

# TECHNICAL REPORT

Munitions Classification Library Update and Expansion

ESTCP Project MR-201424

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## 1.0 INTRODUCTION

This is a summary report on the start of the second phase of the data collection for MR-201424. The second phase entails collecting data with just one advanced TEM system – the MM, in this case – over less common munitions items. The list of munitions to include was developed by surveying geophysicists from the NAOC technology committee, USACE geophysicists, and representatives of the Navy and Air Force. The compiled list was then sent to various curators of munitions collections and two places in particular were identified as good candidates to go visit: the EOD facility at MCB Camp Lejeune and the Navy EOD School/Range OPS at Eglin AFB.

## 2.0 DATA COLLECTION

The equipment was setup in accordance with the procedures and guidelines outlined in section 3.1 of the SOP (Appendix B of MR-201424 DCRv2). The acquisition parameters used for the MM is shown in Tables 4-2 – 4-3 of the same report.

### 2.1 CAMP LEJEUNE

Data were collected with the MM over 51 unique items over a period of 5 days from June 22 to 26, 2015. The collection took place outdoors on the first day (Figure 1) and subsequently moved indoors (Figure 2) as wind was being forecasted.



Figure 1 – Outdoor setup for first day.



Figure 2 – Indoor setup for remaining days.

#### 2.1.1 MEASURED ITEMS

The items measured at Camp Lejeune ranged in size from smaller submunitions, including many grenade and landmine varieties, to a larger projectile and rocket (Figure 3). The specifics of each of the items are tabulated in Table 2-1 below.



Figure 3 – Munitions items measured at Camp Lejeune.

Table 2-1 – The 51 unique items that were collected with the MM at Camp Lejeune.

Name	Mark/Mod	Class*	Fins	Fuse	Spotting Charge	Rotating Band	Condition**	Comments
Fuze	M110	B	N	Y	N	N	W	
Grenade	MkI Mod2	G	N	Y	N	N	U	Illumination
Grenade	MkI Mod2	G	N	Y	N	N	U	Illumination
40mm	M406 HEDP	G	N	N	N	Y	U/P	with 552 Fuse
40mm	M406 HEDP	G	N	N	N	Y	U/P	with 552 Fuse
40mm	xm922 HV	G	N	N	N	Y	U/P	Dummy Round
Grenade	M14	G	N	Y	N	N	U	Incendiary Grenade
Grenade	M67	G	N	Y	N	N	U/P	Fragmentation Grenade
Grenade	M67	G	N	Y	N	N	U/P	Fragmentation Grenade
Grenade	M30	G	N	Y	N	N	U	Practice
Grenade	M30	G	N	Y	N	N	U	Practice
30mm TP-T	PGU-16/A	P	N	Y	N	Y	U/P	

25mm TPT	M793	P	N	Y	N	Y	U/P	
37mm	German ERST	P	N	Y	N	Y	U/P	
37mm	HE	P	N	N	N	Y	F/W	
37mm	MK2 HE	P	N	N	N	Y	F/W	
37mm	MK3 A2	P	N	N	N	Y	F/W	
Booster Cup			N	N	N	N	P	
Rifle Grenade	M18	G	Y	Y	N	N	U/P	Smoke
Grenade	Stick Model 1917	G	N	N	N	N	U/P	
Rifle Grenade	M22A2	G	Y	Y	N	N	U/P	
Rifle Grenade	A/P PGR	G	Y	Y	N	N	U/P	Rocket assist
Grenade	HEAT Type 3 Chinese	G	N	Y	N	N	U/P	
Bomblet	BLU 6/B	S	N	N	N	N	U/P	
Bomblet	M45	S	N	N	N	N	U/P	
Bomblet	M75	S	N	N	N	N	U/P	
Landmine	VS-50	L	N	N	N	N	P	
Landmine	TM46	L	N	N	N	N	P	
Landmine	M15	L	N	N	N	N	P	
Landmine	VS1.6	L	N	N	N	N	P	
Landmine	VS2.2	L	N	N	N	N	P	
Rifle Grenade	M19 WP	G	Y	Y	N	N	U/P	Smoke
Grenade	M18	G	Y	Y	N	N	U/P	Smoke
Rifle Grenade	M31 HEAT	G	Y	Y	N	N	U/P	
60mm	M720 HE	P	Y	Y	N	N	U/P	
60mm	M720 HE	P	Y	N	N	N	U/P	
60mm	M720 HE	P	N	Y	N	N	U/P	
60mm	M302A2 WP	P	Y	Y	N	N	U/P	
60mm	M5 TP-SR	M	Y	Y	N	N	U/P	
60mm	M5 TP-SR	M	Y	N	N	N	U/P	
60mm	M5 TP-SR	M	N	Y	N	N	U/P	
60mm	TAM 1.8 British	M	Y	Y	N	N	U/P	British
60mm	M721	M	Y	Y	N	N	U/P	Illumination
81mm	M853A1	P	Y	Y	N	N	U/P	Illumination
81mm	M43A1 TP	P	Y	N	N	N	U/P	
81mm	HE Type 100 Japanese	P	Y	Y	N	N	U/P	Japanese
2.95in	18 lb cast iron solid shot	P	N	N	N	Y	F/W	
90mm	M71A1	P	N	Y	N	Y	U/P	
120mm	xm1107	M	Y	N	N	N	U/P	Practice
2.75in	M151 RWHE	R WH	Y	Y	N	N	U/P	
175mm	M439A2HE	P	N	N	N	Y	U/P	

\*P = Projectile; G = Grenade; M = Mortar; R = Rocket; S = Submunition; WH = Warhead; L = Landmine

\*\*F/W = Fired/Weathered; W=Weathered; U = Unfired; U/P = Unfired/Pristine; P = Pristine

## 2.2 EGLIN AIR FORCE BASE

Data were collected with the MM over 67 unique items. This occurred over a period of 10 days during July 28 – August 6, 2015. The collection took place indoors (Figure 4).



Figure 4 – The indoor setup at Eglin

### 2.2.1 MEASURED ITEMS

The items measured at Eglin focused on larger items, but again ranged in size from smaller munitions, including more grenade and landmine varieties, to much larger munitions such as the 16-inch projectile (Figure 5) and the Mk6 Underwater Mine (Figure 6). The specifics of each of the items are tabulated in Table 2-2 below.



Figure 5 – Measuring the 16-inch projectile



Figure 6 – Measuring the Mk6 Mine



Table 2-2 – The 67 unique items that were collected with the MM at Eglin.

Name	Mark/Mod	Class*	Fins	Fuze	Spotting Charge	Rotating Band	Condition**	Comments
Fuze	Mk188 Mod0	R WH	N	Y	N	N	P	
5-in	Mk32 Mod0	R WH	N	N	N	N	P	
5-in	Mk32 Mod0	R WH	N	Y	N	N	P	
Fuze	Mk193 Mod0	R WH	N	Y	N	N	P	
5-in	Mk33	R WH	N	N	N	N	P	Eject Flare
5-in	Mk33	R WH	N	Y	N	N	P	Eject Flare
4.5-in	T160ES HE	R	N	N	N	N	W	with Motor
4.5-in	T160ES HE	R	N	N	N	N	W	without Motor
Rocket Motor		R	N	N	N	N	W	
66mm	M72A1	R	Y	Y	N	N	U	with Coupler and Motor
66mm	M74	R	N	Y	N	N	W	with Motor
3.5-in	M30A1	R	Y	Y	N	N	W	WP Smoke with M405 Dummy Fuze and Motor
Rocket Motor		R	Y	N	N	N	W	
3.5-in	M30A1	R	N	Y	N	N	W	WP Smoke with M405 Dummy Fuze but without Motor
105mm	xm314A2E1	P	N	Y	N	Y	U	Illumination Round
105mm	xm314A2E1	P	N	N	N	Y	U	Illumination Round
Fuze	xm565	P	N	Y	N	N	P	
40mm	Mk285 Mod0 PPHE	G	N	N	N	Y	U/P	
Fuze	AN-M110A1 PD	B	N	Y	N	N	P	
Parachute Flare	LUU-2B	Flare	N	Y	N	N	P	
20mm	HE-T (self destruct) Type 100 Japanese	P	N	Y	N	Y	P	Japanese
30mmTP	PGU-15/B	P	N	Y	N	Y	P	without Cartridge
Fuze	M48 PD	B	N	Y	N	N	P	
Fuze	M84 VT/PTTF	M	N	Y	N	N	P	Variable Time Powder Train Fuze
Fuze	Model 1907M PTTF	P	N	Y	N	N	P	
50 cal		Cartridge	N	N	N	N	U/P	
Rifle Grenade	M29	G	Y	Y	N	N	U/P	missing a fin blade
7.2-in Depth Charge	Mousetrap	R-fired DC	Y	Y	N	N	W	with depth charge M136 Fuze
10-lb Bomb	BDU-48/B	B	Y	Y	N	N	U/P	
20-lb Bomb	AN-M42	B	Y	N	N	N	W	
100-lb Bomb	AN-M30A1	B	Y	N	N	N	U/P	
100-lb Bomb	AN-M30A1	B	N	N	N	N	U/P	
Depth Charge	Mk95 Mod0 SUS	DC	Y	Y	N	N	U/P	Signal Underwater Sound Dummy Round
152mm	Concrete Piercing USSR/Foreign	P	N	N	N	Y	U/P	USSR/Foreign
152mm	HE USSR/Europe	P	N	Y	N	Y	U/P	USSR/Europe; with RGM-2 Fuze

155mm	M110A2	P	N	N	N	Y	U	WP Smoke
106mm	Recoilless	P	Y	Y	N	Y	U/P	
Rifle Grenade	M11A4 AT	G	Y	Y	N	N	U/P	Practice
Landmine	M2A1	L	N	Y	N	N	P	with full base
Landmine	M2A1	L	N	Y	N	N	W	with partial base
16-in	Mk13 Mod2	P	N	N	N	Y	W	
4-in	4-in Stokes	P	N	N	N	N	R/W	
Landmine	M16A1 DVC-T	L	N	Y	N	N	P	Practice
105mm SABOT		P	Y	N	N	N	P	
105mm SABOT		P	Y	N	N	N	P	
105mm SABOT		P	N	N	N	N	P	
Landmine	M19	L	N	Y	N	N	P	with Safety Clip
Landmine	M19	L	N	Y	N	N	P	without Safety Clip
Landmine	M19	L	N	Y	N	N	W	Practice
Landmine	M21	L	N	Y	N	N	P	
Landmine	M12	L	N	Y	N	N	W/D	Practice
5-lb Bomb	Mk106	B	Y	N	N	N	R/W	
25-lb Bomb	Mk76	B	Y	N	N	N	R/W	
Smoke Pot	ABC - M5 HC	Smoke Pot	N	N	N	N	W/D	
5-in	Mk48 Mod1	P	N	N	N	Y	P	Illumination Round
2.36-in	M6	R	N	Y	N	N	U/P	with Motor without Fins
2.36-in	M6	R	Y	Y	N	N	U/P	with Motor with Fins
Rocket Motor		R	Y	Y	N	N	U/P	
2.36-in	M6	R	N	N	N	N	U/P	
Rifle Grenade	M9A1	G	Y	Y	N	N	U/P	
3-in	3-in Stokes	P	N	Y	N	N	U/R	
4.52-in	4.52-in Parrot	P	N	N	N	N	F/W	
6-in	6-in READ-Parrot	P	N	N	N	N	F/W	
Rocket Motor	Mk40 Mod3	R	Y	N	N	N	U/P	
250-lb Bomb	Mk-81	B	N	N	N	N	W	
Underwater Mine	Mk6	Mine	N	N	N	N	W	
Grenade	M69	G	N	Y	N	N	U/P	

\*P = Projectile; G = Grenade; M = Mortar; R = Rocket; S = Submunition; WH = Warhead; L = Landmine; DC = Depth Charge

\*\*F/W = Fired/Weathered; W=Weathered; U = Unfired; U/P = Unfired/Pristine; P = Pristine; R/W = Rusty/Weathered; U/R = Unfired/Rusty; W/D = Weathered/Dented

## 2.3 DATA COLLECTION PROCEDURES

The data collection procedures and guidelines are fully outlined in the SOP. This starts with an initial system check (section 3.2), followed by the system calibration check (section 3.3) and a few other steps (section 3.4) before getting into the data collection activities (sections 3.5-3.7).



All inversions of library quality data collected over each munitions item as stipulated by the steps of section 3.6C of the SOP were held to MQO 4 of section 4. The extracted  $\beta$ s were subsequently displayed in a series of panel plots that summarized the extent of the variability in the  $\beta$ s across orientations and depths. These are provided as PDFs in the ‘Polarizabilities Plots’ folder.

## 2.4 DATA PRODUCTS

The current data products are HDF5 files for every unique munitions item for each of the three pulse settings. These are provided in the ‘Lib\_HDF5Files’ folder and contain all the available library data for the given pulse setting, as well as the item metadata (see Figures 7 & 8 as examples).

The library data includes the following:

- The extracted  $\beta$  decays along the 3 principal axes of the item and the associated times in the decay for all orientation and depth configurations measured
- The additional estimated fit parameters – i.e. X, Y, Z, yaw, pitch, roll, 1-(fit error) and fit coherence
- The full filenames of the data and backgrounds used in deriving the library data

The metadata includes all the information given by the row entries of Table 1 in Appendix A of the SOP and represents all the useful descriptive information that can be obtained for a munitions item. Photographs of the item are included in the metadata.

The raw data (TEM files), background files, polarizability plots, and HDF5 files are available on Parsons FTP site until Friday, September 25. After that date they can be requested by contacting Nagi Khadr at [nagi.khadr@parsons.com](mailto:nagi.khadr@parsons.com) or Craig Murray at [craig.murray@parsons.com](mailto:craig.murray@parsons.com).

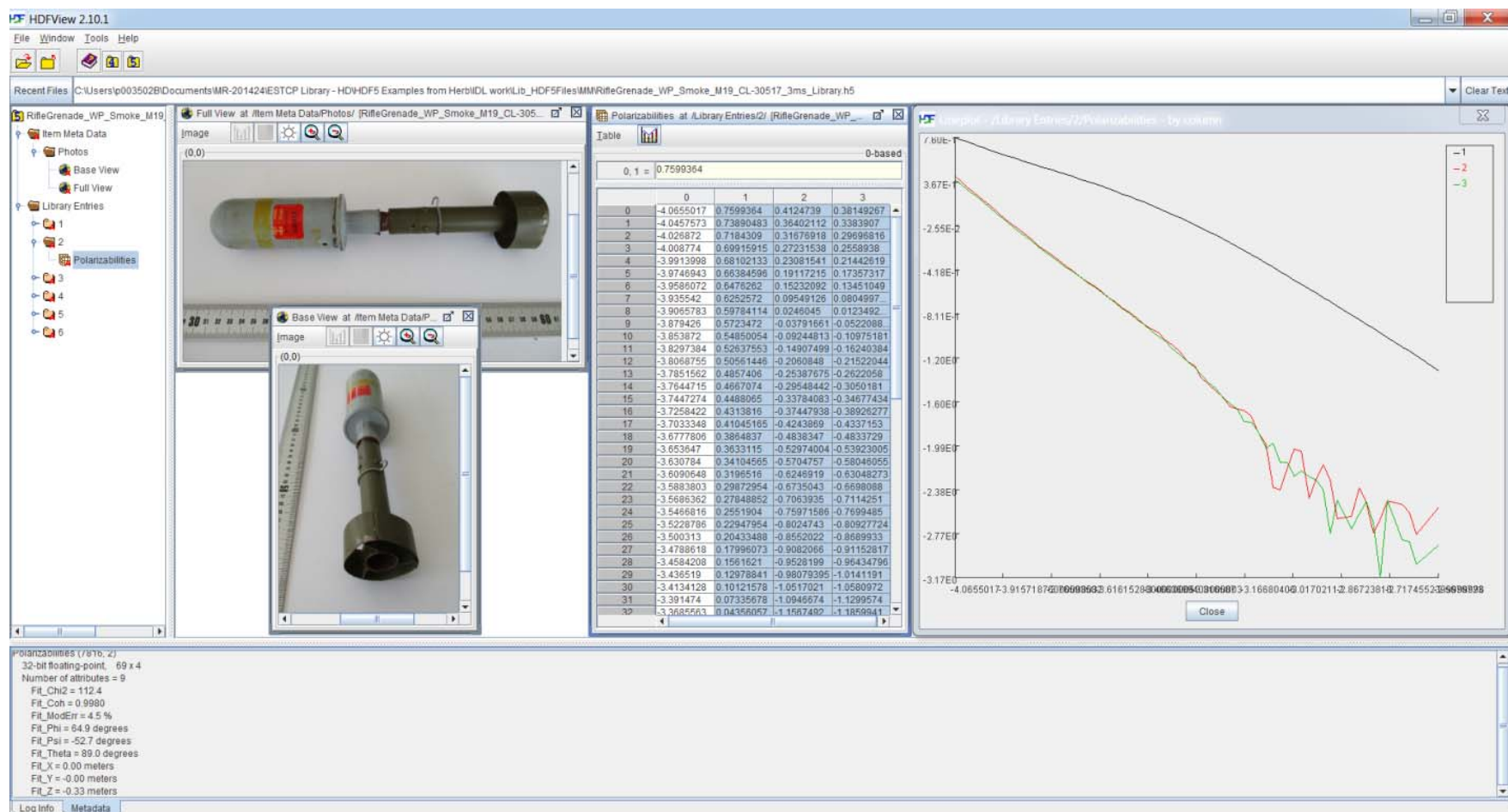


Figure 7 – The HDF5 file for the WP Smoke M19 Rifle Grenade measured with the 3ms pulse setting at Camp Lejeune

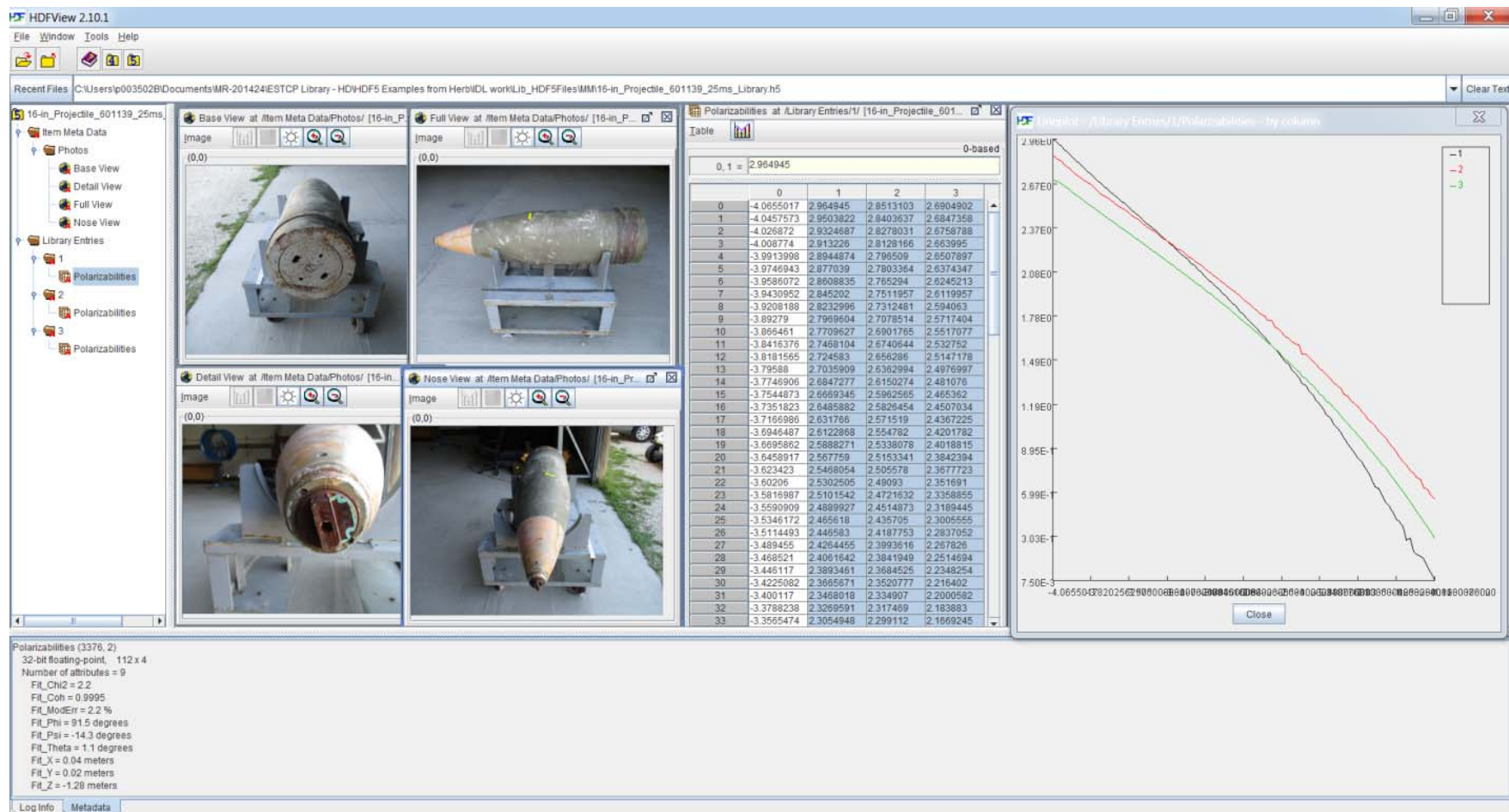


Figure 8 – The HDF5 file for the 16-inch projectile measured with the 25ms pulse setting at Eglin