IALA MODEL COURSE

L2.9.1 – L2.9.9

AIDS TO NAVIGATION - TECHNICIAN TRAINING

MODULE 9 ELEMENTS 1-9

LEVEL 2 - INTRODUCTION TO RADIONAVIGATION AND DIFFERENTIAL GLOBAL NAVIGATION SATELLITE SYSTEMS

Edition 2.0

June 2016
Revisions to this IALA Document are to be noted in the table prior to the issue of a revised document.

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<th>Page / Section Revised</th>
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<td>June 2016</td>
<td>Pages 3, 7, 8, 10 &amp; 12</td>
<td>Minor text amendments and update of Teaching Modules</td>
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FOREWORD

The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) recognises that training in all aspects of Aids to Navigation (AtoN) service delivery, from inception through installation and maintenance to replacement or removal at the end of a planned life-cycle, is critical to the consistent provision of that AtoN service.

Taking into account that under the SOLAS Convention, Chapter 5, Regulation 13, paragraph 2; Contracting Governments, mindful of their obligations published by the International Maritime Organisation, undertake to consider the international recommendations and guidelines when establishing aids to navigation, including recommendations on training and qualification of AtoN technicians, IALA has adopted Recommendation E-141 on Standards for Training and Certification of AtoN personnel.

IALA Committees working closely with the IALA World Wide Academy have developed a series of model courses for AtoN personnel having E-141 Level 2 technician functions. This model course on AtoN Service Craft and Buoy Tenders should be read in conjunction with the Training Overview Document IALA WWA.L2.0 which contains standard guidance for the conduct of all Level 2 model courses.

This model course is intended to provide national members and other appropriate authorities charged with the provision of AtoN services with specific guidance on the training of AtoN technicians in an introduction to service craft and buoy tenders. Assistance in implementing this and other model courses may be obtained from the IALA World Wide Academy at the following address:

The Secretary-General
IALA
10 rue des Gaudines
78100 Saint Germain-en-Laye
France
Tel: (+) 33 1 34 51 70 01
Fax: (+) 33 1 34 51 82 05
e-mail: academy@iala-aism.org
Internet: www.iala-aism.org
PART 1- COURSE OVERVIEW

1. SCOPE

This course is intended to provide technicians with the theoretical training necessary to have a basic understanding of radionavigation including Differential Global Navigation Satellite Systems (DGNSS).

This course is intended to be supported by further training modules on the practical operation and maintenance of radar beacons; the Automatic Identification System (AIS); aspects of power supplies; lightning protection and the maintenance of structures. Details of these supporting model courses can be found in the Level 2 Technician training overview document IALA WWA L2.0.

2. OBJECTIVE

Upon successful completion of Elements 9.1-9.5 of this course, participants will have acquired sufficient theoretical knowledge and skill to undertake the practical elements of Module 9 (9.6 – 9.9) which will enable them to maintain DGNSS transmission stations whilst on the job within their organizations.

3. COURSE OUTLINE

The first theoretical part of this course is intended to cover the knowledge required for a technician to understand the principles of radionavigation systems including DGNSS and the importance of uninterrupted Position, Navigation and Timing (PNT). This section comprises 5 classroom training modules and a site visit designed to consolidate theoretical knowledge. The second more practical part of this course covers the operation and maintenance of DGNSS transmission stations. It comprises 2 classroom modules and 2 modules undertaken at a DGNSS transmission site.

It is expected that not all trainee technicians will require to take the second part of the complete course. Successful participants who have proved their competency only in the theoretical part of this Module may be awarded a Certificate of Competence covering only Elements 9.1-9.5. Participants who have proved their competency in both the theoretical and practical aspects of this course should be awarded a Certificate of Competence covering the whole of Module 9. Each training module begins by stating its scope and aims, and then provides a teaching syllabus.

4. TEACHING MODULES

<table>
<thead>
<tr>
<th>Module Title</th>
<th>Time in hours</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to radionavigation systems</td>
<td>2.0</td>
<td>This module describes the basic functions and types of radionavigation systems, covering GNSS and terrestrial systems.</td>
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<tr>
<td></td>
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<td><strong>Note:</strong> Radar beacons are covered in Level 2 Module 7 and the Automatic Identification System (AIS) in L2 Module 8</td>
</tr>
<tr>
<td>Position, Navigation and Timing (PNT)</td>
<td>1.0</td>
<td>This module describes the concepts of PNT, and how they are calculated.</td>
</tr>
</tbody>
</table>
Accuracy, integrity, continuity, availability and vulnerability | 2.0 | This module describes the factors that can affect the performance of radionavigation signals.

Applications of GNSS on AtoN | 0.5 | This module describes which AtoN components rely on GNSS signals for their effective operation (e.g. Monitoring, light synchronisation).

Introduction to DGNSS and principles of operation | 2.0 | This module describes the principles of the transmission of differential signals from a DGNSS shore station or AIS base station.

Evaluation | 0.5 | Written test.

**Total Hours** | **8** | Two day course

An optional visit to a DGNSS transmission station would be desirable to consolidate theoretical knowledge gained in Modules 9.1 – 9.5.

**Table 2**  **Table of Optional Teaching Modules**

<table>
<thead>
<tr>
<th>Module Title</th>
<th>Time in hours</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>DGNSS receivers; integrity and reference modules</td>
<td>3.0</td>
<td>This module describes the principles of how GNSS receivers are used to produce DGNSS corrections, and how the integrity of the transmitted signal is monitored.</td>
</tr>
<tr>
<td>DGNSS transmission stations</td>
<td>3.0</td>
<td>This module describes the principles of how DGNSS transmitters are used to broadcast DGNSS corrections.</td>
</tr>
<tr>
<td>DGNSS operation and maintenance</td>
<td>4.0</td>
<td>This module reinforces Modules 6 &amp; 7 with practical training and should be undertaken at a DGNSS transmission site or a live test facility.</td>
</tr>
<tr>
<td>Monitoring of accuracy and signal strength</td>
<td>2.0</td>
<td>This module describes the principles of how DGNSS services are monitored to ensure that IALA performance standards are met.</td>
</tr>
<tr>
<td>Evaluation</td>
<td>0.5</td>
<td>Written test</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>13</strong></td>
<td>Two day course</td>
</tr>
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</table>

**5. SPECIFIC COURSE RELATED TEACHING AIDS**

1. This course involves both classroom instruction and a visit to a DGNSS transmission station. Classrooms should be equipped with blackboards, whiteboards, and overhead projectors to enable presentation of the subject matter.
2. A large scale general arrangement diagram of the DGNSS transmission station should be available to each participant.
3. Hand-held satnav receiver(s)
4. Relevant DGNSS and transmitter hardware (Modules 6 & 7)
5. Test equipment (Modules 8 & 9).
6. ACRONYMS

To assist in the use of this model course, the following acronyms have been used:

AIS Automatic Identification System
AtoN Aid(s) to Navigation
ATU Automatic Tuning Unit
DGNSS Differential Global Navigation Satellite System(s)
GNSS Global Navigation Satellite System(s)
HP Hewlett Packard
IALA International Association of Marine Aids to Navigation and Lighthouse Authorities
ID Identity
kHz Kilohertz
L Level
LF Low Frequency
MF Medium Frequency
PC Personal Computer
PNT Position, Navigation and Timing
RAIM Receiver Autonomous Integrity Monitoring
RF Radio Frequency
SOLAS International Convention for the Safety of Life at Sea, 1974 (as amended)
UTC Universal Time Co-ordinated
WGS84 World Geodetic Spheroid (1984)
WWA World Wide Academy
WWRNP IALA World-Wide Radio Navigation Plan

7. DEFINITIONS

The definition of terms used in this Guideline can be found in the International Dictionary of Marine Aids to Navigation (IALA Dictionary) at http://www.iala-aism.org/wiki/dictionary

8. REFERENCES

In addition to any specific references required by the Competent Authority, the following material is relevant to this course:

1 IALA NAVGUIDE.
2 IALA Recommendations A-124/16 on DGNSS broadcasts from an AIS Service.
3 IALA Recommendation R-115 on the Provision of Maritime Radionavigation Services in the frequency band 283.5 – 315kHz in Region 1 and 285 – 325 kHz in Region 2 and 3.
4 IALA Recommendation R-121 for the Performance and Monitoring of a DGNSS Service in the Band 283.5 – 325kHz.
5 IALA Recommendation R-129 on GNSS Vulnerability and Mitigation Measures.
6 IALA Recommendation R-135 on the Future of DGNSS.
7 IALA World-Wide Radio Navigation Plan (WWRNP).
IALA Guideline 1060 on Recapitalisation of DGNSS.

Technical documentation from DGNSS equipment manufacturers.
PART 2 – TEACHING MODULES

1. MODULE 1 – INTRODUCTION TO RADIONAVIGATION SYSTEMS

1.1. SCOPE

This module describes the basic functions and types of radionavigation systems not covered in other Modules.

1.2. LEARNING OBJECTIVE

To gain a basic understanding of the function and types of both terrestrial and satellite radionavigation systems.

1.3. SYLLABUS

1.3.1. LESSON 1 – TERRESTRIAL RADIONAVIGATION SYSTEMS

1. History of radionavigation systems.
2. Hyperbolic radionavigation system.
3. e-Loran.

1.3.2. LESSON 2 – SATELLITE RADIONAVIGATION SYSTEMS

2. Operational and planned GNSS.
3. Military and civilian GNSS signals.
4. Deriving position from satellites.
5. Satellite datum (WGS84) or other datum.
6. Obtaining a position from a hand-held satnav.
7. Introduction to IALA WWRNP.

2. MODULE 2 – POSITION, NAVIGATION AND TIMING

2.1. SCOPE

This module describes the concepts of PNT, and how they are calculated.

2.2. LEARNING OBJECTIVE

To gain a basic understanding of PNT and augmentation systems and their vital importance to safe navigation.

2.3. SYLLABUS

2.3.1. LESSON 1 – POSITION, NAVIGATION AND TIMING

1. Concept of location and time.
2. PNT services from satellite (including ephemeris etc.).
3. Uses and users of PNT services.
4. Accurate time (UTC).
5. Alternative sources of time.
2.3.2. Lesson 2 - Satellite and Ground Based Augmentation Systems
1 Introduction to Satellite Based Augmentation Systems.
2 Introduction to Ground Based Augmentation Systems.

3. Module 3 – Accuracy, Availability, Continuity, Integrity and Vulnerability

3.1. Scope
This module describes the basic performance parameters of a radionavigation system, and identifies factors that can affect the accuracy and uninterrupted receipt of radionavigation signals.

3.2. Learning Objective
To gain a basic understanding of how a radionavigation system performance can be defined, and identifies errors inherent in GNSS and its potential vulnerability.

3.3. Syllabus

3.3.1. Lesson 1 – Radionavigation System Parameters
1 Accuracy.
2 Availability.
3 Continuity.
4 Integrity (including RAIM).
5 Coverage.

3.3.2. Lesson 2 – GNSS Errors
1 Signal, clock and orbit errors.
2 Atmospheric delays.
3 Geometric Dilution of Position.
4 Multipath errors.

3.3.3. Lesson 3 – Physical and Intentional Interference
1 GNSS signal strength.
2 Space weather (including Coronal Mass Ejections) and their effect on GNSS signals.
3 Jamming and spoofing.
4 HP microwave signal damage.

4. Module 4 – Applications of GNSS on AtoN

4.1. Scope
This module describes which AtoN components rely on GNSS signals for their effective operation.

4.2. Learning Objective
To gain a basic understanding of which AtoN are dependent on uninterrupted PNT.
4.3. SYLLABUS

4.3.1. LESSON 1 – REVIEW OF RADIONAVIGATION COMPONENTS FITTED TO ATON STATIONS
1. AtoN dependency on PNT (monitoring, synchronisation)
2. AIS

5. MODULE 5 – INTRODUCTION TO DGNSS AND PRINCIPLES OF OPERATION

5.1. SCOPE
This module describes the principles of the transmission of differential signals from a DGNSS shore station.

5.2. LEARNING OBJECTIVE
To gain a basic understanding of the principles of differential corrections to GNSS with theoretical training consolidated through a site visit.

5.3. SYLLABUS

5.3.1. LESSON 1 – INTRODUCTION TO DGNSS
2. ITU standard formats.
3. Geostationary satellite corrections to portable systems.
4. IALA MF DGNSS beacons and coverage.
5. Basic components of a DGNSS transmission station (including redundancy).
6. Introduction to integrity and reference modules; how integrity is achieved.
8. AIS Message 17.

5.3.2. LESSON 2 – DGNSS SITE VISIT
1. Visit DGNSS site.
2. Identify key components and their functions.

6. MODULE 6 – DGNSS RECEIVERS; INTEGRITY AND REFERENCE STATIONS

6.1. SCOPE
This module describes the principles of how GNSS receivers are used to produce DGNSS corrections, and how the integrity of the transmitted signal is monitored.

6.2. LEARNING OBJECTIVE
To gain a satisfactory understanding of the components of a DGNSS shore station.

6.3. SYLLABUS

6.3.1. LESSON 1 – DGNSS REFERENCE STATION
1. Components (receiver, processor, modulator, antenna, cabling).
Setting of parameters in accordance with IALA Recommendation R-121 on the Performance and Monitoring of DGNSS Services in the Frequency Band 283.5 – 325 KHz (e.g. Position, frequency, ID, Mask angle, message types).

Setting up of modulator.

Significance of antenna position / survey.

Power supplies.

Lightning protection.

LESSON 2 – DGNSS INTEGRITY MONITOR

Components (receiver, processor, demodulator, antenna, cabling).

Setting of parameters in accordance with IALA Recommendation R-121 on the Performance and Monitoring of DGNSS Services in the Frequency Band 283.5 – 325 KHz (e.g. Position, frequency, ID, Mask angle, alarm levels).

MODULE 7 – DGNSS TRANSMISSION STATIONS

SCOPE

This module describes the principles of how DGNSS transmitters are used to broadcast DGNSS corrections.

LEARNING OBJECTIVE

To gain a satisfactory understanding of the components of a DGNSS transmitter station.

SYLLABUS

LESSON 1 – DGNSS TRANSMITTER STATION

Components (Transmitter, Aerial Tuning Unit, Aerial).

Components of transmitter and adjustments (e.g. threshold levels).

RF Safety.

Use of Low power settings and dummy load.

Power supplies.

Lightning protection.

LESSON 2 – AERIAL TUNING UNIT

Aerial electrical characteristics / radio propagation.

Components (coil, tuning tap, auto-tuning, feedback to transmitter).

RF Safety.

Tuning for reactive and resistive loads.

Engineering for large or small aerials / wider bandwidth.

Lightning protection.

LESSON 2 – MF/LF AERIAL SYSTEM

Components (mast, guys, insulators, ground plane).

Safety (Physical and RF).

Cleanliness of Insulators, tracking.
8. MODULE 8 – DGNSS OPERATION AND MAINTENANCE

8.1. SCOPE
This module reinforces Modules 6 & 7 with practical training and should be undertaken at a DGNSS transmission site or a live test facility.

8.2. LEARNING OBJECTIVE
To gain a satisfactory understanding of practical aspects of DGNSS operation and maintenance.

8.3. SYLLABUS

8.3.1. LESSON 1 – DGNSS TRANSMITTER & ATU
1. Hands-on setting up of Reference Station.
2. Hands-on setting up of Integrity Monitor.
3. Modulator.
4. GNSS/DGNSS antennae.
5. Fault identification.
6. Use of Low power settings and dummy load.
7. Power supplies.
8. Lightning protection.

8.3.2. LESSON 2 – MF/LF AERIAL SYSTEM
1. Physical inspection.

9. MODULE 9 – MONITORING OF ACCURACY AND SIGNAL STRENGTH

9.1. SCOPE
This module describes the principles of how DGNSS services are monitored to ensure that IALA performance standards are met.

9.2. LEARNING OBJECTIVE
To gain a satisfactory understanding of how a DGNSS service is monitored and verified. It is not intended to provide a detailed knowledge of the manufacturer-specific site communications equipment.

9.3. SYLLABUS

9.3.1. LESSON 1 – CONTROL AND MONITORING FUNCTION
1. Components (software, PC, router, modem).
   Use of software locally and remotely / network security.
2. Reset functionality.
4 Use of Far Field Monitors.

9.3.2. LESSON 2 – CALIBRATION AND VERIFICATION OF SERVICE
1 Accuracy monitoring against local or national benchmarks.
2 Range measurement.
3 Range and station parameter calculations.