

# Data Quality Factors for Marine UXO Surveys

BASTA Workshops

*Magnetic & hydrographic surveys*

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# Timetable

## 09:00 – Introduction

- Introduction of data quality factors and their role in the EOD workflow
- Introductory round of the participants

## 09:30 – Step 1: Identify relevant data quality factors

## 10:30 – Short break

## 10:40 – Step 2: Define threshold values for relevant data quality factors

## 11:45 – Conclusion

## 12:00 – End of the workshop

## Hints:

- workshop will be recorded (only for internal use)
- ask questions at any time (raise hands function)
- results will be distributed to participants



# BASTA Project Goals



- Advance data acquisition through ultra-high-resolution 3D sub-bottom profiling (SBP) and intelligent AUV-based magnetic mapping as part of an adaptive and iterative survey approach
- **Foster sustainable use of survey and WW I/II archived data** within a multi-sensor database for advanced data processing of Big Data using artificial intelligence for detecting/identifying munition with uncertainty levels
- Discuss and formulate new tools, methods and workflows with stakeholders to formalize **recommendations for industry and governments**

# Quality Factors: In General

Qualitative  $\longrightarrow$  Quantitative

Guidelines

Questionnaire to experts

Updated  
Guideline

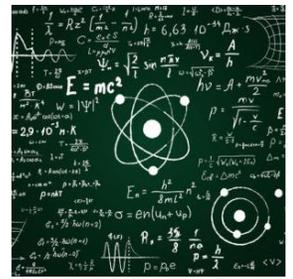
Tutorial  
Paper

Theory  
Workshops



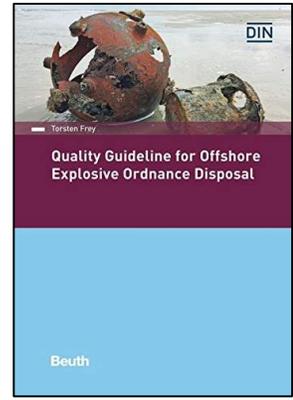
Parameter	Variable	Unit	Minimum value (SI)	Maximum value (SI)	Reference Object	Minimum value (SI)	Maximum value (SI)	Reference Object	Minimum value (SI)	Maximum value (SI)	Comment
Number of observations	n	[int]	0.15	0.20	0.15	0.15	0.20	0.15	0.15	0.20	
Time interval	Δt	[min]	30.0	15.0	30.0	30.0	15.0	30.0	30.0	15.0	
Start exploration time	t_start	[min]	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	
End exploration time	t_end	[min]	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	
Depth of observation	z	[m]	41.12, 5.2, 3.2, 1.0, 0.3	70, 20, 30, 3, 1, 0.3	300, 50, 40, 30, 12, 5, 2, 3	1000, 720, 500, 200, 120, 90, 50					
Depth of observation	z	[m]	0.5, 2	0.5, 2	0.5, 2	0.5, 2	0.5, 2	0.5, 2	0.5, 2	0.5, 2	
Depth of observation	z	[m]									

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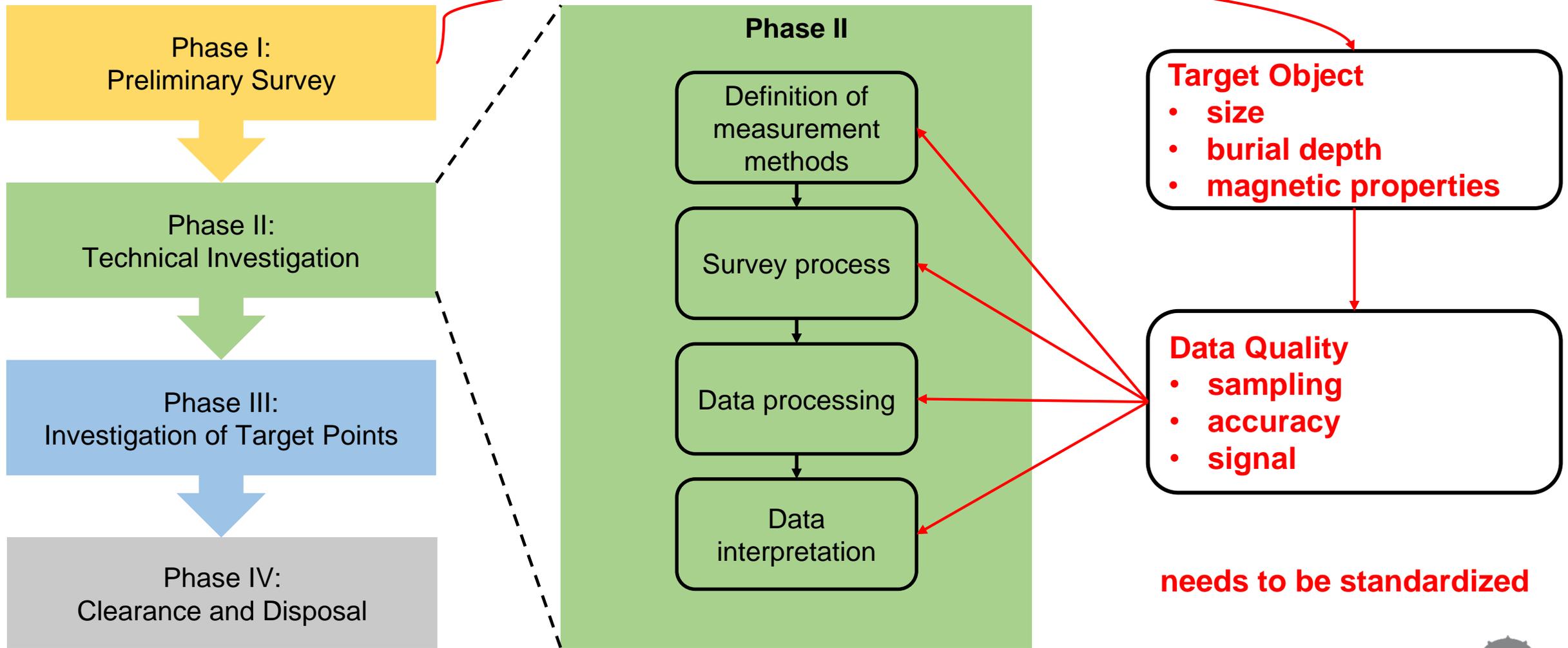
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# EOD Workflow



# Quality Factors: Main Goal

Define a standardized list of all quality factors that are relevant for UXO surveys:

## **Definitions of Quality Factors from experts**

- jointly define accepted standards
- gathering information in standardized way will improve the workflows (data processing and interpretation)

## **Thresholds are objective and theoretical requirements for the detection of a specific target**

- whether a sensor (MBES, SSS, MAG, SBP) is feasible for this purpose is evaluated in a second step
- thresholds give a hint on the data usability for a specific target (no strict limit between good and bad data)
- common understanding of relevant quality factors and thresholds improves customer-client-communications

**Provide a tool for Quality Factors and Threshold definitions to those who are new to the field**

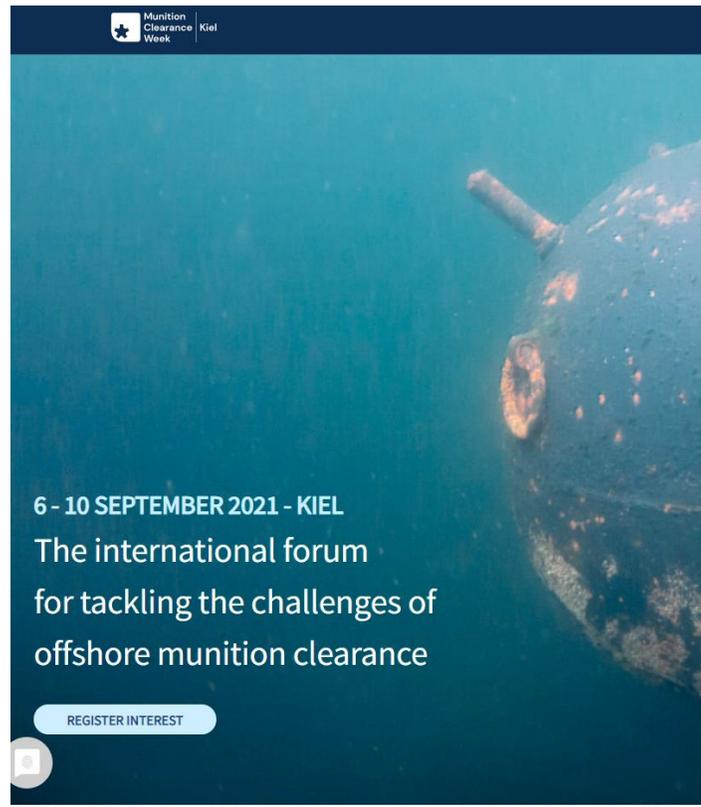
# Quality Factors: Outcome

## Workshop results

- feedback to participants
- discussion at KMCW

## Updated Guideline Document

## Tutorial Paper

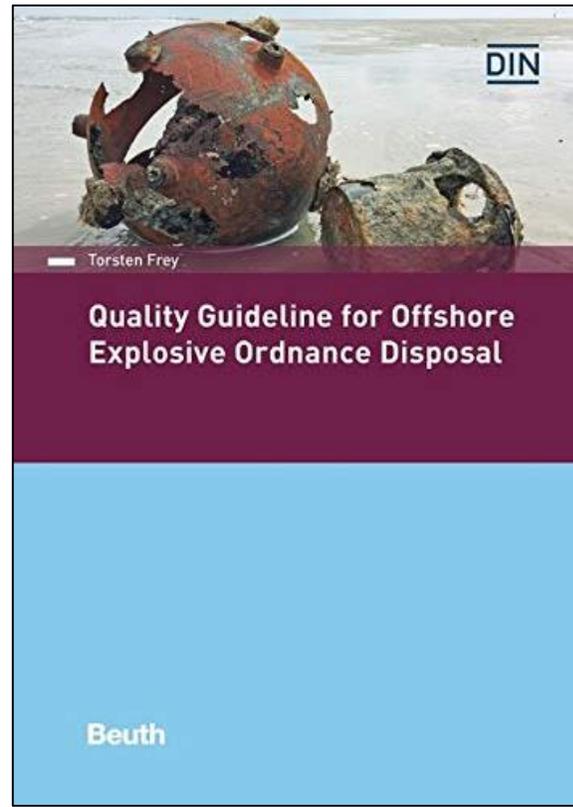


Munition Clearance Week Kiel

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The international forum for tackling the challenges of offshore munition clearance

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DIN

Torsten Frey

Quality Guideline for Offshore Explosive Ordnance Disposal

Beuth

Tutorial for marine UXO surveys including data quality control

Daniel Wehner\*, Torsten Frey†, ...

**ABSTRACT**

**INTRODUCTION**

Old ammunition or unexploded ordnance (UXO) poses a threat during offshore work, e.g. pipeline laying or platform constructions, and to the marine environment, considering chemical munition. If UXO detection and clearance activities are executed erroneously, managed poorly or even overall omitted, UXO threaten the lives of construction workers, the construction schedule, the marine fauna and the public image of the involved parties. The increase in knowledge about the potential UXO impacts has created an urge to address the challenge on a strategic level. Therefore, a "Quality Guideline for Offshore UXO Treatment" was developed (Frey, 2020). The quality guideline addresses the four phases (I) desk based pre-investigation, (II) technical investigation, (III) investigation of suspected UXO sites and (IV) clearance and disposal of present UXO. We focus on the technical investigation in phase II that consists mostly of geophysical survey methods using different hydroacoustic and magnetic sensors. Conducting these surveys is a complex task as the target object (munition object) is difficult to define and the combination of different sensors complicates the survey planning. Hence, in practice knowledge about munition types, geophysical survey methods (including computer and electronic skills), data processing and management is required to successfully complete an UXO project. In addition, performing an UXO campaign can easily lead to large amounts of data for a multi-sensor survey. For a 1x1 km<sup>2</sup> survey area the amount of data could be around ??? TB, depending on the target object. Therefore, detecting small UXO items of a few meters or less than one meter in the survey data is a demanding and time consuming task. A common, practical guideline for the workflow of phase II and a definition of data quality parameters for all different sensor types could support all involved people and save processing time. This would also simplify communication between different parties involved in the project.

The basis for the described workflow is the guideline written by Frey (2020) which describes the entire workflow for an UXO campaign, from the desktop study until the removal of UXOs. Another guideline that describes a workflow for UXO surveys for the specific cases of offshore cable installation is given in OWA (2020). This guideline focuses on the risk assessment for the entire project for a cable installation, while describing the technical survey in some detail. Simms et al. (2004) describe a workflow for UXO detection surveys on land. They discuss UXO characteristics, different sensors that are applicable and how the sensors are influenced by the environmental setting. A description of geophysical survey practices for marine surveys with a focus on archeological applications is given by Plets R. (2013), which to some extent is similar to UXO surveys. Further documents that describe the processes of marine UXO surveys and clearance are (GICHD, 2016; UNMAS, 2014; SUT, 2014; IOGP, 2009). There are only very few guidelines and standards that give a quantitative description on the data requirements needed for marine survey. Those that are partly relevant for marine UXO surveys are

- IHO S-44 Standards for Hydrographic Surveys (IHO, 2020)
- Guidance for geophysical surveying for UXO and boulders supporting cable installation (OWA, 2020)
- Hydrographic Surveys Specifications and Deliverables (NOAA, 2019)
- Subsea power cables in shallow water (DNV GL AS, 2016)

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# Application 1: Desk Study

## Benefit of data quality factors:

- prepare and design technical investigations for specific target
- objectively check the quality of acquired data

**Desk Study Template**






  
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04.03.2021

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02.03.2021

**3. Target/Reference Object**

The target/reference object is the output of the study under section 2. If a technical UXO survey is considered necessary, the parameters in Table 3 is mandatory. If a technical UXO survey is not considered necessary, the parameters in Table 3 are left blank.

**Table 3: Target/Reference object defined from desk study results**

Parameter	Value
Munition Type	
Shortest Dimension	
Burial Depth	
Iron Mass	
Net Explosive Mass	
Magnetic Moment	
Residual Field Amplitude (max. at 2, 3, 4, 5, 6, 8, 10 m)	
Sensing Range	
...	

**4. Technical Survey Concept**

**4.1 Data Quality Factors**

The data quality factors result directly from the parameters of the target/reference object in Table 3. The data quality factors are theoretical/empirical values that help to check the feasibility of the individual survey technique for the purpose of detecting the target object.

**4.1.1 Multibeam**

**Table 4: Data quality factors for a Multibeam survey**

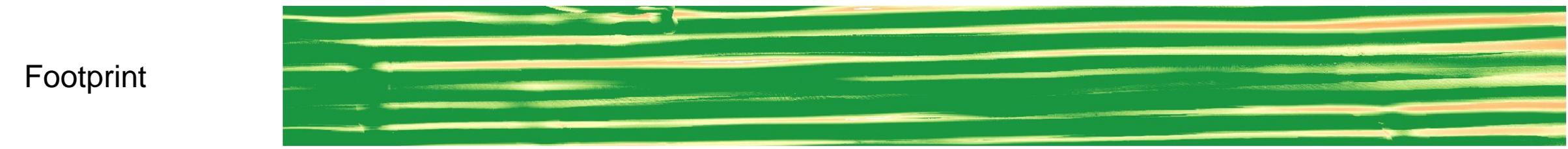
Parameter	Value

# Application 2: Vintage Data

**Benefit of data quality factors:** check the quality of pre-existing data with respect to defined target object



Are we able to detect *GP 500 lb M64 (USA)* in these data?

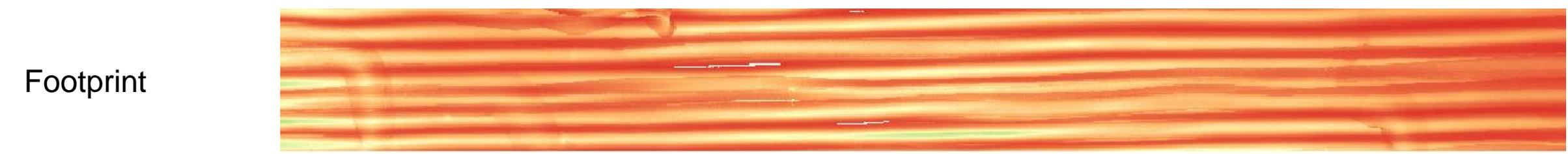
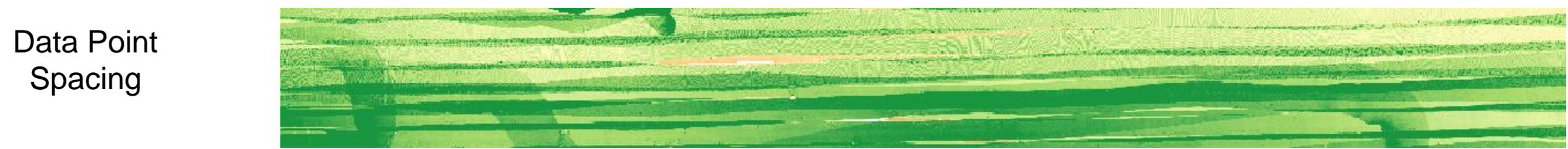


# Application 2: Vintage Data

**Benefit of data quality factors:** check the quality of pre-existing data with respect to defined target object



Are we able to detect *155mm shell BL Mark VII (GB)* in these data?



# Workshop: Today's Schedule

Define a general table with all quality factors that are relevant for the survey to detect an object:

- Step 1a** Which quality factors of the target/reference object need to be provided after the risk assessment and desk study but **before** the selection of the sensors?
- Step 1b** Which quality factors are important to determine whether the survey data are fit for the purpose of detecting a given target object?
- Step 2** What are the minimum threshold values for the quality factors in Step 1b?

**Step 1a**

Target/Reference Object			
Parameter	Variable	Unit	Example
Munition type		[-]	155mm shell BL Mark VII (nation: GB)
Shortest dimension	$d$	[m]	0.15
Burial depth	$z$	[m]	1
Iron mass	$M$	[kg]	34.9
Net explosive mass	$NEM$	[kg]	10.5
Magnetic moment	$m$	[Am <sup>2</sup> ]	0.4 - 2
Residual field amplitude (max.) at 2, 3, 4, 5, 6, 8, 10 m	$B$	[nT]	41, 12, 5, 2.5, 2, 1, 0.5
Sensing range	$l$	[m]	$l = l[S/N \geq 3]$

Side Scan Sonar			
Quality Factor	Variable	Unit	BASTA value/equation
Data point spacing	$x$	[m]	$x \leq d/3$
Beam footprint (along track)	$F_{\parallel}$	[m]	$F_{\parallel} \leq d/2$
Signal footprint (across track)	$F_{\perp}$	[m]	$F_{\perp} \leq d/2$
Altitude (height above seafloor)	$h_m$	[m]	$h_m \geq r/10$ ( $r_{90} < 7$ )
Line spacing (Coverage)	$n$	[-]	$n \geq r$ (200% coverage)
Horizontal positioning accuracy of vessel (above water)	$e_h$	[m]	$\leq 0.1$
Vertical positioning accuracy of vessel (above water)	$e_v$	[m]	$\leq 0.1$
Horizontal positioning accuracy of sensor (underwater)	$\delta_h$	[m]	$\leq 1$
Vertical positioning accuracy of sensor (underwater)	$\delta_v$	[m]	$\leq 0.2$
Pitch (additionally added parameter)	$\theta_p$	[°]	
Roll (additionally added parameter)	$\theta_r$	[°]	
Yaw (additionally added parameter)	$\theta_y$	[°]	
Signal-to-noise ratio (additionally added parameter)	S/N	[-]	
Acoustic frequency (Resolution)	$f$	[kHz]	$\geq 500$
Pulse length (additionally added parameter)	$\tau$	[ms]	

**Step 1b**

Target/Reference Object			
Parameter	Variable	Unit	Example
Munition type		[-]	155mm shell BL Mark VII (nation: GB)
Shortest dimension	$d$	[m]	0.15
Burial depth	$z$	[m]	1
Iron mass	$M$	[kg]	34.9
Net explosive mass	$NEM$	[kg]	10.5
Magnetic moment	$m$	[Am <sup>2</sup> ]	0.4 - 2
Residual field amplitude (max.) at 2, 3, 4, 5, 6, 8, 10 m	$B$	[nT]	41, 12, 5, 2.5, 2, 1, 0.5
Sensing range	$l$	[m]	$l = l[S/N \geq 3]$

Side Scan Sonar			
Quality Factor	Variable	Unit	BASTA value/equation
Data point spacing	$x$	[m]	$x \leq d/3$
Beam footprint (along track)	$F_{\parallel}$	[m]	$F_{\parallel} \leq d/2$
Signal footprint (across track)	$F_{\perp}$	[m]	$F_{\perp} \leq d/2$
Altitude (height above seafloor)	$h_m$	[m]	$h_m \geq r/10$ ( $r_{90} < 7$ )
Line spacing (Coverage)	$n$	[-]	$n \geq r$ (200% coverage)
Horizontal positioning accuracy of vessel (above water)	$e_h$	[m]	$\leq 0.1$
Vertical positioning accuracy of vessel (above water)	$e_v$	[m]	$\leq 0.1$
Horizontal positioning accuracy of sensor (underwater)	$\delta_h$	[m]	$\leq 1$
Vertical positioning accuracy of sensor (underwater)	$\delta_v$	[m]	$\leq 0.2$
Pitch (additionally added parameter)	$\theta_p$	[°]	
Roll (additionally added parameter)	$\theta_r$	[°]	
Yaw (additionally added parameter)	$\theta_y$	[°]	
Signal-to-noise ratio (additionally added parameter)	S/N	[-]	
Acoustic frequency (Resolution)	$f$	[kHz]	$\geq 500$
Pulse length (additionally added parameter)	$\tau$	[ms]	

**Step 2**

Target/Reference Object			
Parameter	Variable	Unit	Example
Munition type		[-]	155mm shell BL Mark VII (nation: GB)
Shortest dimension	$d$	[m]	0.15
Burial depth	$z$	[m]	1
Iron mass	$M$	[kg]	34.9
Net explosive mass	$NEM$	[kg]	10.5
Magnetic moment	$m$	[Am <sup>2</sup> ]	0.4 - 2
Residual field amplitude (max.) at 2, 3, 4, 5, 6, 8, 10 m	$B$	[nT]	41, 12, 5, 2.5, 2, 1, 0.5
Sensing range	$l$	[m]	$l = l[S/N \geq 3]$

Side Scan Sonar			
Quality Factor	Variable	Unit	BASTA value/equation
Data point spacing	$x$	[m]	$x \leq d/3$
Beam footprint (along track)	$F_{\parallel}$	[m]	$F_{\parallel} \leq d/2$
Signal footprint (across track)	$F_{\perp}$	[m]	$F_{\perp} \leq d/2$
Altitude (height above seafloor)	$h_m$	[m]	$h_m \geq r/10$ ( $r_{90} < 7$ )
Line spacing (Coverage)	$n$	[-]	$n \geq r$ (200% coverage)
Horizontal positioning accuracy of vessel (above water)	$e_h$	[m]	$\leq 0.1$
Vertical positioning accuracy of vessel (above water)	$e_v$	[m]	$\leq 0.1$
Horizontal positioning accuracy of sensor (underwater)	$\delta_h$	[m]	$\leq 1$
Vertical positioning accuracy of sensor (underwater)	$\delta_v$	[m]	$\leq 0.2$
Pitch (additionally added parameter)	$\theta_p$	[°]	
Roll (additionally added parameter)	$\theta_r$	[°]	
Yaw (additionally added parameter)	$\theta_y$	[°]	
Signal-to-noise ratio (additionally added parameter)	S/N	[-]	
Acoustic frequency (Resolution)	$f$	[kHz]	$\geq 500$
Pulse length (additionally added parameter)	$\tau$	[ms]	

# Workshop: Today's Schedule

## **Step 1a: Quality Factors – Target Object**

1. Quick review of quality factors
2. Vote on quality factors („yes“, „no“)
3. Discuss quality factor, if necessary (depends on voting results)

## **Step 1b: Quality Factors – Sensor**

1. Quick review of quality factors
2. Vote on quality factors („yes“, „no“)
3. Discuss quality factor, if necessary (depends on voting results)

## **Step 2: Threshold Values – Sensor**

1. Quick review of thresholds
2. Vote on thresholds („yes“, „no“)
3. Discuss threshold, if necessary (depends on voting results)

# Participants MAG 1 (March 16, 2021)

- **Daniel Wehner** (EGEOS)
- **Torsten Frey** (GEOMAR)
- **Jack Brighthouse** (ALM Geophysics Limited)
- **Tommy Kaltofen** (Atlas Elektronik GmbH)
- **Elena Berndt** (50Hertz Transmissions GmbH)
- **Wim de Klerk** (TNO)
- **Vincent Hoffman** (UXSolutions)
- **Marco Gilissen** (Fugro)
- **Bart van der Speeten** (Adede bvba)
- **Michiel Künzel** (League Geophysics)
- **Dorthe Reng Erbs-Hansen** (Vattenfall Vindkraft A/S)
- **Wolfgang Süß** (Sensys Sensorik & Systemtechnologie GmbH)
- **Mikkel Klahn** (Vattenfall Vindkraft A/S)
- **Marc Seidel** (GEOMAR)

# Participants HA 1 (March 18, 2021)

- **Daniel Wehner** (EGEOS)
- **Torsten Frey** (GEOMAR)
- **Arno Duijster** (TNO)
- **Rick Babicz** (EdgeTech)
- **Nick Lawrence** (EdgeTech)
- **Kevin Rychert** (EdgeTech)
- **Oivind Midtgaard** (FFI)
- **Miłosz Grabowski** (IO PAN)
- **Peter Nieuwveld** (Fugro)
- **Dorthe Reng Erbs-Hansen** (Vattenfall Vindkraft A/S)
- **Mikkel Klahn** (Vattenfall Vindkraft A/S)
- **Mareike Kampmeier** (GEOMAR)
- **Jacek Bełdowski** (IO PAN)

## Participants HA 2 (March 23, 2021)

- **Daniel Wehner** (EGEOS)
- **Torsten Frey** (GEOMAR)
- **Matthias Grün** (Eggers Gruppe)
- **Manfred Stender** (Fugro)
- **Joseph Hine** (Vattenfall Vindkraft A/S)
- **Rasmus Juncher** (Vattenfall Vindkraft A/S)
- **Holger Schmaljohann** (WTD 71)
- **Annelies Vanstrealen** (Ørsted)

# Participants MAG 2 (March 25, 2021)

- **Daniel Wehner** (EGEOS)
- **Torsten Frey** (GEOMAR)
- **Matthias Strahser** (Eggers Gruppe)
- **Peter Nieuwveld** (Fugro)
- **Manfred Stender** (Fugro)
- **Joseph Hine** (Vattenfall Vindkraft A/S)
- **Rasmus Juncher** (Vattenfall Vindkraft A/S)

# Conclusion

- Results will be distributed to all participants (updated quality factor tables)
- Final discussions potentially at **Kiel Munitions Clearance Week (KMCW)**
  - 06.09. – 10.09.2021 in Kiel, Germany
  - [www.munitionclearanceweek.org](http://www.munitionclearanceweek.org)
- Any further comments/suggestions/references/... regarding the data quality factors can be send via e-mail after the workshop
  - please send until 01.04.2021
  - send to [tfrey@geomar.de](mailto:tfrey@geomar.de) and [dwehner@egeos.de](mailto:dwehner@egeos.de)
- The presentation will be available at the BASTA webpage
  - [www.basta-munition.eu](http://www.basta-munition.eu)

**Thank you for your contributions!**