

**2024 MCM**  
**Problem B: Searching for Submersibles**



Maritime Cruises Mini-Submarines (MCMS), a company based in Greece, builds **submersibles** capable of carrying humans to the deepest parts of the ocean. A submersible is moved to the location and deployed untethered from a host ship. MCMS now wishes to use their submersible to take tourists on adventures exploring the bottom of the Ionian Sea for sunken shipwrecks. Before they can do this, however, they need to win approval from regulators by developing safety procedures in case of a loss of communication to the host ship and possible mechanical defects including a loss of propulsion of the submersible. In particular, they would like you to develop a model to predict the location of the submersible over time. Unlike in a typical search and rescue on land or on the surface of a sea, the defective submersible could potentially find itself positioned on the sea floor or at some point of **neutral buoyancy** underwater. Its position could further be affected by currents, differing densities in the sea, and/or the geography of the sea floor. Your tasks are to:

- **Locate** - Develop a model(s) that predicts the location of the submersible over time.
  - What are the uncertainties associated with these predictions?
  - What information can the submersible periodically send to the host ship to decrease these uncertainties prior to an incident? What kinds of equipment would the submersible need to do so?
- **Prepare** - What, if any, additional search equipment would you recommend the company carry on the host ship to deploy if necessary? You may consider different types of equipment but must also consider costs associated with availability, maintenance, readiness, and usage of this equipment. What additional equipment might a rescue vessel need to bring in to assist if necessary?
- **Search** - Develop a model that will use information from your location model(s) to recommend initial points of deployment and search patterns for the equipment so as to minimize the time to location of a lost submersible. Determine the probability of finding the submersible as a function of time and accumulated search results.
- **Extrapolate** - How might your model be expanded to account for other tourist destinations such as the Caribbean Sea? How will your model change to account for multiple submersibles moving in the same general vicinity?

Prepare a report of no more than 25 pages providing the details of your plan. Include a two-page memo of your report addressed to the Greek government to help win approval.

## 2024 MCM 问题 B: 寻找潜水器



Maritime Cruises Mini-Submarines (MCMS) 是一家总部位于希腊的公司，该公司建造的潜水器能够将人类运送到海洋的最深处。潜水器被移动到该位置，并不受主机的束缚。MCMS 现在希望使用他们的潜水器带领游客冒险探索爱奥尼亚海底部的沉船残骸。然而，在他们做到这一点之前，他们需要通过制定安全程序来获得监管机构的批准，以防与东道主失去通信以及可能的机械缺陷，包括潜水器的推进力损失。特别是，他们希望您开发一个模型来预测潜水器随时间推移的位置。与陆地或海面上的典型搜索和救援不同，有缺陷的潜水器可能会发现自己位于海底或水下中性浮力的某个点。它的位置可能进一步受到洋流、海洋密度和/或海底地理的影响。您的任务是：

- 定位 - 开发一个模型来预测潜水器随时间推移的位置。
  - 与这些预测相关的不确定性是什么？
  - 潜水器可以定期向主办船发送哪些信息，以在事故发生前减少这些不确定性？潜水器需要什么样的设备才能做到这一点？
- 准备 - 如有必要，您建议公司携带哪些额外的搜索设备在主机上部署？您可以考虑不同类型的设备，但也必须考虑与此设备的可用性、维护、准备和使用相关的成本。如有必要，救援船可能需要携带哪些额外设备来协助？
- 搜索 - 开发一个模型，该模型将使用来自您的位置模型的信息来推荐设备的初始部署点和搜索模式，以最大限度地减少丢失潜水器的位置时间。确定找到潜水器的概率作为时间和累积搜索结果的函数。
- 外推 - 如何扩展您的模型以考虑其他旅游目的地，例如加勒比海？您的模型将如何变化，以考虑在同一附近移动的多个潜水器？

准备一份不超过 25 页的报告，提供您的计划的详细信息。附上一份两页的备忘录，将您提交给希腊政府的报告，以帮助获得批准。

Your PDF solution of no more than 25 total pages should include:

- One-page Summary Sheet.
- Table of Contents.
- Your complete solution.
- Two-page memo.
- References list.
- [AI Use Report](#) (If used does not count toward the 25-page limit.)

**Note:** There is no specific required minimum page length for a complete MCM submission. You may use up to 25 total pages for all your solution work and any additional information you want to include (for example: drawings, diagrams, calculations, tables). Partial solutions are accepted. We permit the careful use of AI such as ChatGPT, although it is not necessary to create a solution to this problem. If you choose to utilize a generative AI, you must follow the [COMAP AI use policy](#). This will result in an additional AI use report that you must add to the end of your PDF solution file and does not count toward the 25 total page limit for your solution.

## Glossary

**Submersible:** A submersible is an underwater vehicle which needs to be transported and supported by a larger watercraft or platform. This distinguishes submersibles from submarines, which are self-supporting and capable of prolonged independent operation at sea.

**Neutral buoyancy** occurs when an object's average density is equal to the density of the fluid in which it is immersed, resulting in the buoyant force balancing the force of gravity that would otherwise cause the object to sink (if the body's density is greater than the density of the fluid in which it is immersed) or rise (if it is less). An object that has neutral buoyancy will neither sink nor rise.

总页数不超过 25 页的 PDF 解决方案应包括：

- 一页摘要表。
- 目录。
- 您的完整解决方案。
- 两页备忘录。
- 引用列表。
- AI 使用报告（如果使用不计入 25 页限制）。

注意：完整的 MCM 提交没有具体的最小页面长度要求。您最多可以使用 25 页来完成所有解决方案工作以及要包含的任何其他信息（例如：图纸、图表、计算、表格）。接受部分解决方案。我们允许谨慎使用 ChatGPT 等 AI，尽管没有必要为此问题创建解决方案。如果您选择使用生成式 AI，则必须遵循 COMAP AI 使用策略。这将导致一个额外的 AI 使用报告，您必须将其添加到 PDF 解决方案文件的末尾，并且不计入解决方案的 25 页总页数限制。

## 词汇表

**潜水器：**潜水器是一种水下航行器，需要由更大的船只或平台运输和支撑。这将潜水器与潜艇区分开来，潜艇是自支撑的，能够在海上长时间独立运行。

当物体的平均密度等于它所浸入的流体的密度时，就会发生中性浮力，导致浮力平衡重力，否则会导致物体下沉（如果物体的密度大于它所浸入的流体的密度）或上升（如果它较小）。具有中性浮力的物体既不会下沉也不会上升。

## Use of Large Language Models and Generative AI Tools in COMAP Contests

This policy is motivated by the rise of large language models (LLMs) and generative AI assisted technologies. The policy aims to provide greater transparency and guidance to teams, advisors, and judges. This policy applies to all aspects of student work, from research and development of models (including code creation) to the written report. Since these emerging technologies are quickly evolving, COMAP will refine this policy as appropriate.

Teams must be open and honest about all their uses of AI tools. The more transparent a team and its submission are, the more likely it is that their work can be fully trusted, appreciated, and correctly used by others. These disclosures aid in understanding the development of intellectual work and in the proper acknowledgement of contributions. Without open and clear citations and references of the role of AI tools, it is more likely that questionable passages and work could be identified as plagiarism and disqualified.

Solving the problems does not require the use of AI tools, although their responsible use is permitted. COMAP recognizes the value of LLMs and generative AI as productivity tools that can help teams in preparing their submission; to generate initial ideas for a structure, for example, or when summarizing, paraphrasing, language polishing etc. There are many tasks in model development where human creativity and teamwork is essential, and where a reliance on AI tools introduces risks. Therefore, we advise caution when using these technologies for tasks such as model selection and building, assisting in the creation of code, interpreting data and results of models, and drawing scientific conclusions.

It is important to note that LLMs and generative AI have limitations and are unable to replace human creativity and critical thinking. COMAP advises teams to be aware of these risks if they choose to use LLMs:

- **Objectivity:** Previously published content containing racist, sexist, or other biases can arise in LLM-generated text, and some important viewpoints may not be represented.
- **Accuracy:** LLMs can ‘hallucinate’ i.e. generate false content, especially when used outside of their domain or when dealing with complex or ambiguous topics. They can generate content that is linguistically but not scientifically plausible, they can get facts wrong, and they have been shown to generate citations that don’t exist. Some LLMs are only trained on content published before a particular date and therefore present an incomplete picture.
- **Contextual understanding:** LLMs cannot apply human understanding to the context of a piece of text, especially when dealing with idiomatic expressions, sarcasm, humor, or metaphorical language. This can lead to errors or misinterpretations in the generated content.
- **Training data:** LLMs require a large amount of high-quality training data to achieve optimal performance. In some domains or languages, however, such data may not be readily available, thus limiting the usefulness of any output.

## 在COMAP竞赛中使用大型语言模型和生成式AI工具

这项政策的动机是大型语言模型（LLMs）和生成式人工智能辅助技术的兴起。该政策旨在为团队、顾问和评委提供更大的透明度和指导。本政策适用于学生工作的各个方面，从模型的研究和开发（包括代码创建）到书面报告。由于这些新兴技术正在迅速发展，COMAP将酌情完善这一政策。

团队必须对他们使用 AI 工具的所有情况开诚布公。一个团队及其提交越透明，他们的工作就越有可能被其他人完全信任、欣赏和正确使用。这些披露有助于理解智力工作的发展和对贡献的正确承认。如果没有对人工智能工具的作用进行公开和明确的引用和参考，有问题的段落和作品更有可能被认定为抄袭并被取消资格。

解决问题不需要使用人工智能工具，尽管允许负责任地使用它们。COMAP认识到生成式人工智能作为生产力工具的价值LLMs，可以帮助团队准备提交;例如，在总结、释义、语言润色等时，为结构产生初步想法。在模型开发中，有许多任务需要人类的创造力和团队合作，而依赖人工智能工具会带来风险。因此，我们建议在将这些技术用于模型选择和构建、协助创建代码、解释模型的数据和结果以及得出科学结论等任务时要谨慎。

需要注意的是，LLMs生成式人工智能有局限性，无法取代人类的创造力和批判性思维。COMAP建议团队在选择使用LLMs以下方法时注意这些风险：

- **客观性：**以前发布的内容包含种族主义、性别歧视或其他偏见可能会出现在生成的文本中LLM，并且可能无法代表一些重要的观点。
- **准确性：**LLMs可以“产生幻觉”，即产生虚假内容，尤其是在其领域之外使用或处理复杂或模棱两可的主题时。他们可以生成在语言上但在科学上不合理的内容，他们可能会弄错事实，并且它们已被证明可以生成不存在的引文。有些人LLMs只接受过特定日期之前发布的内容的培训，因此呈现出不完整的画面。
- **语境理解：**LLMs不能将人类的理解应用于一段文本的上下文，尤其是在处理惯用语、讽刺、幽默或隐喻语言时。这可能会导致生成的内容出现错误或误解。
- **训练数据：**LLMs需要大量高质量的训练数据才能达到最佳性能。然而，在某些领域或语言中，这些数据可能不容易获得，从而限制了任何输出的有用性。

## Guidance for teams

Teams are required to:

1. **Clearly indicate the use of LLMs or other AI tools in their report**, including which model was used and for what purpose. Please use inline citations and the reference section. Also append the Report on Use of AI (described below) after your 25-page solution.
2. **Verify the accuracy, validity, and appropriateness** of the content and any citations generated by language models and correct any errors or inconsistencies.
3. **Provide citation and references, following guidance provided here.** Double-check citations to ensure they are accurate and are properly referenced.
4. **Be conscious of the potential for plagiarism** since LLMs may reproduce substantial text from other sources. Check the original sources to be sure you are not plagiarizing someone else's work.

**COMAP will take appropriate action  
when we identify submissions likely prepared with  
undisclosed use of such tools.**

## Citation and Referencing Directions

Think carefully about how to document and reference whatever tools the team may choose to use. A variety of style guides are beginning to incorporate policies for the citation and referencing of AI tools. Use inline citations and list all AI tools used in the reference section of your 25-page solution.

Whether or not a team chooses to use AI tools, the main solution report is still limited to 25 pages. If a team chooses to utilize AI, following the end of your report, add a new section titled Report on Use of AI. This new section has no page limit and will not be counted as part of the 25-page solution.

Examples (this is *not* exhaustive – adapt these examples to your situation):

### **Report on Use of AI**

1. OpenAI *ChatGPT* (Nov 5, 2023 version, ChatGPT-4)  
Query1: *<insert the exact wording you input into the AI tool>*  
Output: *<insert the complete output from the AI tool>*
2. OpenAI *Ernie* (Nov 5, 2023 version, Ernie 4.0)  
Query1: *<insert the exact wording of any subsequent input into the AI tool>*  
Output: *<insert the complete output from the second query>*
3. Github *CoPilot* (Feb 3, 2024 version)  
Query1: *<insert the exact wording you input into the AI tool>*  
Output: *<insert the complete output from the AI tool>*
4. Google *Bard* (Feb 2, 2024 version)  
Query: *<insert the exact wording of your query>*  
Output: *<insert the complete output from the AI tool>*

## 团队指南

### 团队必须：

1. 在报告中明确指出人工智能工具的使用LLMs或其他工具，包括：  
使用了模型以及用于什么目的。请使用内联引文和参考文献部分。此外，在 25 页的解决方案后附加 AI 使用报告（如下所述）。
2. 验证内容的准确性、有效性和适当性以及语言模型生成的任何引用，并纠正任何错误或不一致之处。
3. 按照此处提供的指导提供引文和参考文献。仔细检查引文，确保它们准确无误并被正确引用。
4. 请注意抄袭的可能性，因为LLMs可能会复制大量文本  
来自其他来源。检查原始来源以确保您没有剽窃他人的作品。

当我们发现可能使用此类工具未公开使用此类工具准备的提交内容时，COMAP将采取适当的行动。

## 引文和参考文献说明

仔细考虑如何记录和引用团队可能选择使用的任何工具。各种风格指南开始纳入引用和引用人工智能工具的政策。使用内联引文，并列出 25 页解决方案的参考部分中使用的所有 AI 工具。

无论团队是否选择使用 AI 工具，主要解决方案报告仍限制在 25 页以内。如果团队选择使用 AI，请在报告末尾添加标题为“AI 使用报告”的新部分。此新部分没有页数限制，不会计为 25 页解决方案的一部分。

示例（这并非详尽无遗 - 请根据您的情况调整这些示例）：

### 人工智能使用报告

1. OpenAI ChatGPT（2023年11月5日版，ChatGPT-4）  
Query1: <插入您在 AI 工具中输入的确切措辞>输出: <插入 AI 工具的完整输出>
2. OpenAI Ernie（2023 年 11 月 5 日版，Ernie 4.0）  
Query1: <将任何后续输入的确切措辞插入 AI 工具>输出: <插入第二个查询的完整输出>
3. Github CoPilot（2024 年 2 月 3 日版）  
Query1: <插入您在 AI 工具中输入的确切措辞>输出: <插入 AI 工具的完整输出>
4. Google Bard（2024年2月2日版）  
查询: <插入查询的确切措辞>输出: <插入 AI 工具的完整输出>