**PROBLEM A:** **Managing The Zambezi River**

The Kariba Dam on the Zambezi River is one of the larger dams in Africa. Its construction was controversial, and a 2015 report by the Institute of Risk Management of South Africa included a warning that the dam is in dire need of maintenance. A number of options are available to the Zambezi River Authority (ZRA) that might address the situation. Three options in particular are of interest to ZRA:

(Option 1) Repairing the existing Kariba Dam, (Option 2) Rebuilding the existing Kariba Dam, or (Option 3) Removing the Kariba Dam and replacing it with a series of ten to twenty smaller dams along the Zambezi River.

There are two main requirements for this problem:

Requirement 1 ZRA management requires a brief assessment of the three options listed, with sufficient detail to provide an overview of potential costs and benefits associated with each option. This requirement should not exceed two pages in length, and must be provided in addition to your main report.

Requirement 2 Provide a detailed analysis of Option (3) - removing the Kariba Dam and replacing it with a series of ten to twenty smaller dams along the Zambezi river. This new system of dams should have the same overall water management capabilities as the existing Kariba Dam while providing the same or greater levels of protection and water management options for Lake Kariba that are in place with the existing dam. Your analysis must support a recommendation as to the number and placement of the new dams along the Zambezi River.

In your report for Requirement 2, you should include a strategy for modulating the water flow through your new multiple dam system that provides a reasonable balance between safety and costs. In addition to addressing known or predicted normal water cycles, your strategy should provide guidance to the ZRA managers that explains and justifies the actions that should be taken to properly handle emergency water flow situations (i.e. flooding and/or prolonged low water conditions). Your strategy should provide specific guidance for extreme water flows ranging from maximum expected discharges to minimum expected discharges. Finally, your recommended strategy should include information addressing any restrictions regarding the locations and lengths of time that different areas of the Zambezi River should be exposed to the most detrimental effects of the extreme conditions.

Your MCM submission should consist of three elements: a standard 1 page MCM Summary Sheet, a 1-2 page brief assessment report (Requirement 1), and your main MCM solution (Requirement 2) not to exceed 20 pages for a maximum submission of 23 pages. Note: Any appendices or reference pages you include will not count towards the 23 page limit.

**A题中文翻译：**

问题A：管理赞比西河

赞比西河上的卡里巴水坝是非洲较大的水坝之一。它的建设是有争议的，南非风险管理研究所的2015年报告包括一个警告，大坝是急需维护。赞比西河管理局（ZRA）可提供若干选择，以解决这一问题。 ZRA特别感兴趣的有三个选项：

（选项1）修复现有的Kariba水坝（选项2）重建现有的Kariba水坝，或（选项3）拆除Kariba水坝，并更换为沿赞比西河的一系列十到二十个较小的水坝。

这个问题有两个主要要求：

要求1 ZRA管理要求对所列出的三个选项进行简要评估，并提供足够的详细信息，以提供与每个选项相关的潜在成本和收益的概述。此要求的长度不应超过两页，除了主要报告之外，还必须提供此页面。

要求2对选项（3）进行详细分析 - 删除Kariba水坝，并用赞比西河沿岸一系列十至二十个较小的水坝替代。这个新的水坝系统应该与现有的Kariba水坝具有相同的整体水管理能力，同时为现有的水坝提供与卡里巴湖相同或更高水平的保护和水管理选择。您的分析必须支持关于沿赞比西河新坝的数量和位置的建议。

在您的要求2报告中，您应该包括一个策略，用于调节通过您的新多坝系统的水流，从而在安全和成本之间提供合理的平衡。除了解决已知或预测的正常水循环，您的战略应为ZRA经理提供指导，解释和证明应当采取的行动，以正确处理应急水流情况（即洪水和/或长期低水位状况）。您的策略应为从最大预期排放到最小预期排放的极端水流提供具体指导。最后，您的建议战略应包括解决对赞比西河不同地区暴露于极端条件最有害影响的位置和时间长度的任何限制的信息。

您的MCM提交应包括三个要素：标准的1页MCM摘要表，1-2页简要评估报告（要求1）和您的主要MCM解决方案（要求2）不超过20页，最多提交23页面。注意：您加入的任何附录或参考页面不会计入23页的上限。

**PROBLEM B:** **Merge After Toll**

Multi-lane divided limited-access toll highways use “ramp tolls” and “barrier tolls” to collect tolls from motorists. A ramp toll is a collection mechanism at an entrance or exit ramp to the highway and these do not concern us here. A barrier toll is a row of tollbooths placed across the highway, perpendicular to the direction of traffic flow. There are usually (always) more tollbooths than there are incoming lanes of traffic (see former 2005 MCM Problem B). So when exiting the tollbooths in a barrier toll, vehicles must “fan in” from the larger number of tollbooth egress lanes to the smaller number of regular travel lanes. A toll plaza is the area of the highway needed to facilitate the barrier toll, consisting of the fan-out area before the barrier toll, the toll barrier itself, and the fan-in area after the toll barrier. For example, a three-lane highway (one direction) may use 8 tollbooths in a barrier toll. After paying toll, the vehicles continue on their journey on a highway having the same number of lanes as had entered the toll plaza (three, in this example).

Consider a toll highway having L lanes of travel in each direction and a barrier toll containing B tollbooths (B > L) in each direction. Determine the shape, size, and merging pattern of the area following the toll barrier in which vehicles fan in from B tollbooth egress lanes down to L lanes of traffic. Important considerations to incorporate in your model include accident prevention, throughput (number of vehicles per hour passing the point where the end of the plaza joins the L outgoing traffic lanes), and cost (land and road construction are expensive). In particular, this problem does not ask for merely a performance analysis of any particular toll plaza design that may already be implemented. The point is to determine if there are better solutions (shape, size, and merging pattern) than any in common use.

Determine the performance of your solution in light and heavy traffic. How does your solution change as more autonomous (self-driving) vehicles are added to the traffic mix? How is your solution affected by the proportions of conventional (human-staffed) tollbooths, exact-change (automated) tollbooths, and electronic toll collection booths (such as electronic toll collection via a transponder in the vehicle)?

Your MCM submission should consist of a 1 page Summary Sheet, a 1-2 page letter to the New Jersey Turnpike Authority, and your solution (not to exceed 20 pages) for a maximum of 23 pages. Note: The appendix and references do not count toward the 23 page limit.

**B题中文翻译：**

问题B：收费后合并

高速路的收费站会通过"匝道收费"和"过卡收费"两种方式来收取驾驶员的高速费。匣道收费是一种在入口和出口的回道处设立的收费站，但是今天这个不在我们的讨论范围之列。过卡收费是一排垂直高速路行驶方向设立的的许多收费窗口。而这些收费窗口通常都会比车道条数要多(详情参见2005 年MCM的B题)。因此，当汽车驶出收费站之后，车流必须从较宽的收费站出口呈扇形快速并入车道较少的常规机动车道。收费广场是为改善过卡之后的拥堵状况建立的，包括收费站之前多车道区域，收费站本身以及经过收费站之后的扇入区域。举个例子，一条单向的三车道高速路需要8个收费窗口，在支付过桥费后，驾驶员可以继续保持与自己进收费广场之前的相同数量的车道（在该示例中为三个）的高速公路上继续行驶。

试考虑一个收费高速公路上两个方向都有L条车道，每个方向上有B个收费站(B>L), 请确定你设计的收费区域的形状，大小以及当汽车从驶出B时如何将车道进行合并至L条车道。

在你的设计中请注明一些重要事项如事故预防， 吞吐量(即每小时有多少车辆从收费广场驶出，驶入L条车道。)成本(土地和公路建设的费用很昂贵) ，重点在于并非只是对现有的收费广场进行性能分析，请试着探索是否有比现今采用的更好的收费解决方案(包括形状，大小以及收费方式)。

请确定你的解决方案在小车流量和大车流量下的性能表现。随着更多的私家(自驾)车进入其中，你的解决方案会有什么改变昵?你的解决方案会如何影响常规收费站(需要人员进行收费) ，不找零(自动化的)收费站以及电于收费站的比例(比如通过车内的发射器应答器来收取费用) ?

您的MCM提交应包括1页摘要表，1-2页给新泽西州收费公路管理局的信件，以及您的解决方案（不超过20页），最多23页。注意：附录和参考文献不计入23页的限制。

**PROBLEM C:“Cooperate and navigate”**

Traffic capacity is limited in many regions of the United States due to the number of lanes of roads.

For example, in the Greater Seattle area drivers experience long delays during peak traffic hours

because the volume of traffic exceeds the designed capacity of the road networks. This is particularly

pronounced on Interstates 5, 90, and 405, as well as State Route 520, the roads of particular interest

for this problem.

Self-driving, cooperating cars have been proposed as a solution to increase capacity of highways

without increasing number of lanes or roads. The behavior of these cars interacting with the existing

traffic flow and each other is not well understood at this point.

The Governor of the state of Washington has asked for analysis of the effects of allowing self-driving,

cooperating cars on the roads listed above in Thurston, Pierce, King, and Snohomish counties. (See

the provided map and Excel spreadsheet). In particular, how do the effects change as the

percentage of self-driving cars increases from 10% to 50% to 90%? Do equilibria exist? Is there a

tipping point where performance changes markedly? Under what conditions, if any, should lanes be

dedicated to these cars? Does your analysis of your model suggest any other policy changes?

Your answer should include a model of the effects on traffic flow of the number of lanes, peak and/or

average traffic volume, and percentage of vehicles using self-driving, cooperating systems. Your

model should address cooperation between self-driving cars as well as the interaction between selfdriving

and non-self-driving vehicles. Your model should then be applied to the data for the roads of

interest, provided in the attached Excel spreadsheet.

Your MCM submission should consist of a 1 page Summary Sheet, a 1-2 page letter to the

Governor’s office, and your solution (not to exceed 20 pages) for a maximum of 23 pages. Note: The

appendix and references do not count toward the 23 page limit.

Some useful background information:

 On average, 8% of the daily traffic volume occurs during peak travel hours.

 The nominal speed limit for all these roads is 60 miles per hour.

 Mileposts are numbered from south to north, and west to east.

 Lane widths are the standard 12 feet.

 Highway 90 is classified as a state route until it intersects Interstate 5.

 In case of any conflict between the data provided in this problem and any other source, use the

data provided in this problem.

Definitions:

milepost: A marker on the road that measures distance in miles from either the start of the route or a

state boundary.

average daily traffic: The average number of cars per day driving on the road.

interstate: A limited access highway, part of a national system.

state route: A state highway that may or may not be limited access.

route ID: The number of the highway.

increasing direction: Northbound for N-S roads, Eastbound for E-W roads.

decreasing direction: Southbound for N-S roads, Westbound for E-W roads.

**C题中文翻译：**

问题C：“合作和导航”

由于道路的数量，美国许多地区的交通容量有限。

例如，在大西雅图地区，司机在交通高峰时段遇到长时间的延误

因为交通量超过了道路网络的设计容量。这是特别

在州际公路5号，90号和405号以及州道路520号，特别感兴趣的道路上发布

对于这个问题。

自动驾驶，合作车已被提出作为增加公路容量的解决方案

而不增加车道或道路的数量。这些汽车的行为与现有的交互

交通流和对方在这一点上还不太了解。

华盛顿州州长要求分析允许自驾的影响，

在Thurston，Pierce，King和Snohomish县上列的道路上合作汽车。 （看到

提供的地图和Excel电子表格）。特别是，效果如何改变

自驾车的百分比从10％增加到50％到90％？是否存在平衡？有没有

性能变化明显的倾翻点？在什么条件下，如果有的话，应该有车道

专用于这些车？您对模型的分析是否表明有任何其他政策变化？

您的答案应包括对车道数量，峰值和/或车道数量的影响的模型

平均交通量，以及使用自动驾驶，合作系统的车辆的百分比。你的

模型应该解决自驾车之间的合作以及自驱动车之间的相互作用

和非自驾车辆。您的模型应该应用于的道路的数据

利息，在附加的Excel电子表格中提供。

您的MCM提交应包含1页的摘要表，1 - 2页的信

总督办公室和您的解决方案（不超过20页），最多23页。注意：

附录和参考文献不计入23页的限制。

一些有用的背景信息：

平均而言，每日交通量的8％发生在高峰旅行时间。

所有这些道路的名义速度限制为每小时60英里。

里程数从南到北，从西到东。

车道宽度是标准的12英尺。

高速公路90被分类为状态路线，直到它与州际5相交。

如果此问题中提供的数据与任何其他来源之间存在冲突，请使用

这个问题提供的数据。

定义：

milepost：在路上测量距离，从路线的起点或a

状态边界。

平均每日交通量：在道路上行驶的平均每天的汽车数量。

州际公路：作为国家系统的一部分的有限进出高速公路。

国家路线：可能受限或不受限制的国家公路。

路由ID：高速公路的编号。

增加方向：N-S道北行，E-W道东行。

下降方向：N-S道南行，E-W道西行。

**PROBLEM E:** **Sustainable Cities Needed!**

Background:

Many communities are implementing smart growth initiatives in an effort to consider long range, sustainable planning goals. “Smart growth is about helping every town and city become a more economically prosperous, socially equitable, and environmentally sustainable place to live.”[2] Smart growth focuses on building cities that embrace the E’s of sustainability—Economically prosperous, socially Equitable, and Environmentally Sustainable. This task is more important than ever because the world is rapidly urbanizing. It is projected that by 2050, 66 percent of the world’s population will be urban—this will result in a projected 2.5 billion people being added to the urban population.[3] Consequently, urban planning has become increasingly important and necessary to ensure that people have access to equitable and sustainable homes, resources and jobs.

Smart growth is an urban planning theory that originated in 1990’s as a means to curb continued urban sprawl and reduce the loss of farmland surrounding urban centers. The ten principles for smart growth are[4]

1 Mix land uses

2 Take advantage of compact building design

3 Create a range of housing opportunities and choices

4 Create walkable neighborhoods

5 Foster distinctive, attractive communities with a strong sense of place

6 Preserve open space, farmland, natural beauty, and critical environmental areas

7 Strengthen and direct development towards existing communities

8 Provide a variety of transportation choices

9 Make development decisions predictable, fair, and cost effective

10 Encourage community and stakeholder collaboration in development decisions

These broad principles must be tailored to a community’s unique needs to be effective. Thus, any measure of success must incorporate the demographics, growth needs, and geographical conditions of a city as well as the goal to adhere to the three E’s.

Tasks:

The International City Management Group (ICM) needs your help implementing smart growth theories into city design around the world. Select two mid-sized cities (any city with a population of between 100,000 and 500,000 persons), on two different continents.

1.Define a metric to measure the success of smart growth of a city. It shouldconsider the three E’s of sustainability and/or the 10 principles of smart growth.

2.Research the current growth plan of the selected cities. Measure and discusshow the current growth plan of each city meets the smart growth principles. Howsuccessful are the current plans according to your metric?

3.Using smart growth principles develop a growth plan for both cities over the nextfew decades. Support why you chose the components and initiatives of yourplans based on the geography, expected growth rates, and economicopportunities of your cities. Use your metric to evaluate the success of yoursmart growth plans.

4.Also using your metric, rank the individual initiatives within your redesigned smartgrowth plan as the most potential to the least potential. Compare and contrastthe initiatives and their ranking between the two cities.

5.Suppose the population of each city will increase by an additional 50% by 2050,explain in what way(s) your plan supports this level of growth?

Your ICM submission should consist of a 1 page Summary Sheet and your solution cannot exceed 20 pages for a maximum of 21 pages. Note: The appendix and references do not count toward the 20 page limit.

References:

[1] Smart Growth: Improving lives by improving communities. https://smartgrowthamerica.org/

[2] EPA, “This is Smart Growth.” 2016

https://www.epa.gov/smartgrowth/smart-growth-publication[3] World Urbanization Prospects. United Nations. 2014. https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf

[4] EPA, “Smart Growth: A Guide to Developing and Implementing Greenhouse Gas Reductions Programs.” 2011. http://www.sustainablecitiesinstitute.org/Documents/SCI/Report\_Guide/Guide\_EPA\_SmartGrowthGHGReduction\_2011.pdf

[5] Duany, Andres, Jeff Speck and Mike Lydon. The Smart Growth Manual. McGraw-Hill. 2010.

**E题中文翻译：**

问题E：需要可持续城市！

背景：

为了考虑和达到长期的可持续稳定发展的规划目标，许多社区正在实施智能化的初步增长计划。“智能化的增长会帮助每一个小镇和城市的经济变得更加繁荣，社会更加平等，变成从环境上来说更加适合可持续性稳定发展的居住地”。[2] 智能化增长侧重于城市建设，尤其注重可持续发展的经济体：经济繁荣，社会平等，和环境可持续性。 对于现在来说，这个任务比以往都重要，因为这个世界正在迅速地城市化。 预计到2050年，城市人口将达到世界总人口的66%，也就是说这将导致25亿人口会加入世界城市人口。[3] 因此城市建设变得越来越重要和必要，以确保人们有社会平等和和持续性发展的家园，资源，和工作机会。

智能化增长是一种起源于上个世纪90年代的城市规划理论。它的目标是遏制城市的持续蔓延以及以城市为中心的周边农田的流失和减少。智能化增长的十大原则是[4]

. 1 混合搭配土地的用途

. 2 最大化利用紧凑的建筑设计

. 3 创造更多的住房机会和选择

. 4 创造步行街道

. 5 培养独特，有吸引力，和具有强烈当地地方感的社区

. 6 保留开放空间，农田，自然景观，以及关键的环境地带

. 7 加强和领导对于现有社区的发展

. 8 提供多种交通工具的选择

. 9 使得开发决策的结果可预测，公平，具有较高性价比

. 10 鼓励社区和获利者在开发决策中的合作

这些广义的原则必须适应和满足每一个社区的特殊需求才会变得有效。因此，任何成功的衡量标准都必须包括一个城市的人口统计，增长需求和地理条件，以及严格遵守三个E的目标。

任务：

国际城市管理集团（ICM）需要你帮助他们实施智能化增长理论到世界各地的城市建设。 选择两个在不同洲的中型城市（人口在10万到50万的任何城市）。

1. 定义一个可以衡量城市智能化增长成功率的指标。请考虑并且结合到可持续性发展的三个E和、或智能化增长的是个原则。

2. 研究所选择城市的当前发展计划。衡量并讨论所选择城市当前的增长计划是如何遵从智能化增长的原则的。根据你的指标，分析一下当前的计划是否成功，成功的程度如何。

3. 使用智能化增长的原则为两个城市做一个在未来几十年里的增长计划。说明与解释你是如何根据城市的地理位置，预期增长率和经济机会来安排你的增长计划的。使用你以上的指标来评定一下这个增长计划的成功率。

4. 使用你的指标，把你重新设计的智能化增长计划中的每项计划从最具潜力到最不具潜力排一个名次。比较和对比这些和两个城市之间排名的关系。

5. 假设每个城市的人口在2050年会增长50%，解释一下你的计划会以什么样的方式来支持这种规模的成长。