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Inaugural Francesco Berlingieri Lecture
UNMANNED VESSELS: CHALLENGES AHEAD

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Mr President, friends of the Comité Maritime International

1. May I join with Lord Philips in first welcoming you all to this Conference in London; and to say that it is a particular honour and pleasure to deliver this Inaugural Francesco Berlingieri Lecture.

2. As many of you will know, Francesco Berlingieri was a renowned lawyer and jurist, head of the leading Italian law firm which still carries his family name and, of course, the President of the Comité Maritime International for some 25 years from 1976-1991. I was still a novice in 1976. That was the year when I started as a young barrister. I soon learned that Francesco Berlingieri was one of the great shipping lawyers of his time – like a God in the firmament. He was a great sailor and prolific author. He had an immense knowledge of shipping law with a broad vision which transcended national boundaries and a passion for the unification of maritime law in all its aspects – which is, of course, the principal object of the CMI.

3. What I did not know until recently was that in 1977, he was elected a Member of the Commercial Court Users' Committee here in London; in the same year, 1977, he was elected an Honorary Member of the United States Maritime Law Association; in 1981 an Honorary Member of the

Canadian Bar Association; and in 1984 an Honorary Proctor in Admiralty by the Maritime Law Association of the United States. In 1993 he was presented with the Order of the British Empire (OBE) upon the proposal of the Master of the Rolls, Lord Donaldson in recognition of his valuable service to British maritime interests. These honours bestowed on Francesco Berlingieri illustrate the very high regard in which he was held around the world.

4. If I might add - he was also a great listener and someone who was willing to change his mind. I know this because if you look at one of his many books, International Maritime Conventions Vol 2, you will see that he says – at footnote 129 - that he had changed his mind on the topic of wrongful arrest of ships as a result of reading an article I had written. That is a topic which is currently being considered by a working group of the CMI which will, I understand, meet this afternoon. Unfortunately, I will be unable to join you later but I am sure that Francesco would join me in wishing you well in your endeavours.

5. I am also sure that Francesco would be excited by the present topic concerning unmanned vessels. As I recollect, he was someone who was always looking to the future as much as the past – ready to take on the challenges of the day. And there can be no doubt that unmanned vessels will be at the centre of the future of shipping and provide an important challenge to all parts of the shipping community.

6. At the outset, I should confess that I am very much a newcomer to this area of shipping – although in one sense everyone is a relative

newcomer. We are all on a steep learning curve. What I have learnt is that the technology is developing at an incredible rate. Of that there is no doubt. Many things that were only a pipedream a few years ago now seem likely to become a reality in the very near future. And it is plainly of paramount importance to ensure that the existing international regulatory framework is reviewed and updated as necessary to accommodate this new technology and to allow it to operate safely. That is the main focus of the International Working Group on Unmanned Ships which was set by the CMI in 2015.

7. As I shall mention in a moment, the IWG has done much work since then; and there is much work still to do. I do not wish to encroach on that work. For present purposes, I do no more than offer a few thoughts and highlight a number of the challenges that lie ahead. I should make clear that I do not pretend that these are necessarily original thoughts. On the contrary, I am deeply grateful for the insights provided to me by a number of individuals with whom I have been in contact over the past few months including Mr Tom Birch Reynardson, Mr Robert Veal, Ms Lina Wiedenbach and Professor Henrik Ringbom.

8. To go back almost to the beginning, the concept of an unmanned surface vehicle is not new. Apparently, the first demonstration was performed by Nikola Tesla in 1898 when he was granted a U.S. patent for a *"Method of and Apparatus for Controlling Mechanism of Moving Vessels or Vehicles"*. The patent covered *"...any type of vessel or vehicle which is capable of being propelled and directed such as a boat, a balloon or a carriage."* Well, that was some 120 years ago. And now it is certainly a "hot topic".

9. Although the title of this talk refers to "unmanned vessels', that is a very wide term that is often used generically and embraces a variety of control methods that fit broadly into two main categories.

10. The first category relates to vessels that are remote-controlled by one or more shoreside controllers using electronic computer equipment. This is either done by using line-of-sight communication or, increasingly, the use of the global positioning system (GPS) to control vessels remotely over the horizon. In one sense, these vessels are not "unmanned" at all. Rather, they are "manned" but the "manning" is done by personnel who are not on board.

11. The second category includes vessels that are pre-programmed and thereafter they use a combination of sonar radar, advanced computer software as well as very fast control algorithms to form a pre-determined nautical circuit without any human interaction whatsoever. These are generally referred to as autonomous unmanned vessels (AUVs).

12. However, the terms "unmanned" and "autonomous" are often used interchangeably; and, in truth, this binary distinction is an over-simplification. For example, one study refers to 5 levels of "autonomy" viz. (i) human on board; (ii) operated; (iii) directed; (iv) delegated; (iv) monitored; and (v) autonomous. It has been said that the reality is that the developers of the technology recognise up to 10 or even 15 different levels of "autonomy" and that it is more of a "continuum".

13. The IMO has established its own "Degrees of Autonomy" at MSC[1] viz.

    a. Ship with automated processes and decision support. Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated.
    b. Remotely controlled ship with seafarers on board. The ship is controlled and operated from another location, but seafarers are on board.
    c. Remotely controlled ship without seafarers on board. The ship is controlled and operated from another location. There are no seafarers on board.
    d. Fully autonomous ship. The operating system of the ship is able to make decisions and determine actions by itself.

14. If anyone doubts the important part that unmanned vessels will play in the future, they need only carry out a quick search on the internet. You will immediately find a vast amount of information – including numerous articles, photographs and videos[2].

15. For example, in December last year, Harbin Engineering University and Shenzhen HiSiBi Boats Company revealed what Chinese state media claimed was the fastest unmanned waterborne surface vehicle,

[1] http://www.imo.org/en/mediacentre/pressbriefings/pages/08-msc-99-mass-scoping.aspx
[2] See, for example, the Industry Code of Practice for Maritime Autonomous Systems Ships (MASS) published by Maritime UK: https://www.maritimeuk.org/media-centre/publications/industry-code-conduct-maritime-autonomous-systems/

the Tianxing-1. The 12.2-metre electric-gasoline hybrid has a top speed of over 50 knots (93 km/h)[3].

16. In February this year, a Chinese company, Yunzhou-Tech (along with the Zhuhai's municipal government and the Wuhan University) started construction of the Wansham Marine Test Field. The 771 square kilometre (225 square nautical mile) zone. This will allow for the testing of autonomous maritime technology and is claimed to be the largest testing facility of its kind in the world[4].

17. Also in February this year, China celebrated the opening of its Hong Kong-Zhuhai-Macao Bridge by holding the largest cooperative unmanned boat manoeuvre in history using 81 boats. The video clip released by Chinese state media shows 56 unmanned boats coordinating a set of manoeuvres near the Wanshan Islands south of Hong Kong[5]. The vessels avoid "obstacles" and manoeuvre into various shapes and patterns without hitting one another. The clip ends with the swarm recreating the shape of an aircraft carrier while a larger – but also unmanned – boat passes through them, recreating a fighter jet taking off.

18. This is just the tip of the iceberg. Other countries including the UK and the USA are fast developing technologies which will make unmanned vessels not only a reality – but a commonplace. Much of the current project work is for military purposes and therefore secret. But one can

[3] https://www.janes.com/article/76440/china-displays-new-armed-unmanned-surface-vehicle
[4] https://worldmaritimenews.com/archives/243840/china-building-asias-1st-test-area-for-autonomous-vessels/
[5] https://thedefensepost.com/2018/06/02/china-56-boat-drone-swarm-hong-kong/

readily find information on the internet which shows that this is not just science fiction.

19. For example, Israel has developed an unmanned boat known as the Katana Unmanned Surface Vehicle (USV)[6]. It measures 11.9m in overall length and 2.81m in width, has a platform weight of 6,500kg, and can carry payloads up to 2,200kg. It can be deployed in search and rescue, intelligence gathering, protection of exclusive economic zones, homeland and harbour security, and surveillance of coastal, as well as shallow and territorial waters, fire-fighting, and public safety and security. It can also be used for surveillance and protection of oil and gas, and other critical assets.

20. In the UK, Rolls Royce has revealed plans for an autonomous, single role, naval vessel with a range of 3500 miles. According to their webpage[7], the vessel concept is capable of operating beyond the horizon for over 100 days, will displace 700 tonnes and reach speeds above 25 knots. The 60m long vessel is designed to perform a range of single role missions, for example, patrol & surveillance, mine detection or fleet screening.

21. Although the pioneer work has been primarily in the military field, there is no doubt that the technology will soon be introduced for use in ordinary cargo ships.

22. For example, last year, Rolls Royce and global towage operator, Svitzer, successfully demonstrated the world's first remotely operated

[6] http://www.iai.co.il/2013/36771-46331-en/Groups_SystemMissileandSpace_MLM_Products.aspx
[7] https://www.rolls-royce.com/media/press-releases/2017/12-09-2017-rr-reveals-plans-for-autonomous-naval-vessel.aspx

commercial vessel in Copengaen harbour, Denmark[8]. It is equipped with a Rolls-Royce Dynamic Positioning System, which is the key link to the remote controlled system. The vessel also features a range of sensors which combine different data inputs using advanced software to give the captain an enhanced understanding of the vessel and its surroundings. The data is transmitted reliably and securely to a Remote Operating Centre (ROC) from where the Captain controls the vessel.

23. At this very moment, the world's first fully electric and autonomous cargo ship is being built in Vard Brevik, Norway – the *Yara Birkeland*[9]. The design is for a 120 TEU (twenty-foot equivalent units) open top container ship. It will be a fully battery powered solution, prepared for autonomous and unmanned operation with zero emissions. The ship's navigation and autonomous operations will be supported by a number of proximity sensors, including a radar, a light detection and ranging (LIDAR) device, an automatic identification system (AIS), an imaging system and an infrared (IR) camera. Loading and discharging will be done automatically using electric cranes and equipment. The ship will not have ballast tanks, but will use the battery pack as permanent ballast. The ship will also be equipped with an automatic mooring system - berthing and unberthing will be done without human intervention, and will not require special implementations dock-side.

24. Unmanned vessels provide obvious potential advantages both in terms of running costs and environmental considerations. For example, I have already mentioned that the *Yara Birkeland* will have zero emissions.

[8] https://www.rolls-royce.com/media/press-releases/2017/20-06-2017-rr-demonstrates-worlds-first-remotely-operated-commercial-vessel.aspx
[9] https://www.yara.com/knowledge-grows/game-changer-for-the-environment/

Once in full operation, it will apparently replace 40,000 truckloads per year reducing NOx and CO2 emissions in the process.

25. However, there is no doubt that the introduction of these new unmanned vessels presents many challenges.

26. Plainly, the technological challenges are significant at many levels. Needless to say, the vessels must be capable of providing the particular services required. At present, the main focus would appear to be for unmanned vessels to be used on relatively short passages in inland waterways or, at least, close to the shore. For example, the *Yara Birkeland* will sail on two routes, between Herøya and Brevik (~7 nautical miles (13 km)) and between Herøya and Larvik (~30 nautical miles (56 km)), carrying chemicals and fertiliser. It will probably be some years before we see unmanned vessels performing longer ocean voyages but it seems likely that this is only a matter of time.

27. Safety is paramount. This is an area which has been the subject of a number of studies; but, once again, there is plainly a lot more work to do. For example, in its 2016 annual overview, the European Maritime Safety Agency found that 62% of the 880 accidents occurring globally during the period 2011-2015 were caused by "human erroneous action"[10]. This might suggest that unmanned ships would have fewer accidents. That conclusion is supported to some extent by another important study from March 2017 which analysed 100 accidents that occurred between 1999 to 2015[11]. The researchers attempted to assess

[10] http://www.emsa.europa.eu/news-a-press-centre/external-news/item/2903-annual-overview-of-marine-casualties-and-incidents-2016.html
[11] https://www.sciencedirect.com/science/article/pii/S0951832016303337?via%3Dihub

whether the accidents would have been more or less likely to happen if the vessel had been unmanned. They found that the likelihood of groundings or collisions might have been decreased significantly if those vessels had been unmanned. But they also concluded that where accidents do happen, the consequences may be more severe without a crew to intervene. In particular, accidents involving fires may be more serious if there is no crew to act as firefighters. Thus, although the total number of accidents may decrease with unmanned vessels, it is very uncertain whether the overall risk of loss and damage would decrease significantly if ships were unmanned.

28. Unsurprisingly, the various classification societies have been hard at work. For example, last year Lloyds Register produced its own *"LR Code for Unmanned Marine Systems"*[12]; and only a few months ago, DNV-GL produced its own Class Guideline entitled *"Autonomous and Remotely Operated Ships"*[13]. Both of these documents provide a detailed framework for the assurance of safety and operational requirements for unmanned marine systems.

29. The insurance position is also crucial. That is a topic that has been the subject of consideration by, in particular, the Insurance Institute of London (IIL) and the International Group of P&I Clubs which has set up a special IG autonomous vessels working group. To a large extent, insurers have historically been largely content to provide hull or cargo cover without much detailed consideration of the underlying technology of the vessels concerned; that has been left to the general regulatory

[12] https://www.lr.org/en/unmanned-code/
[13] http://rules.dnvgl.com/docs/pdf/dnvgl/cg/2018-09/dnvgl-cg-0264.pdf

framework and, more specifically, the Classification Societies. Thus, hull policies will, of course, generally include a specific warranty that the vessel will be properly classed. However, this underlines even more the importance of an adequate regulatory framework and proper classification rules.

30. So far as Club cover is concerned, the position is potentially more complicated for at least two reasons.

31. First, a threshold question arises with regard to the potential legal liability of a shipowner in circumstances where, for example, an autonomous vessel is navigated from ashore and there is a collision or grounding as a result of a software problem caused by some third party – for example, the manufacturer or installer of the automation system or internet provider. In truth, this is not necessarily very different from the legal problems which can arise in the conventional context. In each case, the broad question arises as to whether the shipowner can avoid liability because of the fault of the manufacturer or installer of the software system or the third party provider. In the context of the Hague Rules, this in turn will focus on the scope of the obligation of due diligence to make the ship seaworthy before and at the beginning of the voyage under Art III.1; and the various defences which may be available under Art IV.2 including, of course, sub-paragraph (p) – ***"latents defect not discoverable by due diligence".*** In one sense, these are not new problems at all. However, as automation systems become more complex, one may assume that these issues will perhaps become increasingly important. Similarly, it seems to me that the question of

rights of recourse will also become increasingly significant – and complex.

32. Second, the P&I Clubs will no doubt have to consider the scope of particular rules. For example, Club Rules generally refer to crew serving on-board. In the ordinary course, one would suppose that loss of life/personal injury of those navigating/operating the autonomous vessel from ashore would be beyond the scope of cover; and that such risks would be regarded as a matter of shoreside liability and insurance arrangements. However, it may be that the clubs may wish to extend cover to include such risks. It is noteworthy that at least one Club has produced a bespoke set of Rules for unmanned vessels[14].

33. So far as pooling arrangements are concerned, it would seem that the main pooling agreement operates to pool all claims arising in connection with the operation of a ship save to the extent excluded. Such exclusions do not appear to bite as against unmanned vessels in a way in which they would otherwise not bite against traditional vessels and therefore, in principle, autonomous vessels should not be excluded from pooling.

34. I leave for the last, the work of the CMI. I have already referred to the importance of the general regulatory framework. The difficulty here is that such framework is very fragmented: it is to be found in more than 50 IMO Legal Instruments and a variety of national laws.

35. As I have already mentioned, the CMI set up an International Working Group on Unmanned Ships in 2015. The main purpose of the IWG is to

[14] https://www.shipownersclub.com/pi-cover-autonomous-vessels/

identify the legal issues surrounding the uptake of unmanned shipping and to provide an international legal perspective to the issues involved. Following the production of a Position Paper[15], the IWG has carried out two main exercises. These are explained in the written submission of the IWG earlier this year to the Maritime Safety Committee of IMO.

36. The first main exercise was the circulation in early 2017 of a Questionnaire to the 52 National Maritime Law Associations which are members of the CMI[16]. The Questionnaire focused on how national laws will respond to unmanned shipping in the context of the various international conventions including UNCLOS, the IMO Conventions, COLREGS and the STCW Convention. The IWG has now received some 23 responses. These have now been summarised and collated. They can be viewed on the CMI website.

37. This was followed by a scoping exercise undertaken by members of the IWG and also students from Hamburg Maritime University and Researchers from Tokyo University of the main international conventions with respect to Maritime Autonomous Surface Ships (MASS)[17]. As stage 1 of the project, the IWG selected what are considered to be the conventions most relevant to unmanned shipping and therefore most urgently requiring review. For that purpose, some 8 conventions were selected including the International Convention for the Safety of Life at Sea (SOLAS), The International Regulations for Preventing Collisions at Sea (COLREGS), The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

[15] https://comitemaritime.org/work/unmanned-ships/
[16] https://comitemaritime.org/work/unmanned-ships/
[17] https://comitemaritime.org/work/unmanned-ships/

(STCW) and The International Convention for the Prevention of Pollution from Ships (MARPOL). The "scoping" exercise involved an analysis of the main provisions of these 8 Conventions to see how they would apply to unmanned ships.

38. It is, of course, recognised by the IWG that a review of all conventions will be necessary but that work can and should proceed on the conventions selected in order to establish a *modus operandi* which can be applied across the legal and regulatory framework. A further complication is that the various instruments emanate from different IMO subcommittees. So effective co-ordination is very important.

39. In broad terms, the IWG has identified provisions in the instruments which have been examined in the course of the scoping exercise which may either require amendment or clarification.

40. To repeat, I do not wish to encroach upon the important work of the IWG. However, I would certainly wish to congratulate those concerned on the work that has been done so far and to emphasise the importance of the work that still needs to be done. With that in mind, it is perhaps useful to focus on a number of broad issues that arise for consideration.

41. The first and most fundamental question is whether ships without any crew on board are to be regarded as "ships" or "vessels" within the meaning of the conventions at all. Those terms are used interchangeably in UNCLOS but neither is defined. Other conventions contain certain definitions which do not appear to require or depend upon any particular level of crewing. However, there is obviously much sense in

eliminating any uncertainty and providing a clear definition – or at least a universal term that makes it plain that the concept of a ship or vessel does not necessarily depend upon the extent to which any crew may or may not be on board. From a practical point of view, it seems to me that that makes obvious sense. After all, the risks and dangers created by vessels are broadly similar – whether they are manned or unmanned.

42. However, that really is only just the beginning. The real problem is that there are many provisions in the Conventions which make no sense whatever with regard to unmanned vessels or at least give rise to fundamental difficulties of interpretation and application with regard to unmanned vessels.

43. For example:

    a. The International Convention for the Safety of Life at Sea (SOLAS) obliges contracting states to ensure minimum standards, in particular, in construction, equipment and operation with a view to ensuring the safety of life at sea. The SOLAS Convention is supplemented by a highly detailed annex which spans 12 chapters. Chapter II-1 deals with the ships' structure, subdivision and stability, machinery and electrical. Regulation 5-1 includes a requirement that the Ship's *"...master...be supplied with information....as is necessary to enable him by rapid...process to obtain accurate guidance as to the stability of the ship under varying operating conditions."* So, the obvious question arises as to how this applies in the case of an unmanned ship. Similarly, Chapter III prescribes the life-saving appliances to be carried on

board the relevant ship and corresponding arrangements. In the context of passenger ships, Regulation 10 requires that *"...there shall be sufficient crew members, who may be deck officers or certified persons on board for operating the survival craft and launching arrangements."* Although the chapter permits the use of alternative designs, it will be difficult for an unmanned ship to comply with this regulation. Even more important is Chapter V Regulation 14 which requires that all ships are *"...sufficiently and efficiently manned...."* There has been some debate about the scope and effect of this provision. On its face, it does not prohibit unmanned vessels. However, the counter-argument is that there is underlying assumption of some minimum manning by crew on board the ship. Another crucial provision is Regulation 24 which requires that in "*hazardous navigational situations*" it shall be possible to establish *"manual control of the ship steering immediately".* The concept of *"manual control"* is somewhat elusive. The suggestion has been made that it may be performed remotely. I have to say that I find it difficult to agree with that suggestion. But there is no doubt that this needs to be addressed.

b. Similar difficulties arise with regard to numerous provisions contained in the International Regulations for Preventing Collisions at Sea (COLREGs). For example, Rule 2 (Responsibility) provides: *"(a) Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precautions which may be required by the ordinary practice of*

seamen, or by the special circumstances of the case." It has been said that this is the elephant in the room: the *"ordinary practice of seamen"* is not an entirely satisfactory benchmark of responsibility in the case of an unmanned vessel. More specifically, Rule 5 requires that *"...every vessel...at all times [maintains] a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances.... to make a full appraisal of the situation and risk of collision."* So the question arises as to what is meant by a proper look-out by *"sight and hearing"*. The view expressed by the IWG is that the reference to *"sight and hearing"* clearly requires a human input in surveying and assessing the situation and collision risk, consistently with Rule 2; and that, as such, autonomous ships relying, for instance, on algorithmic collision avoidance technology would not satisfy the requirement of appraisal by "sight and hearing". However, as the IWG Paper also points out, the present generation of unmanned craft use sophisticated aural and camera sensors to project the vessel's vicinity to shore-based remote controller; and that this arguably satisfies the Rule 5 requirement with the requisite human input still firmly in the appraisal process in the sense that the use of an electronic aids does not take the arrangement outside of the spirit or wording of Rule 5. Neither does its shore-based orientation. However, I agree with the IWG that this is a point which must be clarified.

c. The Convention on Standards of Certification, Training and Watchkeeping (STCW), amongst other things, prescribes

qualification standards for masters, officers and watchkeeping personnel on board seagoing ships. It also deals with watchkeeping procedures. In terms of the STCW's watchkeeping requirements, Chapter VIII is titled "Standards regarding watchkeeping". Part 4, paragraph 10 (Watchkeeping at Sea) states *"when deciding the composition of the watch on the bridge … the following factors, inter alia, shall be taken into account"*. One of such listed factors includes "at no time shall the bridge be left unattended". In addition, paragraph 24 provides that *"the officer in charge of navigational watch shall…. keep the watch on the bridge…[and]…in no circumstances leave the bridge until properly relieved"*. Furthermore, paragraph 24.2 provides that the officer in charge of the navigational watch shall "*in no circumstances leave the bridge until properly relieved"*. As pointed out by the IWG, to the extent that the STCW Convention finds application, these provisions presents difficulty for unmanned ships.

44. These are just some of the difficult provisions in a few of the main Conventions. They are just a few examples – but they highlight the problems which exist with regard to the existing regulatory framework.

45. The challenge for all of us is what to do. How is the international regulatory framework to be updated and adapted to the new world of unmanned vessels?

46. The obvious solution would be to amend each and every Convention so that they all make sense with regard to unmanned vessels and make

proper provision with regard, in particular, to safety. In an ideal world, that probably makes the best sense.

47. However, to review each and every Convention line-by-line and produce appropriate amendments as necessary which would then have to be agreed at the international level by a host of countries and a number of NGOs each with different agendas would seem to be a gargantuan task. As a matter of practical reality that may well be impossible.

48. The alternative is to create some overarching instrument along the lines perhaps of the Polar Code which could address specifically the issue of unmanned vessels. I should immediately make plain that this is not my idea but one that has been suggested to me over the past few months. However, it seems to me that such suggestion has much to commend it and, as I understand, has wide support.

49. For example, the IWG has already identified a number of generic words and terms in each of the major Conventions which they have considered so far which need to be clarified. For example, almost all of the Conventions refer to the "master". It will have to be considered whether the term "master" extends to shore-based personnel and in either case how the regulations can be adapted so that they apply effectively to the reality of command and control being exercised by one or more individuals from the shore or another ship. These generic words/terms tend to be repeated in many of the Conventions and the IWG has suggested that it may be that an overriding instrument can provide a general application of these words across the Conventions without a need to make serial amendments to each Convention.

50. In my view, that is a good starting point. However, it seems to me that, at the very least, serious consideration should be given to a much broader project: the creation of a separate international Code that will apply specifically to unmanned vessels.

51. I recognize fully the burden of that task. It will require a huge amount of work by all concerned. But I am sure that it is a project which deserves the engagement of the CMI. And I am also sure that it is one which would have the full and enthusiastic support of Francesco Berlingieri in whose memory this Lecture is dedicated.