IALA GUIDELINE

G1107
PLANNING AND REPORTING OF TESTBEDS IN THE MARITIME DOMAIN

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DOCUMENT REVISION

Revisions to this document are to be noted in the table prior to the issue of a revised document.

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December 2013	First issue	Council 56
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1. INTRODUCTION

The purpose of this document is to promote the sharing of knowledge and experience gained in the development of test beds in the maritime domain. The document provides guidance on the design, planning and results reporting from these test beds.

ANNEX A provides examples of factors to be considered when designing and planning tests and test cases. The harmonized reporting of the results of testbeds is addressed in ANNEX B.

Testbed managers are encouraged to provide information and results to the IALA Secretariat, so that these can be published on the IALA website *https://www.iala-aism.org/technical/e-nav-testbeds/iala-testbeds-guideline/* for IALA members and the wider maritime community.

2. SCOPE OF THE GUIDELINE

Testbeds in the maritime domain support the development, implementation, demonstration, and evaluation of technologies. These technologies could include digital communications, autonomous technologies, and the human-machine interface in the digitalization of the maritime industry.

The scope of this document is to provide guidance on:

- Design and planning of testbeds.
- Reporting of testbed results, both operational and technical.

3. TESTBEDS

A testbed (also commonly written as 'test bed' in research publications) is a platform for trialling development projects. Testbeds generally involve rigorous, transparent, and replicable testing of scientific theories, innovative solutions, computational tools, and new technologies.

There are several testbeds in the maritime domain. A list can be found on the IALA website [include link]

Testbeds allow for the exploration of the maritime domain through data acquisition, model building, machine learning, identification of requirements, and support for system development. The process includes verification and validation as well as early identification and assessment of new system functionality such as operational usability, areas for enhancement, identification of weaknesses and addressing socio-technical impact.

Equipment developed as part of testbeds should be based on human-centred design processes, so that any operational usability issues are detected early. Ideally, testbeds should be conducted in a controlled environment, so that they do not adversely affect real-life situations, existing services and, more widely, maritime safety. Conclusions can be drawn for many aspects such as functionality, usability, feasibility, and risk.

As technologies, and human-machine interaction with technology, evolves from concept to operational reality, the importance of testbeds continues to grow.

4. PLANNING OF TESTBEDS

Testbeds should be based on a structured, transparent, objective, and repeatable methodology. There should be arrangements in place for collaboration, incorporating user feedback and identifying improvements.

The planning of testbeds should include three design elements:

- Portability – ease with which stakeholders can adapt testbed findings to their own needs
- Transparency – traceability to the original testbed aims
- Relevance – testbeds should be relevant to the maritime domain, for example e-navigation solutions are linked to the objectives of e-navigation

In order to ensure that the testbed objectives are achieved, it is important to adopt a systems engineering approach. This comprises:

- stakeholder identification and analysis for relevance and priority;
- identification and analysis of stakeholders' needs and requirements;
- clear description of the operational and technical functionalities in fulfillment of the stakeholders' needs and requirements;
- verification of the solution against the technical requirements; and
- validation of the tested solution against the set user requirements and the design concept.

The testbed managers should consider applying the process of continual improvement[1] to their projects.

Harmonization of the reporting of results from testbeds will allow the results of testbeds to be shared and compared effectively. Harmonization also allows future meta-analyses[2] of specific aspects. Different organizations can recreate trials both to verify results and refine various factors within the trials, to further develop the concepts being trialled.

4.1. CONSIDERATION WHEN PLANNING A TESTBED IN THE MARITIME DOMAIN

It is advisable that the following factors are considered when planning testbeds as they will, among other things, assist in the harmonized reporting of testbed results.

Where possible, the solutions should address identified user requirements or gaps, such as those indicated in the IMO Strategy Implementation Plan (SIP) for e-navigation (*MSC.1/Circ.1595*).

Testbed considerations include:

- Architecture;

  It is advisable that, (without restricting innovation), testbeds align with the identified architecture and technical / operational services, such as the Maritime Services.

- User and stakeholder involvement;

  Testbeds should ideally involve users and stakeholders at every stage - from planning to implementation and assessment of results.

- Human centred design and software quality assurance principles;

  Human centred design and software quality assurance principles should be considered during the development of technology solutions. There are several references that can be used to support addressing the human element and human centred design for test beds in the maritime domain[3].

1 ISO/IEC 20000-1 – Information technology – Service Management – Part 1: Service Management System Requirements.

2 Meta-analyses are when results from a great number of experiments / tests are gathered, compared and trends, if any, analysed. A single experiment or test usually only offers limited information on a specific question / hypothesis; meta-analyses, however, can represent a bigger picture.

3 References on Human Centred Design include: IMO A.947(23) 'Human element vision, principles and goals for the Organization', MSC.1/Circ.1512 'Guideline on Software Quality Assurance and Human-Centred Design for E-Navigation', MSC.1/Circ,1595 'E-Navigation Strategy Implementation Plan – Update 1', MSC.1/Circ1604 'Interim Guidelines for MASS Trials' and IALA G1171 'Human Factors and Ergonomics in VTS'

- Data structures;
- The Common Maritime Data Structure (CMDS) agreed by IMO is the IHO S-100 Geospatial Information (GI) Registry. Therefore, it is preferable for testbeds to use the IHO S-100 framework for data modelling and exchange; however other data model frameworks may be used. It is advisable that testbeds highlight links to user needs, gap analysis, use cases and solutions identified and documented by IMO, where possible.
- Sharing of information.

  Information on testbeds should be provided on websites for the benefit of the maritime community. Testbed managers are encouraged to provide summary information to the IALA Secretariat for publishing. It would be beneficial if the following information was captured:

  - discussions on methodology of testbeds;
  - notifications of progress on testbeds;
  - exchange of ideas;
  - sharing of lessons learnt.
- Migration and archiving results

  The information from testbeds provides a body of knowledge that supports further development within the maritime domain. The planning of the testbed should include a plan for the migration, retention and archiving of results, including data sets.

4.2. DESIGNING A TESTBED

A testbed is an environment where tests of a concept or hypothesis are conducted. They normally include the following main components:

- One or multiple number of ships where shipborne systems are installed and tested;
- Communication links between ship-to-ship, ship-to-shore, shore-to-shore and shore-to-ship, including terrestrial, non-terrestrial (e.g., drones) and satellite components;
- One or more shore-stations, where shore-based systems are installed and tested:
  - A realistic test environment, which is characterized by a representative sample of users;
  - Representative levels of shipping, including type and density;
  - Realistic meteorological and hydrographic conditions, including tidal heights, tidal streams, sea state, visibility and weather.

A testbed can be categorized as a:

- real-world testbed;
- virtual testbed that is established using simulator(s);
- hybrid testbed, which is a combination of a virtual testbed and a real-world testbed.

A testbed comprises of tests and test cases.

4.3. PLANNING OF TESTS

A test is a series of test cases that can determine the success of a solution or service. The main components of a test include the hypothesis, a set of test cases, results and lessons learnt.

Tests determine the properties or functional capabilities of the tested item. As a test is normally more exacting than a demonstration, as it requires specialized test equipment, configuration, data, and procedures in order to verify that the item satisfies some requirements or validates a hypothesis. The conditions of a test include start and end conditions.

A test case comprises a set of conditions under which the solution or service is determined. It identifies if the test functions as expected by the hypothesis of the test through execution of the scenario and measurement of results. The term 'scenario' is sometimes used interchangeably with 'test cases' depending on type of testbed.

4.4. ANALYSIS OF RESULTS OF TEST CASES

The intent of the analysis of the results of test cases is to compare the findings of the testbed with the elements of the testbed plan, including portability, transparency and relevance. The analysis should elaborate how the results of the testbed specifically fulfil the elements.

5. HARMONIZATION OF REPORTING OF TESTBED RESULTS

A number of testbeds have been completed and are currently established. For testbed results to be useful to other parties, tests/simulations/trials should ideally have scientific rigour with regard to set-up, collection of data, analysis, etc. Additionally:

- results presented should be objective;
- trials should be reproducible (where relevant);
- data gathered, and analysis should be scientifically sound; and
- testbed results should ideally be presented in acceptable scientific formats (e.g., they should be suitable for publication in a peer-reviewed publication).

It is important that the results of testbeds are shared, as there could be outcomes and lessons learnt that will be useful to the maritime community. In order to do this and to allow for ready comparison of the relevant elements of testbed results, reporting of the results of the testing of solutions, systems and services should be harmonized.

A framework, by way of a template for reporting has been developed (see ANNEX B) that addresses the presentation of results. This should be considered when reporting the results of testbeds. Once testbed results are available, organizations are encouraged to send these to the IALA Secretariat for publication.

6. DEFINITIONS

The definitions of terms used in this Guideline can be found in the *International Dictionary of Marine Aids to Navigation* (IALA dictionary) and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

7. ABBREVIATIONS

CMDS	Common Maritime Data Structure
GI	Geospatial Information (IHO)
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ID	Identification (as in Test ID)
IEC	International Electrotechnical Commission

IHO	International Hydrographic Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
SAR	Search and Rescue

8. REFERENCES

[1] IMO. MSC.1/Circ.1595 e-Navigation Strategy Implementation Plan – Update 1

ANNEX A EXAMPLES OF FACTORS TO BE TAKEN INTO ACCOUNT WHEN PLANNING TESTS AND TEST CASES

A.1. AN EXAMPLE OF A TEST DESCRIPTION

Table 1 Example test description

	Item	Description
1	Test ID	A unique identifier for the test.
2	Brief description	A short narrative describing the test and its aims
3	Pre-conditions	Condition for starting and completing the test
4	Configuration of the test system	e.g., ship-shore communications link or other components
5	Participants (if any)	Information (including qualifications) on the person(s) involved in the test/s.
6	Test Cases	A designed set of interactions between test system components
7	Data gathering	A set of parameters to be gathered and method(s) used

A.2. AN EXAMPLE OF A TEST CASE DESCRIPTION

Additionally, for test cases, being a sub-set of a test, the following should be considered:

Table 2 Example sub-set test description

ID	Item	Description
1	Test case ID	An arbitrary unique identifier for the test case
2	Date and time	for the test case
3	Conditions	Condition prevailing at the time
4	Participants (if any)	Qualifications of the person/s involved in test case
5	Data	Data to be collected during the test case, for example ship tracks or other values gathered

ANNEX B REPORTING TEMPLATE

The purpose of this reporting template is to serve as a harmonized framework for reporting results from testbeds in the maritime domain. In order to assist with the reporting of testbed results and to ensure these are available to the maritime domain and development community, all headings should be completed - even those for which there is no information.

Testbed information will assist other organizations to learn more about the solution being tested. It may also offer other ideas to expand and further develop the solution.

Note: Symbols used in the Reporting Template have the following meanings:

Sub-section / Sub-heading

- *Tick box (choose one or more)*
  - Free text field

B.1. CONTENTS OF THE REPORTING TEMPLATE

B.1.1. GENERAL INFORMATION

- Name of testbed
- Location of testbed
- Time and duration of testbed
- Contact person(s)
- Testbed website
- Organization(s) involved
- Funding programme and budget

B.1.2. EXECUTIVE SUMMARY

- A summary in free text

B.1.3. TESTBED INFORMATION

The type of user group(s) involved in the test

- Shipboard users
- Shore-based users
- SAR users

Details of user need / gap considered for the testbed

- Information/data management
- Effective and robust voice communication and data transfer
- Systems and equipment
- Ship reporting
- Traffic monitoring; and/or
- Training and familiarization

The category of user need / gap considered in the testbed

- Technical
- Regulatory
- Operational; and/or
- Training

Details of solution/s considered in the testbed. For example, solutions may be linked to the IMO SIP solutions: :

- S1: Improved, harmonized and user-friendly bridge design
- S2: Means for standardized and automated reporting
- S3: Improved reliability, resilience and integrity of bridge equipment and navigation information
- S4: Integration and presentation of available information in graphical displays received via communication equipment
- S5: Improved Communication of VTS Service Portfolio
  - Other (state in free text)

The category of solution/s considered in the testbed:

- Technical
- Regulatory
- Operational; and/or;
- Training
  - Other (state in free text)

Links to similar / relevant testbeds (if any)

B.1.4. TESTBED METHODOLOGY

Methodology used for data collection and archiving:

- Method
- Validity
- Reliability
- Migration and archiving of results and data sets
- Terms and conditions of use

Summary information on testbed respondents / participants:

- Number
- Background
- Experience
- Demographics

Procedure used in the testbed:

- Testbed setup
- Technical solutions used
- Standards

- Guidance documents
- Standard Operating Procedures
- Analysis of data

B.1.5. TESTBED RESULTS

Summary of findings

- Presentation of data
- Users assessment and experience
- Other comments

B.1.6. CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

- Lessons learnt

Recommendations

- Own plans
- Suggested further studies

B.1.7. PUBLICATIONS

- Peer-reviewed publications
- Technical papers
- Reports
- Communication material

B.1.8. REFERENCE MATERIAL

- List of reference material used in the testbed