation corpus current as DESR, DAFMAN, NAVSEA OP-5, DOE-STD-1212, and AASTP-1 publish updates. Prior analyses remain pinned to the regulation edition they were computed against; the Site Planner decides when to re-run against a new edition.

§ 14 · CLOSING

Closing.

QDArc is a deliberately narrow tool. It does one thing — turn the regulation into accurate, defensible, submittable site plans — and relies on the rest of the safety apparatus (installation commanders, laboratory site offices, host-nation authorities, munitions organizations, service-component safety chains, and accrediting authorities) to do everything around that.

The design choice everywhere in the application is to keep the Site Planner's mental model and the application's model lined up: a PES is a PES, an arc is an arc, a mitigation covers an exposure, and every number on the screen traces back to a regulation citation.

§ 15 · REFERENCES

References.

All references are publicly released. Dates are the publication date shown on each document.

[01] DESR 6055.09 **Defense Explosives Safety Regulation**, Edition 1, Change 2, 25 November 2025.

[02] DESR 6055.09_DAFMAN 91-201 Department of the Air Force supplement to DESR 6055.09, 18 June 2025.

[03] DOE-STD-1212-2025 **DOE Technical Standard: Explosives Safety**, January 2025.

[04] NATO AASTP-1 **NATO Guidelines for the Storage of Military Ammunition and Explosives**, Edition D, Version 1, November 2025.

[05] NATO AASTP-1.1 **Manual for the Development of an Explosives Safety Site Plan Based on AASTP-1**, Edition A, Version 1, March 2023.

[06] DDESB TP-15, Rev 4 **Approved Protective Construction**, 26 July 2020.

[07] DDESB TP-21, Rev 2 **Procedures for the Collection, Analysis, and Interpretation of Explosion-Produced Debris**, 30 November 2017.

[08] DDESB TP-23, Rev 2 **Assessing Explosives Safety Risks, Deviations, and Consequences**, 3 June 2019.

[09] DDESB TP-26 **Guidance for Explosives Safety Site Plans**, 30 January 2014.

[10] UFC 4-420-01 **Unified Facilities Criteria: Ammunition and Explosive Storage Magazines**, 16 January 2025.

[11] MIL-STD-398A **Department of Defense Design Criteria Standard: Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance**, 29 January 2014.

[12] MIL-STD-882E w/Ch 1 **Department of Defense Standard Practice: System Safety**, 27 September 2023.

[13] DA PAM 385-63 **Range Safety**, current edition (referenced for Surface Danger Zone scope distinction).

[14] AFMAN 91-224 **Air Force Range Safety Program**, current edition (referenced for Surface Danger Zone scope distinction).

RECOGNIZED QUANTITATIVE RISK ASSESSMENT TOOLS REFERENCED IN THIS PAPER

- **SAFER** (Safety Assessment for Explosives Risk) — developed by A-P-T Research, Inc.
- **IMESAFR** (Institute of Makers of Explosives Safety Analysis for Risk) — developed by A-P-T Research, Inc.

This white paper is a non-proprietary description of QDArc — what it is, what regulations it implements, and how its workflow runs. It does not include implementation details, organizational identifiers, or any information specific to a particular installation. Its purpose is to let reviewers, prospective customers, and peer subject-matter experts understand QDArc without being exposed to any proprietary or restricted material.

qdarc.com · contact@qdarc.com