Maritime Professional Textbook Series

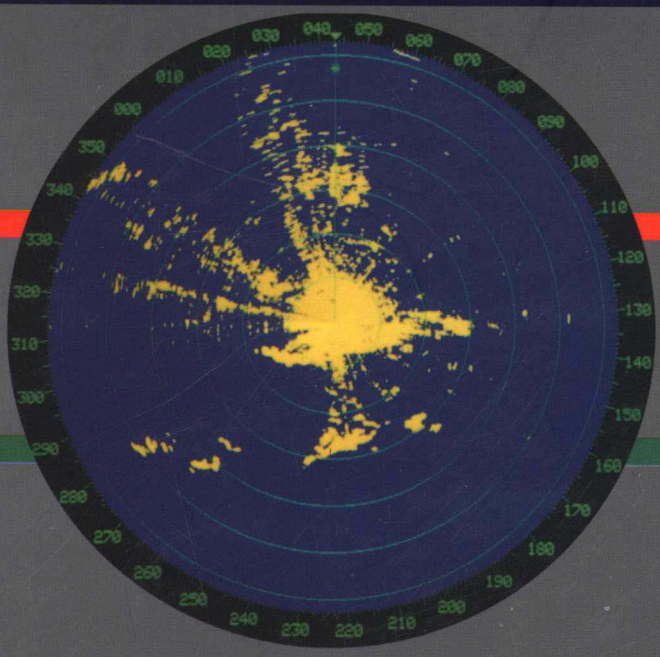
航海仪器

（下册：船舶导航雷达）

Nautical Navigation Instruments

(Volume Two: Shipborne Navigation Radar)

刘 彤 张 斌 著



大连海事大学出版社

Maritime Professional Textbook Series

Nautical Navigation Instruments
(Volume Two: Shipborne Navigation Radar)

航海仪器
(下册:船舶导航雷达)

刘彤 张斌 著

大连海事大学出版社

Introduction

This textbook is the English version of Chinese textbook *Nautical navigation instruments* (*volume two*: *Shipborne navigation radar*), one of maritime professional textbook series, for bilingual education. The contents of the textbook are in accordance with the Manila amendments to the *STCW Convention* and the *Competence Examinations and Assessments Program for Seafarers* laid down by *Maritime Safety Administration of the People's Republic of China*, and combine with cutting – edge technology and practical marine applications. As a result, the book can act as both theoretical textbook for *Shipborne Navigation Radar* and *Nautical Navigation* courses, and training textbook for *Radar Operation and Application* assessment of MSA of China. Therefore, the textbook is good for maritime universities and maritime affairs training agencies to train students and cadets of major of *Navigation*, *Nautical Science* and *Marine Management*, as well as the standing reference book for personnel engaged in nautical science expertise.

图书在版编目(CIP)数据

航海仪器. 下册,船舶导航雷达 = Nautical navigation instruments. volume two: shipborne navigation radar : 英文 / 刘彤,张斌著. —大连:大连海事大学出版社, 2013.10
ISBN 978-7-5632-2937-6

Ⅰ.①航… Ⅱ.①刘… ②张… Ⅲ.①航海仪器—高等学校—教材—英文 ②航海导航—导航雷达—高等学校—教材—英文 Ⅳ.①U666.15

中国版本图书馆 CIP 数据核字(2013)第 249045 号

大连海事大学出版社出版

地址:大连市凌海路 1 号 邮编:116026 电话:0411-84728394 传真:0411-84727996
http://www.dmupress.com E-mail:cbs@dmupress.com
大连住友彩色印刷有限公司印装 大连海事大学出版社发行
2013 年 10 月第 1 版 2013 年 10 月第 1 次印刷
幅面尺寸:185 mm × 260 mm 印张:16.25
字数:319 千 印数:1 ~ 2000 册

出版人:徐华东
责任编辑:姜建军 杨 淼 责任校对:刘牧园
封面设计:王 艳 版式设计:叶 子
ISBN 978-7-5632-2937-6 定价:33.00 元

Maritime Professional Textbook Series

Nautical Navigation Instruments
(Volume Two: Shipborne Navigation Radar)

航海仪器
(下册:船舶导航雷达)

刘 彤 张 斌 著

大连海事大学出版社

前　言

海上运输是交通运输的重要组成部分，在促进外贸运输发展和推动对外贸易增长等方面以其他运输方式不可比拟的优势发挥出越来越重要的作用。

大连海事大学作为我国唯一的国家重点航海类专业院校，多年来为我国乃至国际海上运输业培养了大量的航海类专业高级人才，对促进航运业的发展起到了重要作用。近年来，随着科学技术的进步和交通运输业的发展，学校针对航海类专业的鲜明特色，在人才培养方案、教学内容及课程体系改革等方面进行了一系列的研究和实践。在此基础上，我校组织编写出一套与新的培养方案、教学内容及课程体系相适应的航海类专业精品系列教材，旨在加强航海类专业建设，提高航海类人才培养的质量和水平，进一步推动高等航海教育的发展。

为了保证航海类专业精品系列教材顺利出版，学校在人力、物力和财力等方面予以充分保证。组织校内航海类专业的资深专家、骨干教师和管理干部做了大量工作，从筹备、调研、编写、评审直至正式出版，历时三载有余。2005 年 5 月，学校先后组织召开了两次航海类专业教学改革研讨会，来自交通部海事局、辽宁海事局、中国远洋运输（集团）总公司、中国海运（集团）总公司、中国船级社等单位的专家对教材编写的筹备工作提出了中肯的意见和建议。2006 年初，教材编写工作正式启动，确定重新编写航海类专业教材 22 种，其中航海技术专业教材 13 种、轮机工程专业教材 9 种。教材编写大纲先后征求了中国远洋运输（集团）总公司、中国海运（集团）总公司及大连海事大学等单位 10 多位专家的意见。学校组织教材主要编写人员分赴北京、天津、青岛、上海、广州、武汉及厦门等多家航运企事业单位进行调研，收集了大量的最新技术资料，同时听取了有关领导和专家的意见。2007 年我校先后召开了五次评审会，来自交通部海事局、驻英大使馆海事处、中国海事服务中心考试中心、辽宁海事局、山东海事局、中国远洋运输（集团）总公司、中国海运（集团）总公司、大连港引航站、上海海事大学、海军大连舰艇学院、大连水产学院、集美大学、青岛远洋船员职业学院及大连海事大学等单位的多位专家对 22 种教材的初稿就内容、文字及体例等方面逐一评审，反复推敲，几易其稿，逐步完善，反复审核，最终正式出版。该套教材中共有 16 种教材入选普通高等教育“十一五”国家级规划教材。

这套航海类专业精品系列教材以履行修订后的 STCW 公约为前提，结合海上运输业发展的国际性和信息性等特点，以更新教学内容为重点，对原有教材做了大量的增删与修改，注重理论基础及内容阐述的逻辑性和准确性，力求反映国内外航海科技领域的新成就与新知识，适应 21 世纪海上运输业对航海类人才的知识、能力和素质结构的要求，兼顾各教材内容之间的衔接与整合，避免重复与遗漏。我衷心地希望，通过全体编写人员的不懈努力，这套精品系列教材，能够进一步加强我校航海类专业的建设，为国内兄弟院校航海类专业的发展提供有益的借鉴，为我国高等航海教育发展尽微薄之力。

教材在编写和出版过程中，得到了方方面面领导、专家和同仁的大力支持和热心帮助（具体名单附后）。我谨代表大连海事大学及教材编写全体成员对以上单位和个人致以最诚挚的谢意。各位专家和同仁渊博的专业知识、严谨的治学态度、精益求精的学术风范以及细致入微

的工作作风为教材的顺利出版作出了卓越的贡献，在很大程度上可以说，这套教材的成功出版，是全体编写人员，各港航企事业单位的领导、专家和同仁共同努力的成果。

航海类专业精品系列教材的编写是一项繁重而复杂的工作，鉴于时间和人力等方面的因素，这套教材在某些方面还不是十分完善，缺点和不妥之处在所难免，希望同行专家不吝指正。同时，希望以此为契机，吸引更多航海技术领域的专家、学者参与到这项工作中来，为我国航海教育献计献策，为我国乃至国际海上运输事业培养出大量高素质的航海类专业人才。

大连海事大学校长

2008 年 3 月

对教材出版给予大力支持和帮助的单位及个人如下：（以姓氏笔画为序）

于晓利	教授	大连海洋大学
于智民	高级船长、高工	中远散货运输有限公司
马文华	高工	大连远洋运输公司
方伟江	轮机长	中海国际船舶管理有限公司上海分公司
王　阳	高工	中海国际船舶管理有限公司大连分公司
王　健	高工、高级引航员	大连港引航站
王国荣	高级轮机长	中远散货运输有限公司
王征祥	船长	中远集装箱运输有限公司
王新全	高工、总轮机长	中国远洋运输（集团）总公司
车　毅	船长	大连远洋运输公司
叶依群	高级船长	中远散货运输有限公司
田喜林	高工	中海国际船舶管理有限公司大连分公司
石爱国	教授	海军大连舰艇学院
任辰西	高级船长	中远散货运输有限公司
刘　屹	高工	大连远洋运输公司
刘世长	船长	日照海事局
孙　广	高工	辽宁海事局
安　彬	高级船长	大连远洋运输公司
邢　钺	高工	中远散货运输有限公司
吴　恒	教授、博导	大连海事大学
吴万千	副教授	青岛远洋船员学院
张仁平	教授	驻英大使馆海事处
张文浩	高工	中远散货运输有限公司
张均东	教授、博导	大连海事大学
张秋荣	教授	上海海事大学
李　录	高级轮机长	广州远洋船员管理公司

李志华	副教授	大连海事大学
李忠华	高工	珠海海事局
李恩洪	船长、高工	交通部海事局
李新江	副教授	大连海事大学
杜荣铭	教授	大连海事大学
杨君浩	轮机长	中海国际船舶管理有限公司上海分公司
沈　毅	工程师	辽宁海事局
邱文昌	教授	上海海事大学
邱铁卫	高级轮机长	大连远洋运输公司
邵哲平	教授、船长	集美大学
邹文生	高级轮机长	大连远洋运输公司
陈志强	高级轮机长	中远集装箱运输有限公司
陈建锋	高工、高级船长	中远散货运输有限公司
周邱克	高工、高级船长	中海客轮有限公司
房世珍	大副	青岛远洋对外劳务合作有限公司
易金华	指导船长、高级船长	中海国际船舶管理有限公司广州分公司
林长川	教授	集美大学
金　松	教授级高工	中国船级社大连分社
金义松	船长、高工	中海国际船舶管理有限公司
姚　杰	教授	大连海洋大学
姜　勇	教授级高工	山东海事局
洪碧光	教授、船长	大连海事大学
赵金文	高工、轮机长	大连远洋运输公司
赵晓玲	副教授	青岛远洋船员学院
赵爱屯	高级船长	中海国际船舶管理有限公司大连分公司
夏国忠	教授	大连海事大学
徐　波	高工	中远集装箱运输有限公司
敖金山	高级船长	枫叶海运有限公司
殷传安	高级轮机长	中海国际船舶管理有限公司大连分公司
郭子瑞	教授	辽宁海事局
郭文生	高级船长	广州远洋船员管理公司
顾剑文	高工	大连国际船员培训中心
崔保东	船长	青岛远洋对外劳务合作有限公司
黄党和	轮机长	中国海事服务中心
蔡振雄	教授	集美大学
魏茂苏	轮机长	青岛远洋对外劳务合作有限公司

Author's Note
——Guide-reading for radar textbook

Shipborne navigation radar is also called civil marine radar, which is an indispensable aid for deck officer to maintain safe navigation with the functions of lookout, position fixing, navigation and collision avoidance. This textbook describes navigation radar system configuration and operational principle concisely, analyses radar performance and functionality in detail, expounds various factors affecting radar performance and radar limitations profoundly, discusses the navigation operating techniques in the process of lookout, position fixing, navigation and collision avoidance systematically and proposes the operation methods and cautions of radar application in navigation comprehensively.

Shipborne Navigation Radar is based on IMO Resolution MSC. 192(79) annex *Revised Recommendation on Performance Standards for Radar Equipment*, IEC 62388 standardization documents *Maritime navigation and radiocommunication equipment and systems - Shipborne radar - Performance requirements, methods of testing and required test results*, Manila amendments to the *STCW Convention and Competence Examinations and Assessments Program for Seafarers* laid down by *Maritime Safety Administration of the People's Republic of China*, which can be used as the textbook for specialty of *Nautical Science*, *Marine Management* and *Instrument Measurement and Control* related to the nautical instrument, especially, for the examination in China to fulfill seafarer competency examination training in implementation of Manila amendments to the *STCW Convention*. Besides, the book can act as the standing reference book for personnel engaged in nautical science expertise.

Part 1 History of radar textbooks and radar performance standards

There are four textbooks recommended by *IMO Model Course* among various shipborne navigation radar textbooks in the world. *Radar Observer's Handbook for Merchant Navy Officers* written by Mr. *W. Burger*, published in 1957 Britain, has dominated seafarer radar training in 20th century with content of both precise theory and wealthy practice, which was renewed 9th version in 1998. *Electronic Aids to Navigation: Radar and ARPA* written by Mr. R. *Lownsborough*, published in 1993 Britain, paid more attention to equipment principles, and had certain practical significance. *Shipborne Radar and ARPA* written by Mr. *H. Subramaniam*, published in 1990 and reprinted in 2010, mainly focused of manual plotting, does not very widely spread. *Radar and ARPA Manual* written by Mr. *A. G. Bole* and Mr. W. O. Dineley, published in 1990, the second Edition in 2005, and expecting the third Edition in the end of 2013, is widely circulated in recent years and suits for marine training. Throughout all above, compared with *IMO Model Course*, the context to explain the equip-

ment principles is far more than needed, while the supports to latest radar performance standards are not enough, not yet has version latter than Manila amendments to the *STCW Convention* for trainee.

In China, *Condensed Marine Radar* (《简明航海雷达》), written by Mr. *Shi Bin* (施彬), published Nov., 1956 by *Shanghai Science and Technology Press*, introduced the basic principles and operation methods of navigation radar systematically and presents the basics of radar observations and plotting. The textbook impacted Chinese early nautical radar technology expertise for a long time. However, electronic navigation technology development is relatively slow during a long period time partly because the domestic political atmosphere impeded the academic development. There was no radar textbook update until 1980s. There were two profoundly influenced versions of official publication of marine radar professional teaching textbooks after the reform and opening-up, which had relatively great impact in maritime teaching, *Marine Radar* (《航海雷达》) written by Mr. *Miao Degang* (缪德刚), Dalian Marine College Press Jun., 1990, and *Marine Radar and ARPA* (《航海雷达与 ARPA》) written by Mr. *Wang Shiyuan* (王世远), *Dalian Maritime University Press* Aug., 1998. The professional perspectives and teaching ideas of these two textbooks have dominated the teaching and training of university undergraduate, junior college education, professional training and seafarer competency assessment training of China. It almost lasted for more than 20 years when the shipborne navigation radar technology grew fastest and made outstanding contributions to the navigational instrument teaching and seafarer training in China. In order to meet the No. 330 documentation *Radar Operation and Professional Simulator Training, Examination and Certification Program for Seafarers in the People's Republic of China* (《中华人民共和国船员雷达操作与模拟器专业培训、考试和发证办法》) issued by the *Harbour Superintendency Administration of the People's Republic of China* (the former of *China MSA*) in 1997, i. e. so called B07/B08 program (Two Radar Certificates)—the certificate training for "*Radar Observation and Plotting and Radar Simulator Training*" and "*Automatic Radar Plotting Aids Training*", Besides those two textbooks, *Radar Observation and Plotting* (《雷达观测与标绘》) written by Mr. *Sun Wenqiang* etc. (孙文强等) were published twice by *Dalian Maritime University Press* in Oct., 1998 and Nov., 2005 respectively, but no textbook has aimed at B08 program yet. During this period, *Harbor Superintendency Administration* recommended internal training materials *Radar Observation and Simulator* (《雷达观测与模拟器》) and *Automatic Radar Plotting Aid* (《自动雷达标绘仪(ARPA)》) written by Mr. *Fang Quangen* (方泉根) and Mr. *Sun Guoyuan* (孙国元), Shanghai Marine College, were widely used by training agencies all over the country. *Automatic Radar Plotting Aid* (《自动雷达标绘仪》) written by Mr. *Wu Jianhua* (吴建华) Jun., 2009, and *Radar Observation and Plotting* (《雷达观测与标绘》) written by Mr. *Zhu Jianguo* (祝建国) and Mr. *Weng Jianjun* (翁建军) Sep., 2010, both published by *Wuhan Technology University Press*, were used in B07/B08 program in Central, eastern and southwestern of China. Besides, *Marine Radar* (《航海雷达》) written by Ms. *Zhang Xinggu* (张杏谷) published by *Dalian Maritime University Press* Aug., 2010, mainly used in navigation teaching and training in *Jimei University*. This is the first time that radar textbook refers to the function AIS reported targets required by IMO MSC. 192(79) Resolution, illustrated the operation of AIS in radar equipment, and lists the Chinese translation version of Resolution MSC. 192(79) in

the appendix.

In fact, the radar performance standards in our textbooks after the reform and opening-up are all based on IMO Resolution A.477(XII) annex *Recommendation on Performance Standards for Radar Equipment* Nov., 1981 and IMO Resolution A.823(19) annex *Recommendation on Performance Standards for Automatic Radar Plotting Aids (ARPAs)* Nov., 1995 until now, while the textbooks never reflect the updates of radar performance standards, i.e. the IMO Resolution MSC. 64(67) annex 4 *Recommendation on Performance Standards for Radar Equipment* adopted Nov., 1996, and Resolution MSC. 192(79) annex 34 *Revised Recommendation on Performance Standards for Radar Equipment*, adopted Dec., 2004 into the seafarers training teaching and assessment program.

Part 2 The development of radar technology and textbook construction

IMO actively promotes the role of electronic information navigation technology in safeguarding navigation since later 1990s, especially entering 21st century. With the development of satellite navigation technology, digital communication technology, sensor network technology and multi-sensor information processing and fusion technology, shipborne navigation radar technology and functions have made great progress. From analog to digital technology, signal processing to information fusion and sole video display radar equipment to multi-sensor integrated information processing, radar has become important core equipment in integrated navigation system, its observations (lookout), position fixing, navigation and collision avoidance functions occupy an irreplaceable important role in integrated navigation system. The techniques involved in current radar system have already covered the technologies and applications of the mainstream nautical instrument. Incomplete, imperfect radar teaching contents will directly affect the quality of professional navigational training, affect the implementation of the STCW Convention, affect the safe navigation. Therefore, the publication of radar textbook has become one of the difficulties and the focuses of the construction of professional textbooks.

Part 3 The study and suggestions and guide-reading for this textbook

For nautical science specialty, radar is a relative difficult course, but also is one of the necessary courses in the competency examination for seafarers' certificate. The difficult factors lie in (1) the complexity of system configurations; (2) the complexity of equipment principles; (3) the complexity of equipment functions; (4) the complexity of human-machine interaction interfaces; (5) the complexity of operation procedures; (6) skilled operation should be based on a profound understanding of the equipment principles; (7) many factors may affect the quality of radar pictures, such as equipment performances, propagation conditions of electromagnetic wave, electromagnetic properties of targets, user operation techniques; (8) the accurate interpretation of radar pictures needs comprehensive knowledge about all above factors and formidable experience about radar observations. Radar course can usually be decomposed into five parts: basic operational principles of the radar equipment, radar operations, radar observations, radar navigation and radar collision avoidance.

This textbook is divided into nine chapters and two annexes. Chapter 1 summarises the progress in the development of shipborne navigation radar from a technical point, aimed to allow readers to understand the basic characteristics of modern radar technology. Chapter 2 introduces the basic characteristics of the radar pictures and the basic physical principles of target measurement, and then focuses on the radar picture presentations and its application to allow readers to become familiar with and master the radar display features. This chapter is recommended two theoretical teaching hours and one hour practice by real radar equipment. Chapter 3 introduces the basic configurations and operational principles of the radar system, which is one of the most difficult chapters of the book. This chapter is also the basis for officer who can operate radar correctly, explain the radar observation phenomena, and master the function of radar. In consideration of the characteristics of nautical science specialty, combined with radar principles to analyse radar operation and observation phenomena, this chapter serves the function to pave the way for the subsequent chapters. It is recommended eight theoretical teaching hours and half an hour practice of real radar equipment for this chapter. Chapter 4 describes the operations of the basic controls and the procedures for radar switch on/off, and the proposed theoretical teaching hours are two and a half and experiment hours are one and a half. Chapter 5 introduces radar observation performance and observation techniques, target observation performance and the factors affecting normal radar observations, which is the focus of the book. This chapter is recommended eight theoretical teaching hours and three hours practice of real radar equipment to comprehend a variety of radar observation phenomena in order to help the observers to find small target in a variety of complex and harsh environments. Chapter 6 describes the basic techniques and cautions for position fixing and navigation by radar, which is the crucial point of *Nautical Navigation* course. This chapter focuses on target identification and selection from the perspective of position fixing by radar. For radar navigation, the functions and operations of chart radar, which is involved for the first time in the radar performance standards of Resolution MSC. 192 (79), are introduced as the emphasis. This chapter is recommended two theoretical teaching hours and two hours practice of the real radar (if available) or simulator. Chapter 7 is another focus – radar collision avoidance function, namely traditional ARPA function and the function extension under the new technical conditions, which is the focus of the development of shipborne navigation radar technology during the last 20 years and an irreplaceable function by other equipment. By intensively studying IMO and IEC latest radar performance standards and IEC 62288 standardization documentation *Presentation of navigation-related information on shipborne navigational displays – General requirements, methods of testing and required test results*, according to the international norms, combining the research and navigation practice, the topics, including the operation methods, advantages and limitations of radar target tracking and AIS reported target information in radar collision avoidance action, are discussed in detail. This chapter is recommended no less than ten theoretical teaching hours, two hours practice of real radar equipment, and thirty hours operations, practices and assessment by radar simulator. Combined more than 20 years of radar installation and maintenance practices, Chapter 8 introduces the knowledge of radar installation, acceptance check and maintenance that are necessary for officer to comprehend from the equipment management. This chapter is

recommended two teaching hours. If equipment maintenance training is intended to be strengthened, such as for the specialty of *Marine Electronics and Electrical Engineering*, this chapter is recommended as one of the key lessons for extra teaching and especially practice hours. Chapter 9 provides an overview of development of a new radar system and its technical characteristics and observation characteristics. For nautical science specialty, the suggested teaching hours are allocated in the following table.

Chapter	Classroom hours	Practice hours (Including assessment)		Note for Assessment of Radar Operation and Application
		Real radar	Radar simulator	
1	0.5	×	×	×
2	2	1	×	(involve all the following assessments)
3	8	0.5	×	×
4	2.5	1.5	×	Radar Basic Operation and Setting
5	8	3	×	Radar position fixing and navigation
6	2	2		
7	10	2	30	Radar and AIS anti-collision operation
8	2	×	×	×
9	1	×	×	×
Total	36	10	30	×

To help readers and professionals and technicians better to understand the principles of radar, to master the knowledge of radar performance accurately, and to use the radar function skillfully, we put IMO MSC. 192(79) radar performance standard and IEC 62288 the standard presentation of navigation – related information on radar display as the annexes. Noticed that the discrepancies between IMO and IEC standards for radar, we add some descriptive comments or explanatory notes.

Part 4 The writers of the book

The writers of this book are *Liu Tong*, *Zhang Bin*, *Yang Xiao*, *Yu Feng*, *Yang Xiao*, *Chen Hali and Gao Zongjiang*, the teachers of *Teaching Branch of Navigation Instrument* of *Navigation College of Dalian Maritime University*. The Chinese version of this book is written by *Liu Tong*, *Yang Xiao*, *Cheng Chuan*, *Chen Duo*, *Quan Dongqun*. Section 3.7 is written by Chen Duo, Section 3.8 is written by Chen Duo, *Liu Tong and Yang Xiao*. Section 5.3 is written by *Cheng Chuan*. Chapter 6 is written by *Chen Duo*, *Yang Xiao* and *Liu Tong*. Section 7.2 ~ 7.6 are written by *Liu Tong* and *Yang Xiao*. Section 8.2 and 8.3 are written by *Quan Dongqun*. Chapter 9 is written by *Yang Xiao*. The other Chapters and Sections are all written by *Liu Tong*.

Part 5 Acknowledgements

Trace back from collecting the references, communicating with the relevant maritime authorities, shipping industry professionals, experts and scholars from teaching and training institutions to

driving the writing, follow the revision of international conventions, the updates of technical standards, the augmentation of instrument capabilities and the process of implementing the STCW Convention, we repeatedly and constantly to modify and improve the materials of the textbook over 5 years. During these years, the authors have finished nearly 10 books already. However, only this *Shipborne Navigation Radar*, we feel fear, anxiety and hesitate because of the shallowness of our scholarship, while making an unauthorised guess for esoteric of modern technology.

Thanks to the devotion of vast ocean to the human world, thanks to the stage of history built by IMO and maritime education in China, thanks to the years of diligent cultivation of *Dalian Maritime University*, thanks to the guides and supports by the experts from shipping industry and relevant enterprises and institutions, all of these urge us to be able to play an insignificant supporting role on the big stage in the vast world, interpret our duties and rack our brains. Since Manila amendments to the *STCW Convention* entered into force, the *Maritime Safety Administration of China* appoints us to revise and draft the syllabus for seafarer examination and assessment. By this opportunity, we learn universal spirit from sailing elite far and near, draw perspectives from senior experts and scholars all around, to fill the interior with theory and polish the exterior with practice. Thanks to the tolerances and trusts of *Chinese Maritime Safety Administration*, *Dalian Maritime University and Dalian Maritime University Press*, and the encouragements and supports from colleagues, although the deadline for manuscripts was put off again and again, we finally dedicate our painstaking fruit. We have done really the hard work we could.

Contents