ENAV15 Input paper

Agenda item 10

Task Number

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**VDES – Waveform Study Proposal**

**1 Summary**

IALA is developing, in conjunction with ITU-R, a digital communications system for the exchange of maritime data between ships and with the shore. The concept, known as the VHF Data Exchange System (VDES), utilises existing AIS frequencies, as well as a set of additional VHF channels identified for this purpose at the ITU World Radiocommunications Conference (WRC) 2012.

The project described in the Annex builds on previous work on the VHF channel properties, will study the candidate waveforms for VDES and propose design criteria for the physical layer of VDES. The output of the study will be used to prepare input papers to the appropriate meetings of IALA and ITU-R, in order to progress the realisation of VDES.

**1.1 Purpose of the document**

The Committee is invited to consider the study proposal in the Annex on the design characteristics of VDES and comment as appropriate.

**1.2 Related documents**

ITU-R Report M.xxxx/2014, VDES Channel Sounding Campaign.

ANNEX

VHF Data Exchange System - Waveform Study

(Proposal from GLA/ITR)

The purpose of this program of work is to evaluate candidate waveforms proposed for the maritime VHF Data Exchange System (VDES). It is recommended that this program of work follows a staged approach, allowing for external review of results and input from the sponsor at each stage.

Phases may be carried out strictly sequentially, however there is scope for some concurrency in phases 2-5. In particular, design components of Phase 3, 4 and 5 could occur prior to completion of the previous phase. A detailed work plan, including timing and resourcing will be prepared during Phase 1.

# Phase 1 - Scoping

This initial work package aims to set the scope of the remaining phases, and to ensure alignment of the proposed work with the needs of the sponsor. This work package will largely consist of literature review and preliminary analysis.

## Activities

* Identification of key input documents: standards and proposals, and related studies
* Identification of user requirements, use cases, figures of merit and test scenarios
* Identification of technical constraints (coexistence, legacy requirements, implementation complexity, regulatory requirements)
* Identification of technical scope (waveform, acquisition, media access, data link, network layer – how much of the system is within scope)
* Identify potential VHF channel models and interference scenarios
* Identification of candidate waveforms (and access protocols if within scope)
* Specify approach for shortlisting of candidates, including performance metrics and test methodology
* Develop proposed work plan for remaining phases, including key review points, milestones, and deliverables.

## Outputs:

* Preliminary Scoping Document (for sponsor review and comment)
* Final Scoping Document
* Workplan for remaining phases

# Phase 2 - Initial Candidate Shortlisting

The purpose of this work package is to agree upon a shortlist of candidate waveforms (and access methods) to be taken forward for implementation within the software reference model. Factors to be considered will include

* Indicative implementation complexity
* Reported performance metrics in the existing literature
* Fit-for-purpose: likely to meet the identified user requirements and technical constraints

This phase of work will also sign off on the features of the VHF channel and interference models to be implemented in the reference model.

## Activities

* Identification of advantages and disadvantages of each initial candidate, in terms of the performance metrics and other considerations developed in the scoping study
* Preliminary performance analysis – mathematical analysis and/or existing results in the literature
* Develop detailed test plan for evaluation of candidate waveforms
* Select components of channel and interference models

## Outputs

* Candidate waveform selection report, including candidate shortlist
* Waveform test plan document
* VHF channel model specification document

# Phase 3 - Reference Model Implementation and Simulation Study

This work package will develop a complete modular software reference model allowing rapid performance comparison of candidate waveforms, and tuning of waveform parameters.

This work package will also optimise the performance of selected candidate waveforms using reference model simulations as a design tool.

## Activities

* Develop reference model architecture
* Select implementation framework (language, revision control and development environment). This will be done with the intention of sharing this framework as far as possible with the embedded system development in Phase 4.
* Specify coding standards and documentation standards (for Phase 3 and 4)
* Specify methodology for integration of reference model assets into embedded system testbed
* Specify user interfaces
* Develop software modules and test vectors for each system component, including candidate transmitter and receiver modules, and channel model components
* Module test, validation and calibration
* Initial performance evaluation of each candidate waveform, following previously developed test plans
* Optimisation and selection of key waveform parameters (iterative optimisation using the reference model as an analysis tool)
* Develop recommendations for waveforms to be taken forward to field trial

## Outputs

* Reference model architecture design document
* Design documentation for each module including external APIs, data formats and key objects
* Preliminary candidate performance analysis document
* Waveform recommendation document

# Phase 4 - Testbed Implementation and Laboratory Performance Evaluation

This package of work will develop the hardware and embedded software systems (most likely based on COTS software defined radio platforms) and test rigs to be used for field trials.

This work package will conduct laboratory trials of the shortlisted candidate waveforms (using a VHF channel emulator) to validate performance prior to field trials.

## Activities

* Specify testbed architecture including test rig automation requirements
* Hardware requirements, specification and procurement
* Develop modules for each system component
* Module test, validation and calibration against reference model (using reference model test vectors where appropriate)
* Specification of data formats (to facilitate data access and use post field trials)
* Development of test rig automation, logging systems and post-processing data analysis tools
* Laboratory-based performance evaluation of each candidate waveform, following previously developed test plans

## Outputs

* Testbed architecture design document
* Design documentation for all testbed modules
* Test methodology document
* Candidate waveform implementation performance results document
* Field-trial ready system

# Phase 5 - Field Trials

The objective of this final phase is to obtain performance results for the final set of waveform candidates in a variety of indicative real-world marine environments.

It is preferable to be able to test all candidate waveforms simultaneously (as far as possible, while maintaining a controlled interference environment) for each location and test scenario.

It may be desirable for initial analysis of trial to be performed near-real-time (e.g. overnight) to allow adaptation of test plans and scenarios during the campaign.

It may also be desirable to stage the field trials into several discrete campaigns to allow the results from one campaign to inform the detailed design of the next campaign.

## Activities

* Identification of test scenarios and key performance metrics
* Selection of test sites
* Specification of testbed system configuration
* Development of test plan and schedule for each test scenario/site
* Execute field trials and capture data
* Analyse field trial data sets
* Where required, investigate features or anomalies within reference model
* Prepare preliminary results and recommendations
* Prepare final report and recommendations

## Outputs

* Field trial design document
* Field trial data sets
* Preliminary field trial report for sponsor review and comment
* Final report and recommendations