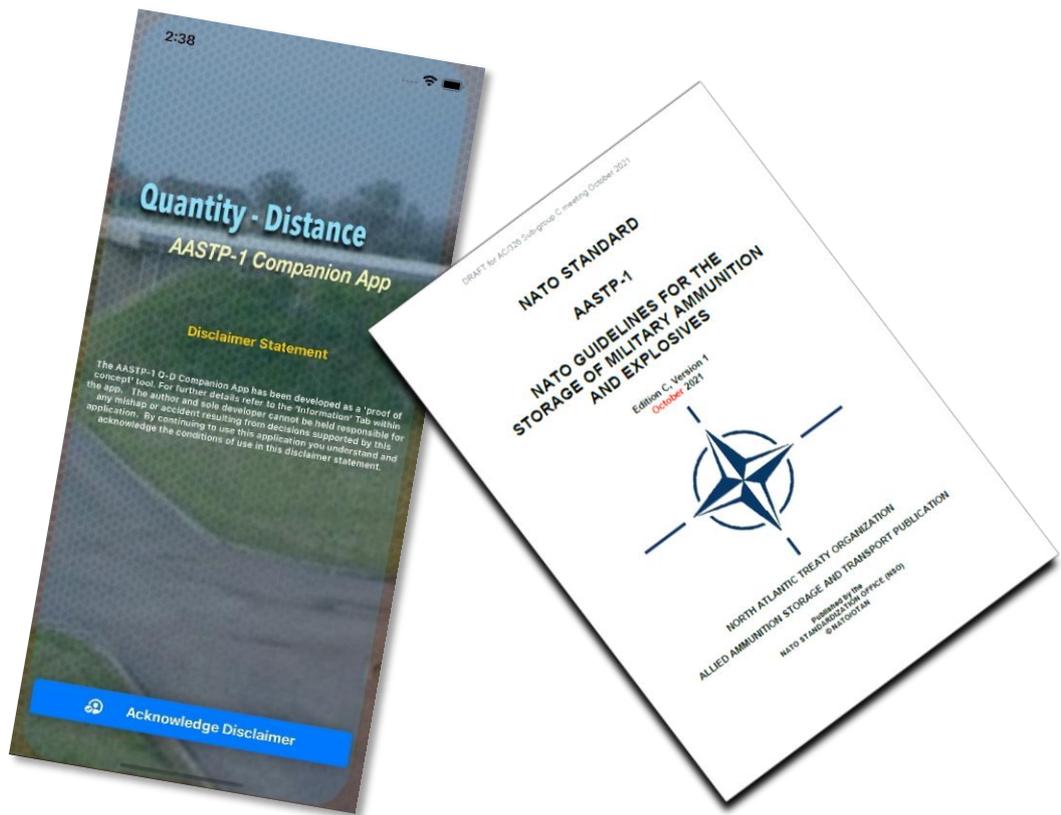


# Q-D Companion Application for Apple Mobile Devices



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## **Abstract / Synopsis**

This paper presents an overview of a locally developed mobile Quantity-Distance (Q-D) companion application for the Apple iPhone. The application is a DOS initiative to complement existing tools available to assist those individuals involved Q-D activities using the latest released of draft NATO Manual AASTP-1, Edition C.

The paper covers the key functional objective assigned during development phase and provides an example scenario that demonstrates the difference between manually conducting a QD assessment compared with that using the application. In concluding, the paper briefly covers opportunities for future improvements to enhance the application's functionality and usefulness to users.

## **About the Author**

Wing Commander Gary Gibbs has complete more than 45 years' service in the Royal Australian Air Force. During this time, Gary has fulfilled in a wide range of roles ranging from staff duties associated with EO policy, licensing and inspection to operational positions that include Air Command Targets Chief and Director Counter Improvised Explosive Devices (CIED) during his deployment to Afghanistan in 2012. Gary was the Commanding Officer of the Defence Explosive Ordnance Training School prior to transferring from permanent duty to active reserve in 2018. He now provides his services to the Directorate of Ordnance Safety in the role of a Technical Staff Officer and is a part-time software developer that has released Apple apps under the heading of ExpSAFE.

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# 1. BACKGROUND

## 1.1 Q-D Principles

Siting new and reviewing existing explosive facilities within a military munition depot involves considerable planning and analysis. A key requirement of siting is the need to minimise injury and damage caused by the initiation of munitions held within a Potential Explosive Site (PES), be it accidental or deliberate. Acknowledging constraints such as cost, available area, and operational requirements make it impractical to prescribe separation distances that would guarantee absolute immunity from an explosion. Therefore, many Nations take a compromise approach.

That approach, commonly referred to as 'Quantity-Distance' or 'Q-D' for short, takes into consideration the probability of an accident and the severity of the resulting damage or injury to identify the necessary distance or the Net Explosives Quantity (NEQ) between a PES and an Exposed Site (ES). Allied Ammunition Storage and Transport Publication 1 (AASTP-1) Manual of NATO Safety Principles for the Storage of Military Ammunition and Explosives covers the basis and philosophies of Q-Ds.

## 2. AIM

The aim of this paper is to provide an insight of a locally developed Q-D application (app) that is available to complement existing MISIAC and other Nation's tools. The app is available to assist those individuals involved Q-D activities based on the latest draft release of NATO Manual AASTP-1 Edition C.

## 3. INTRODUCTION

### 3.1 What is the 'Q-D Companion App'

The Q-D Companion App is a mobile app developed specifically for Apple iPhones to enable users to determine the aboveground NEQ limits for a selected PES in relation to an identified ES. The app enables a 'one-to-one' quick assessment between a PES and ES and outputs the max NEQ limits for each hazard division.

### 3.2 App Development Background

The development of the app commenced in late 2020 following the release of the revised draft AASTP-1 manual, Edition C, to member Nations. The author, with unofficial support within the Directorate of Ordnance Safety, privately scoped the viability to develop a 'proof of concept' application for the Apple iPhone based on informal User Requirements to overcome the perceived complexity associated with the new publication layout and process associated Q-D assessment assessments.

The iPhone, as the target device, was chosen due to the author being an Apple Application Developer who has released other apps under the 'ExpSAFE' software suite. In this case, the development of the app was a personal challenge requiring no Defence funding or resource approvals. Importantly the author is offering to release this free as an Australian Defence

Force initiative to support NATO AC/326 Working Group goals and not seeking any financial gains from its use and distribution, assuming permission is granted to publish the app on the Apple Store.

### 3.3 Functional Design Objective

The key design objective for the Q-D Companion App was the need for a ‘user friendly’ application specifically designed for a mobile device that allowed for quick Q-D assessments. The intent was to overcome the ‘manual’ approach of using the AASTP-1 Q-D interaction matrix tables and calculating the NEQ limits in the field, a process that can be complex, time consuming and prone to unintended errors for someone not experience in site licensing.

## 4. SCENARIO DEMONSTRATION

The following scenario demonstrates the functionality aspects of the Q-D Companion App:

### 4.1 Site Q-D Assessment Task

**Scenario:** Determine the maximum NEQ limits between an identified PES and an ES located 155m apart. The PES is classified as an ‘open stack barricaded’ structure and the ES is classified as ‘Non-Explosives Site Office’ with less than 20 people. For this scenario, the site office is directly supporting the Explosive Storage Area. In terms of HD1.2.1 licensing requirements, the assigned Maximum Credible Event (MCE) is 50kgs NEQ.

### 4.2 Manual Assessment Work Flow

The following workflow is the step through method that determines the NEQ limits for each HD. Refer to AASTP-1 Edition C for specific guidance on the actual process.

#### 4.2.1 AASTP-1 Interactive Matrix

The first step is to choose the correct set of QD interactions from AASTP-1’s interactive matrix based on PES and ES types. For this scenario the PES is an open stack barricaded (identified in the matrix by the letter ‘i’) and the ES is a Non-Explosives Site Office with less than 20 (identified in the matrix by the number ‘26a’ ). Refer the image below.

Releasable to PFP, MD, ICI, Australia, Colombia, Iraq, Japan, the Republic of Korea, Mongolia, New Zealand, Singapore and South Africa AASTP-1

Table 4 – Light Walled Magazines and Open Stacks

PES →	EFFECT	 Open-air stack or light structure, barricaded. Truck, trailer, rail-car or freight container loaded with munitions, barricaded. (i)	 Open-air stack or light structure, unbarricaded. Truck, trailer, rail-car or freight container loaded with munitions, unbarricaded. (j)	See introduction for full instructions and calculation tables for full formula. 1. Select correct PES/ES interaction. 2. Use HD/SsD table to determine applicable calculations 3. Use HD/SsD table to determine quantity, either NEQ or MCE 4. Use associated formula for min Distance or max Quantity.						
				HD/SsD						
ES ↓				1.1	1.2.1	1.2.2	1.2.3	1.3.1	1.3.2	1.6
 26a Office, Non-explosives workshop, Canteen with less than 20 persons who are directly associated with the explosives task in a support role (1.3.7.8)	BLAST	BD26	BD26	NEQ	MCE		MCE			MCE
	DEBRIS & FRAG	DFD20	DFD18	NEQ	MCE		MCE			MCE
	PROG' 1.2.1	P1D3	P1D3		NEQ					
	PROG' 1.2.2	P2D3	P2D3			NEQ				
	THERMAL 1.3.1	TD3	TD3					NEQ		
	THERMAL 1.3.2	TD3	TD3					NEQ	NEQ	NEQ

#### 4.2.2 HD1.1 Determination

**Step 1** - Select appropriate Blast Distance (BD) Code and Debris and Fragment Distance (DFD) Code. For this scenario, the codes are **BD26** and **DFD20** respectively.

**Step 2** – Look-up the corresponding BD26 code in the BD table listing and select the appropriate equation based on given separation distance of 155m.

<b>BD26</b>	D11	1 kg ≤ Q < 2500 kg	$1 \cdot Q^{2/3}$	1 m ≤ D < 185 m	$(D/1)^{1.5}$
		2500 kg ≤ Q < 4500 kg	$3.6 \cdot Q^{1/2}$	185 m ≤ D < 242 m	$(D/3.6)^2$
		4500 kg ≤ Q ≤ 500,000 kg	$14.8 \cdot Q^{1/3}$	242 m ≤ D ≤ 1175 m	$(D/14.8)^3$

**Step 3** – Apply the formula substituting the letter ‘D’ with the given ES distance to determine the NEQ limit for DB26;

$$\text{NEQ} = (155)^{(1.5)} = \mathbf{1\ 929.7\text{kgs}}$$

**Step 4** - Look-up the corresponding DFD20 Code in the DFD table listing and select the appropriate formula based on given separation distance of 155m.

<b>DFD20</b>	0.67 * DFD7	1 ≤ Q < 10	41	D = 41m	1 ≤ Q ≤ 10
		10 ≤ Q < 400	$40.267 + 0.067 \cdot Q$	41 < D < 68	$(D - 40.267) / 0.067$
		400 ≤ Q ≤ 3,375	$0.67 \cdot (100 + 5.5 \cdot (Q - 400)^{0.5})$	68 ≤ D < 268	$((D - 67) / 3.685)^2 + 400$
		3,375 < Q ≤ 5,000	268	D = 268	3,375 < Q ≤ 5,000
		5,000 < Q ≤ 7,020	$0.67 \cdot (0.058 \cdot Q + 110)$	269 < D ≤ 347	$(D - 73.7) / 0.03886$
		7,020 < Q ≤ 500,000	$81.07 \cdot Q^{0.164}$	347 < D ≤ 698	$(D / 81.07)^{(1/0.164)}$

**Step 5** – Apply the formula substituting the letter ‘D’ with the given ES distance to determine the NEQ limit for DFD20:

$$\text{NEQ} = ((155 - 67) / 3.685)^2 + 400 = \mathbf{970.3\text{kgs}}$$

**Step 6** – Compare both the BD26 & DFD20 calculated NEQ values and use the lesser quantity. This case DFD26 is limiting code and therefore the HD1.1 NEQ is limited to **970kgs**.

#### 4.2.3 HD1.2.1 Determination

**Step 1** – Note that the determining HD1.2.1 NEQ limit is a two part process. The first step is to compare the assigned value for MCE (this case 50kgs) with the calculated HD1.1 limit above (970kgs). If MCE were to be greater than HD1.1 limit, HD1.2.1 would equal zero. In this case, MCE is less than the calculated HD1.1 value so proceed to step 2.

**Step 2** – Look-up the corresponding P1D3 code in the P1 table listing and select the appropriate equation based on given separation distance of 155m.

P1D3	D6	$1 \leq Q \leq 50$	60	D = 60	$1 \leq Q \leq 50$
		$50 < Q \leq 500\,000$	$0.67 * (-1.303 * (\ln(Q))^2 + 70.345 * \ln(Q) - 167.648)$	$60 \leq D < 356$	$\text{EXP}(70.345/2.606 - \text{SQRT}((70.345/2.606)^2 - (-167.648 - (D/0.67))/-1.303))$

**Step 3** – Apply the formula substituting the letter ‘D’ with the given ES distance to determine the NEQ limit for P1D3:

$$\text{NEQ} = \text{EXP}(70.345/2.606 - \text{SQRT}((70.345/2.606)^2 - (-167.648 - (155/0.67))/-1.303)) = 626.5\text{kgs}$$

#### 4.2.4 HD1.2.2 Determination

**Step 1** – Look-up the corresponding P2D3 code in the P2 table listing and select the appropriate equation based on given separation distance of 155m.

P2D3	D5	$1 \leq Q < 59$	30	D = 30	$1 \leq Q < 59$
		$59 \leq Q \leq 500\,000$	$0.67 * (1.577 * (\ln(Q))^2 - 2.364 * \ln(Q) + 28.127)$	$30 \leq D \leq 181$	$\text{EXP}(2.364/3.154 + \text{SQRT}((2.364/3.154)^2 - (28.127 - (D/0.67))/1.577))$

**Step 2** – Apply the formula substituting the letter ‘D’ with the given ES distance to determine the NEQ limit for P2D3:

$$\text{NEQ} = \text{EXP}(2.364/3.154 + \text{SQRT}((2.364/3.154)^2 - (28.127 - (155/0.67))/1.577)) = 184\,611\text{kgs}$$

#### 4.2.5 HD1.3 Determination

**Step 1** – Look-up the corresponding TD3 code in the TD table listing and select the appropriate equation based on given separation distance of 155m. This case both HD1.31 and HD1.32 are the same.

TD3	D3	$1 \leq Q < 2500$	60	$1 \leq D < 60$	0
		$2500 \leq Q \leq 500\,000$	$4.3 * Q^{1/3}$	$60 \leq D \leq 342$	$(D/4.3)^3$

**Step 2** - Apply the formula substituting the letter ‘D’ with the given ES distance to determine the NEQ limit for TD3.

$$\text{NEQ} = (155 / 4.3)^3 = 46\,837\text{ kgs}$$

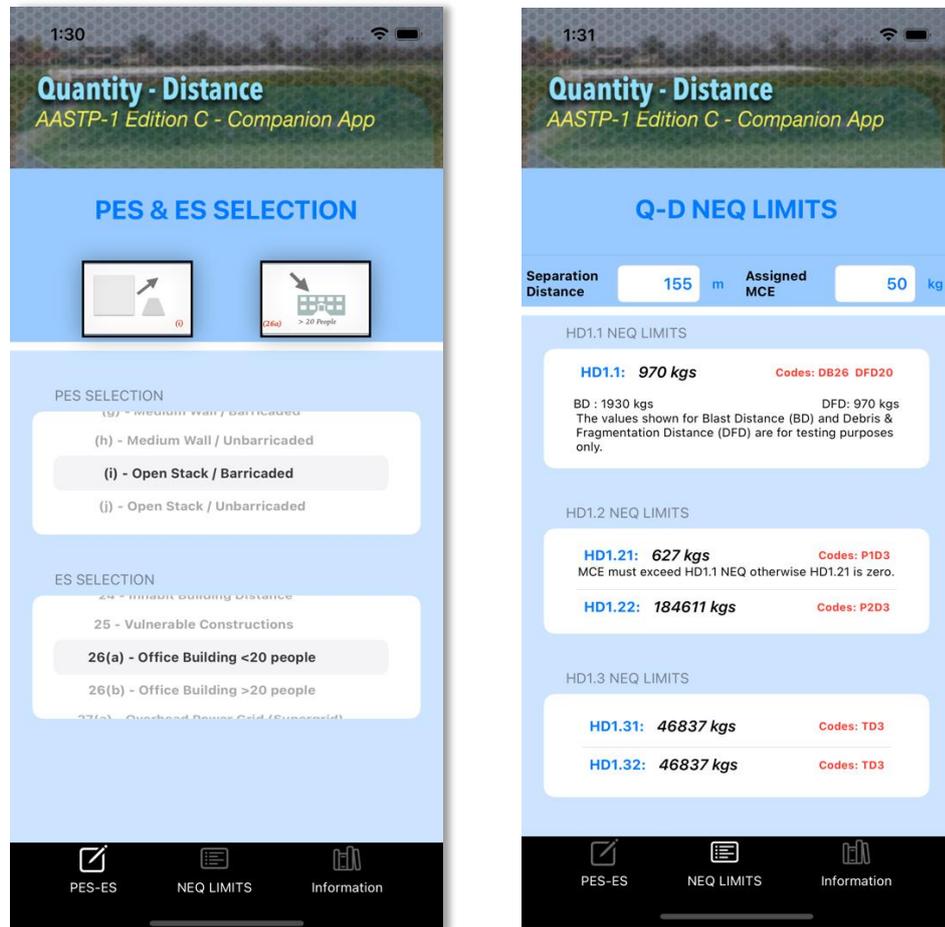
#### 4.2.6 Summary of NEQ Limits

The following is a summary of calculated NEQ limits based on AASTP-1 Edition C formulae for the given scenario.

HD1.1	970kgs	HD1.2.1	627kgs	HD1.3.1	46837kgs
		HD1.2.2	184611kgs	HD1.3.2	46837kgs

### 4.3 QD Companion App Assessment Work Flow

To perform the same task above using the Q-D Companion App, the user selects the appropriate PES and ES via a list 'picker' control from the opening screen and then proceeds to the 'NEQ Limits' screen. Now enter the separation distance between the PES and ES and the assigned MCE limit for the facility. The application will display the results as shown in the screen images below.



*Note to ensure the correct Q-D codes are applied for validation purposes, the app shows which Q-D code were used in determining the accompanying NEQ limits.*

#### 4.3.1 Known Limitations

The current version of the app has two known limitations; it assumes higher degree of protection where two or more choices are available, and for heavy wall buildings, the PES volume of 'less than or equal' to 20m<sup>3</sup> is used for DFD code selection. The released version will rectify these limitations.

## 5. WAY AHEAD

### 5.1 Current Status

As previously alluded to, the Q-D Companion App is a 'proof of concept' with a design functional objective based on a simple user requirement for one-to-one PES and ES assessments. The current version, identified as 0.9 Beta, meets the intended design objective and is available via the Apple 'TestFlight' distribution system for testers. At this stage, only a small number of users have access to the app for evaluation purposes.

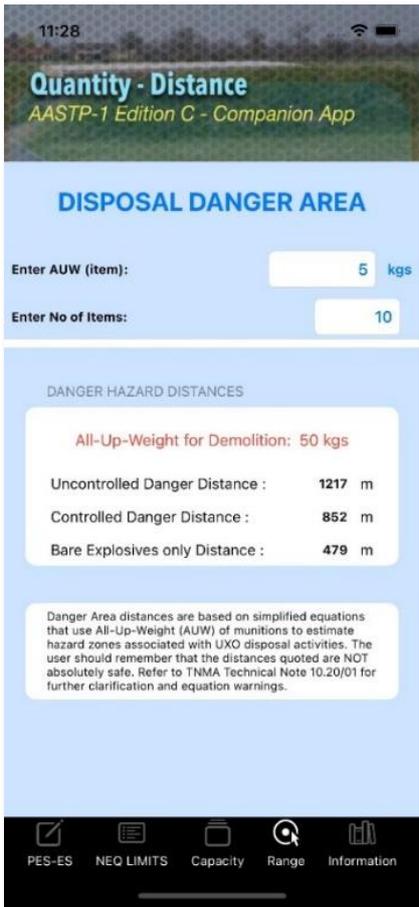
Subject to formal support and release approvals, the application will be available as a 'free download' to all interested parties via the Apple Store.

### 5.2 Foreseen Development Life-Cycle

Depending upon interest, there is the potential to include additional functionality that would enhance the usefulness of the Q-D companion app. For example, the following two modules provide examples of how to expand the app's utility as a 'quick scan' Q-D tool:

- **PES Storage Capacity.** This module estimates a building's 'physical storage capacity' in terms of volume for each HD based on given floor area and munition 'allowable' stack height. In assessing floor area available to munition storage, consideration is given to area taken up by 'access' ways and munition separation requirements.

The screenshot displays the 'Quantity - Distance' app interface. The title bar reads 'Quantity - Distance' and 'AASTP-1 Edition C - Companion App'. The main heading is 'PES STORAGE CAPACITY'. Below this, there are input fields for 'Enter Floor Length: 20 m', 'Enter Floor Width: 15 m', 'Enter % Floor Usable: 50 %', and 'Enter Stack Height: 2.4 m'. A red note states: 'The percentage floor area available takes into account space set aside to working area and forklift access. This is normally between 30-50%.' Below the inputs, the 'PES PHYSICAL DETAILS' section shows: 'Based in input the area available for storage is 600.0 m3.' and 'Total volume available to storage in the PES is 1440.0 m3.' The 'PES STORAGE CAPACITY BY HD' section lists: 'HD1.1 Storage Capacity: 648000 kgs', 'HD1.2 Storage Capacity: 259200 kgs', and 'HD1.3 Storage Capacity: 432000 kgs'. A footer note explains: 'The Density Factor (DF) used in the physical capacity calculation is 450kg/m3 for HD1.1, 180kg/m3 for HD1.2, and 300kg/m3 for HD1.3. The DF values are converted to...'. The bottom navigation bar includes icons for 'PES-ES', 'NEQ LIMITS', 'Capacity', 'Range', and 'Information'.



- **Ordnance Disposal Distances.** This module calculates the hazard boundary distances for the purposes of siting Ordnance Disposal and Burn areas based on IATG 01-80 Disposal Danger Areas.

## 6. CONCLUSION

In concluding, this paper provides a simplistic overview of a locally developed mobile Q-D companion app for the iPhone. The app is a DOS initiative to complement existing tools available to assist those individuals involved Q-D assessments based on NATO Manual AASTP-1 Edition C. Subject to formal approvals, the app will be available as a free download from the Apple Store.