Changing Technologies, Changing Data Uses, Changing Specifications

Simon Ironside
Chair FIG Commission 4, Working Group 4.1
Standards and Guidelines for Hydrography
IHO Standards for Hydrographic Surveys (S-44)

S-44 provides minimum standards for hydrographic surveys dedicated to safety of navigation.
**Introduction**

S-44 is the International Hydrographic Organization’s *minimum* standard ... ‘for the execution of hydrographic surveys for the collection of data ... used to compile navigational charts ... for the safety of surface navigation and the protection of the marine environment’

*Introduction to S-44, 5th Edition February 2008*
Introduction

S-44 is a standard, NOT a specification. It is used either directly by IHO member state organisations or as the basis of national nautical charting specifications i.e. LINZ HYSPEC, NOAA Hydrographic Survey Specifications and Deliverables, FSIS44 (Finnish & Swedish implementation of S-44) etc.
IHO Standards for Hydrographic Surveys (S-44)

Introduction

S-44 is not mandatory for non-governmental organisations (i.e. ports and harbour authorities) even if conducting navigational/UKC surveys
IHO Standards for Hydrographic Surveys (S-44)

**Background**

1\textsuperscript{st} Edition of S-44 published in 1968.

4\textsuperscript{th} Edition (1998) introduced four orders of survey to cover different areas:

Special – critical areas with minimum UKC

1 - ports/harbours and approaches

2 – coastal areas with depths < 200m

3 – depths > 200m and not covered by higher orders of survey
Background

5th Edition (2008) divided Order 1 into 1a and 1b and removed Order 3

Order 1a is essentially the same as 4th Edition Order 1, but requires that surveys locate all targets within the survey area

Order 1b retains the same vertical and horizontal accuracies but removes the need to detect small objects
S-44 5th Edition Classification of Surveys

- Special Order – UKC critical, full seafloor search, depth < 40m
- Order 1a – UKC less critical, full seafloor search but size of features to be detected larger than Special Order, depth 40 – 100m
- Order 1b – UKC non-critical, full seafloor search not required (although permitted line spacing of 3 x average depth limits the size of the feature likely to remain undetected), depth 40 – 100m
- Order 2 – Full sea floor search not required – general seafloor description adequate, line spacing 4 x average depth, depth > 100m
IHO Standards for Hydrographic Surveys (S-44)

**Background**

5th Edition explicitly requires the overall survey system (not just the echo sounder component) to be capable of meeting the Minimum Standards for Hydrographic Surveys laid out in Table 1
S-44 Review

In March 2017 IHO established a Project Team on Hydrographic Surveys (HSPT) under the Hydrographic Services and Standards Committee (HSSC) to review S-44.

FIG Commission 4 (Working Group 4.1) has Observer status on the HSPT and is actively involved in the review process.
IHO Standards for Hydrographic Surveys (S-44)

Terms of Reference – IHO Circular 26/2017

I. Review existing S-44, identify deficiencies

II. Following review update content and structure and publish 6th Edition

III. On completion advise HSSC whether the HSPT continues as a working group or disbands
IHO Standards for Hydrographic Surveys (S-44)

Hydrographic Surveys Project Team (HSPT)

Chair - Christophe Vrignaud (FRA)
Vice Chair - Nickolas Roscher (BRA)
Secretary - David Wyatt (IHO)
44 Members - 16 Member States, Observers
(including FIG), Expert Contributors and IHO
HSPT1 Principal Activities/Achievements

“Kick off” meeting in PARIS, 20-22 June 2017 (28 representatives - 13 Member States, Observers, Expert Contributors and IHO).

Three outcomes:

1. Identification of S-44 limitations
2. Questionnaire
3. S-44 “Table 1” possible evolutions
Surveyors face increasingly more efficient technologies (coverage, accuracy, new features).

Does the S-44 need to be more constrained or more flexible in order to accommodate data that might be less accurate but remain priceless when information is missing?
S-44 Considerations

Bathymetric surveys for public maritime policies are sometimes undertaken by untrained people, or, using inappropriate hydrography specifications.

Knowledge of hydrographic surveys standards is very important not only for the hydrographic community, but also for private/public contracting bodies.
(see the “European Coastal Mapping” project conclusions)
HSPT1 Principal Activities/Achievements

S-44 Considerations

“Hydrographic Needs” extend beyond safety of navigation (see “Blue Economy”)

Does the S-44 have to deal exclusively with safety of navigation or take into account other hydrographic needs?
HSPT1 Principal Activities/Achievements

S-44 Limitations – 10 identified:

1 - S-44 only focused on the nautical chart and an associated depth classification (possible solution: matrix or updated table)
2 – Difficult to overview all requirements (possible solution: matrix or updated table)
3 - Limited number of definitions (possible solution: support and liaison with the DQWG and VIM3)
4 - Misalignment between S-44 and CATZOC (possible solution: contacts with S-101WG and DQWG)
5 - Grid resolution and bathymetric surfaces not addressed (contact with S-102WG)
6 - Confusion between a-priori TPU and a-posteriori Qualification (review specific chapters of the S-44)
7 - S-44 should remain technological neutral (review specific S-44 chapters)
8 - Confusion of metadata attributes
9 - Outdated chapters
10 - Annexes A & B to be placed in C-13 - Manual on Hydrography?

AUS + GER : Coordinating Editors (compiling all proposals/solutions from members for the 6th Ed. draft)
Views of S-44 users gauged including practitioners, stakeholders and the wider hydrographic community on a range of topics

Disseminated by IFHS, IHO, FIG and HSPT members. Closed Thursday 30th November 2017

500 replies received (61% involved in Navigation and Charting sector). Analysis by FIG, IFHS and Chair now complete and will directly inform 6th Edition discussions at HSPT2 meeting in Brazil in June.
## IHO Standards for Hydrographic Surveys (S-44)

### TABLE 1
Minimum Standards for Hydrographic Surveys
*(To be read in conjunction with the full text set out in this document.)*

<table>
<thead>
<tr>
<th>Reference</th>
<th>Order</th>
<th>Spectral</th>
<th>1a</th>
<th>1b</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>Description of areas.</td>
<td>Areas where under-keel clearance is critical</td>
<td>Areas shallower than 100 metres where under-keel clearance is less critical but features of concern to surface shipping may exist.</td>
<td>Areas shallower than 100 metres where under-keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.</td>
<td>Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Maximum allowable THU 95% Confidence level</td>
<td>2 metres</td>
<td>5 metres + 5% of depth</td>
<td>5 metres + 5% of depth</td>
<td>20 metres + 10% of depth</td>
</tr>
<tr>
<td>Para 3.2 and note 1</td>
<td>Maximum allowable TVU 95% Confidence level</td>
<td>(a = 0.25) metre (b = 0.0075)</td>
<td>(a = 0.5) metre (b = 0.013)</td>
<td>(a = 0.5) metre (b = 0.013)</td>
<td>(a = 1.0) metre (b = 0.023)</td>
</tr>
<tr>
<td>Glossary and note 2</td>
<td>Full Sea floor Search</td>
<td>Required</td>
<td>Required</td>
<td>Not required</td>
<td>Not required</td>
</tr>
<tr>
<td>Para 3.4</td>
<td>Feature Detection</td>
<td>Cubic features &gt; 1 metre</td>
<td>Cubic features &gt; 2 metres, in depths up to 40 metres; 10% of depth beyond 40 metres</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Para 3.0 and note 4</td>
<td>Recommended maximum Line Spacing</td>
<td>Not defined as full sea floor search is required</td>
<td>Not defined as full sea floor search is required</td>
<td>3 \times) average depth or 25 metres, whichever is greater For bathymetric lidar a spot spacing of 5 \times) 5 metres</td>
<td>4 \times) average depth</td>
</tr>
</tbody>
</table>

| Chapter 2 and note 5 | Positioning of fixed aids to navigation and topography significant to navigation. (95% Confidence level) | 2 metres | 2 metres | 2 metres | 5 metres |
| Chapter 2 and note 5 | Positioning of the Coastline and topography less significant to navigation (95% Confidence level) | 10 metres | 20 metres | 20 metres | 20 metres |
| Chapter 2 and note 5 | Mean position of floating aids to navigation (95% Confidence level) | 10 metres | 10 metres | 10 metres | 20 metres |
HSPT1 Principal Activities/Achievements

Table 1 Possible Evolution
Three options agreed to be investigated

Option A  Table 1 with only slight modifications
Option B  Option A + Matrix approach
Option C  Option B + Recommendations

Task lead by PRT/CAN/BRA
### HSPT1 Principal Activities/Achievements

**Table 1 with slight modifications**

Only slight changes (such as including current measurements, seabed classification, and why not « grid/point cloud » considerations?)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Special</th>
<th>1a</th>
<th>1b</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>UKC critical</td>
<td>Areas &lt;100m UKC required</td>
<td>Areas &lt;100m UKC not required</td>
<td>Areas &gt;100m</td>
</tr>
<tr>
<td><strong>Total Horizontal Uncertainty (m)</strong></td>
<td>2.0</td>
<td>5+5% depth</td>
<td>5+5% depth</td>
<td>20+10% depth</td>
</tr>
<tr>
<td><strong>Total Vertical Uncertainty (m)</strong></td>
<td>a = 0.25 b=0.0075</td>
<td>a = 0.5 b=0.013</td>
<td>a = 0.5 b=0.013</td>
<td>a = 1.0 b=0.023</td>
</tr>
<tr>
<td><strong>Feature Detection (m^2)</strong></td>
<td>1.0</td>
<td>2 or 10% Depth after 40m depth</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Seafloor Coverage / Line Spacing</strong></td>
<td>100%</td>
<td>100%</td>
<td>3 x average depth or 25 meters</td>
<td>4 x average depth</td>
</tr>
<tr>
<td><strong>Positioning of Fixed Aids (m)</strong></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td><strong>Positioning of Coastline &amp; Topography (m)</strong></td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Floating Navigation Aids (m)</strong></td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

FIG Congress 2018 Istanbul
### Matrix Approach

Allows other “Hydrographic Needs” (more strict or flexible) to be considered with an extended list of criteria

→ S-44 could therefore propose **Recommendations** for other (non SON) types of surveys

<table>
<thead>
<tr>
<th>Description</th>
<th>UKC (Exclusive Order)</th>
<th>Marine Renewable Energy</th>
<th>Oceanic</th>
<th>Engineering (Dredging?)</th>
<th>Engineering 2 (Cables, Pipes?)</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High-accuracy - dredge, build, UKC critical</td>
<td>Survey dedicated for MRE farm</td>
<td>Oceanic soundings</td>
<td>High vertical accuracy</td>
<td>High horizontal accuracy and detection capability</td>
<td></td>
</tr>
<tr>
<td>Total Horizontal Uncertainty (m)</td>
<td>1</td>
<td></td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Total Vertical Uncertainty (m)</td>
<td>a = 0.15 b=0.0075</td>
<td></td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Feature Detection (m²)</td>
<td>0.5</td>
<td></td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Sea Floor Coverage / Line Spacing</td>
<td>200%</td>
<td></td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Positioning of Fixed Aids (m)</td>
<td>1</td>
<td></td>
<td>NA</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Positioning of Coastline &amp; Topography (m)</td>
<td>5</td>
<td></td>
<td>NA</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Floating Navigation Aids (m)</td>
<td>10</td>
<td></td>
<td>NA</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Final Survey Data Grid Resolution (m²)</td>
<td>0.5</td>
<td></td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Grid Source Sounding Density (nts/bin)</td>
<td>10</td>
<td></td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
# HSPT1 Principal Activities/Achievements

## Matrix (prototype)

Grey cells used for S-44 Orders (5th edition) (backward compatibility)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Feature Detection (m²)</td>
<td>?</td>
<td>0.25</td>
<td>?</td>
<td>1.0</td>
<td>2.0</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>10% depth beyond 40m</td>
<td>?</td>
</tr>
</tbody>
</table>
## HSPT1 Principal Activities/Achievements

### Matrix (prototype)

Yellow cells used for S-44 Order 1a

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total Horizontal Uncertainty (m)</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>2.0</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>5-5% depth</td>
<td>20+10% depth</td>
</tr>
<tr>
<td>2</td>
<td>Total Vertical Uncertainty (m)</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>0.25</td>
<td>0.0075</td>
<td>5</td>
<td>0.5</td>
<td>0.013</td>
<td>1.0</td>
<td>0.023</td>
</tr>
<tr>
<td>11</td>
<td>Current (speed/direction)</td>
<td>0.1 knot</td>
<td>10°</td>
<td>Not Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Seafloor characterization</td>
<td>Mandatory</td>
<td>Not Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Table Evolution**

The table can be now filled using known specifications but with a code, in accordance with the matrix.

Backward compatibility is available and other needs can be considered.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Special</th>
<th>1a</th>
<th>1b</th>
<th>2</th>
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<td>Description</td>
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<td>Areas &lt;100m UKC not required</td>
<td>Areas &gt;100m</td>
</tr>
<tr>
<td>Total Horizontal Uncertainty</td>
<td>2.0 1E</td>
<td>5+5% depth 1J</td>
<td>5+5% depth 1J</td>
<td>20+10% depth 1K</td>
</tr>
<tr>
<td>(m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Vertical Uncertainty</td>
<td>a = 0.25 b=0.0075</td>
<td>a = 0.5 b=0.013</td>
<td>a = 0.5 b=0.013</td>
<td></td>
</tr>
<tr>
<td>(m)</td>
<td>2C</td>
<td>2D</td>
<td>2D</td>
<td></td>
</tr>
<tr>
<td>Feature Detection (m²)</td>
<td>1.0 3D</td>
<td>2 (3E) or 10% Depth (4I) after 40m depth</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Seafloor Coverage / Line Spacing</td>
<td>100% 4C</td>
<td>100% 4C</td>
<td>3 x average depth or 25 meters 4H</td>
<td>4 x average depth 4I</td>
</tr>
<tr>
<td>Positioning of Fixed Aids (m)</td>
<td>2 5F</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Positioning of Coastline &amp; Topography (m)</td>
<td>10 6E</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Floating Navigation Aids (m)</td>
<td>10 7D</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>
Outstanding Issues

• The matrix approach maintains the core philosophy of S-44 concept, but allows expansion and future growth.

• S-44 review ToR directs HSPT to focus on support of safety of navigation data products and services... whereas HSSC objectives are ...
“to promote and coordinate the development of standards, specifications and guidelines for official products and services to meet the requirements of mariners and other users of hydrographic information”.

• Where is the line between the two?
Outstanding Issues

• Does the “Matrix approach” meet the expectations of the HSSC?

63% = Yes
HSPT Work Programme

- Development of Table/Matrix prototypes (BRA, PRT, CAN) - ongoing
- End November 2017: closing date for the Questionnaire - completed
- Consolidation and analysis of Questionnaire responses (IFHS/FIG/Chair) - completed
- Intersessional work on S-44 limitations and solutions, including Table/Matrix (Coordinating Editors and all Members) - ongoing
- May 2018: report to HSSC-10 on the ongoing activities
- July 2018: HSPT2 Second meeting (Niteroi, Brazil)
- 2019: draft of Sixth Edition to be submitted to HSSC and proposal for a HSWG, if required.
Welcome to Niteroi, Brazil HSPT2!