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

10, rue des Gaudines - 78100 Saint Germain en Laye, France
Tél. +33 (0)1 34 51 70 01- Fax +33 (0)1 34 51 82 05 - contact@iala-aism.org
www.iala-aism.org

International Association of Marine Aids to Navigation and Lighthouse Authorities
Association Internationale de Signalisation Maritime

DOCUMENT REVISION

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

Date	Page / Section Revised	Requirement for Revision
June 2016	Pages 3, 7, 8, 10 & 12	Minor text amendments and update of Teaching Modules

CONTENTS

CONTENTS

List of Tables

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 1 ***Table of Teaching Modules***

Module Title	Time in hours	Overview
Introduction to radionavigation systems	2.0	This module describes the basic functions and types of radionavigation systems, covering GNSS and terrestrial systems. **Note:** Radar beacons are covered in Level 2 Module 7 and the Automatic Identification System (AIS) in L2 Module 8
Position, Navigation and Timing (PNT)	1.0	This module describes the concepts of PNT, and how they are calculated.

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

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

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).

8 IALA Guideline 1060 on Recapitalisation of DGNSS.

9 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

1 History of Global Navigation Satellite 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

1 Principles of differential corrections to pseudoranges.

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.

7 Virtual reference stations.

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).

2 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).

3 Setting up of modulator.

4 Significance of antenna position / survey.

5 Power supplies.

6 Lightning protection.

6.3.2. LESSON 2 – DGNSS INTEGRITY MONITOR

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

2 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).

7. MODULE 7 – DGNSS TRANSMISSION STATIONS

7.1. SCOPE

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

7.2. LEARNING OBJECTIVE

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

7.3. SYLLABUS

7.3.1. LESSON 1 – DGNSS TRANSMITTER STATION

1 Components (Transmitter, Aerial Tuning Unit, Aerial).

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

3 RF Safety.

4 Use of Low power settings and dummy load.

5 Power supplies.

6 Lightning protection.

7.3.2. LESSON 2 – AERIAL TUNING UNIT

1 Aerial electrical characteristics / radio propagation.

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

3 RF Safety.

4 Tuning for reactive and resistive loads.

5 Engineering for large or small aerials / wider bandwidth.

6 Lightning protection.

7.3.3. LESSON 2 – MF/LF AERIAL SYSTEM

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

2 Safety (Physical and RF).

3 Cleanliness of Insulators, tracking.

4 Lightning protection.

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.

3 Performance monitoring against IALA standards (IALA Recommendation R-121 on the Performance and Monitoring of DGNSS Services in the Frequency Band 283.5 – 325 KHz).

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.