**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。

附件

http://blog.sciencenet.cn/static/ueditor/dialogs/attachment/fileTypeImages/icon_default.png[2017\_MCM\_Problem\_C\_Data.xlsx](http://blog.sciencenet.cn/home.php?mod=attachment&filename=2017_MCM_Problem_C_Data.xlsx&id=94053)

http://blog.sciencenet.cn/static/ueditor/dialogs/attachment/fileTypeImages/icon_default.png[2017\_MCM\_Problem\_C\_Map.pdf](http://blog.sciencenet.cn/home.php?mod=attachment&filename=2017_MCM_Problem_C_Map.pdf&id=94054)

**C题重要提示：**

**The 2016 MCM introduces a new modeling challenge – Problem C - that is best described asData Insights. Problem C is intended to focus on and amplify specific elements of mathematicalmodeling challenges associated with data. In this sense, techniques stemming from statistics andpattern classification will play a larger role in creating a mathematical model on this problem than in previous contests.**

**While not a ‘big data’ challenge in the sense of teams needing to develop specialized computerscience-based data handling algorithms and analysis techniques or have access to highperformance computing platforms, the problem will provide teams with an opportunity toencounter real-world, challenging data that have interesting characteristics. Naturally occurringcomplicating factors such as data set size (but not big data), blend of data types, breadth ofrepresentation in data elements, cross-discipline sources, time series dependencies, censored ormissing data, and others could present themselves depending on the specifics of the modelingproblem.**

**MCM Problem C: Data Insights**

**Teams will be given access to database files that will be made available from a publicwebsite.**

**The database files will be compressed for size but the file size could still be 100mbs ormore and teams should take this into consideration prior to choosing Problem C.**

**Each zipped file may include the database files along with the data dictionary, datamapping file, and program code to create value labels.**

**The database will be made available in multiple formats SAS, SPSS, STATA and CSV.**

**Software such as Statistica, JMP, SAS, SPSS, Excel, R, Matlab or other applications maybe used to aid in your solution but no one particular piece of software is endorsed orrequired. If specialized software or custom code is used to support the contest effort,teams should take care to clearly communicate an understanding of the mathematics andassumptions applied via tools and algorithms in the software.**

**When submitting your final electronic solution you are NOT required to submit back thedatabase file or any data for that matter. The only thing that should be submitted is yourelectronic (word or PDF) solution.**

**PROBLEM D: Optimizing the Passenger Throughput at an Airport Security Checkpoint**

Following the terrorist attacks in the US on September 11, 2001, airport security has been significantly enhanced throughout the world. Airports have security checkpoints, where passengers and their baggage are screened for explosives and other dangerous items. The goals of these security measures are to prevent passengers from hijacking or destroying aircraft and to keep all passengers safe during their travel. However, airlines have a vested interest in maintaining a positive flying experience for passengers by minimizing the time they spend waiting in line at a security checkpoint and waiting for their flight. Therefore, there is a tension between desires to maximize security while minimizing inconvenience to passengers.

During 2016, the U.S. Transportation Security Agency (TSA) came under sharp criticism for extremely long lines, in particular at Chicago’s O’Hare international airport. Following this public attention, the TSA invested in several modifications to their checkpoint equipment and procedures and increased staffing in the more highly congested airports. While these modifications were somewhat successful in reducing waiting times, it is unclear how much cost the TSA incurred to implement the new measures and increase staffing. In addition to the issues at O’Hare, there have also been incidents of unexplained and unpredicted long lines at other airports, including airports that normally have short wait times. This high variance in checkpoint lines can be extremely costly to passengers as they decide between arriving unnecessarily early or potentially missing their scheduled flight. Numerous news articles, including [1,2,3,4,5], describe some of the issues associated with airport security checkpoints.

Your Internal Control Management (ICM) team has been contracted by the TSA to review airport security checkpoints and staffing to identify potential bottlenecks that disrupt passenger throughput. They are especially interested in creative solutions that both increase checkpoint throughput and reduce variance in wait time, all while maintaining the same standards of safety and security.

The current process for a US airport security checkpoint is displayed in Figure 1.

• Zone A:

o Passengers randomly arrive at the checkpoint and wait in a queue until a security officer can inspect their identification and boarding documents.

• Zone B:

o The passengers then move to a subsequent queue for an open screening line; depending on the anticipated activity level at the airport, more or less lines may be open.

o Once the passengers reach the front of this queue, they prepare all of their belongings for X-ray screening. Passengers must remove shoes, belts, jackets, metal objects, electronics, and containers with liquids, placing them in a bin to be X-rayed separately; laptops and some medical equipment also need to be removed from their bags and placed in a separate bin.

o All of their belongings, including the bins containing the aforementioned items, are moved by conveyor belt through an X-ray machine, where some items are flagged for additional search or screening by a security officer (Zone D).

o Meanwhile the passengers process through either a millimeter wave scanner or metal detector.

o Passengers that fail this step receive a pat-down inspection by a security officer (Zone D).

• Zone C:

o The passengers then proceed to the conveyor belt on the other side of the X-ray scanner to collect their belongings and depart the checkpoint area.

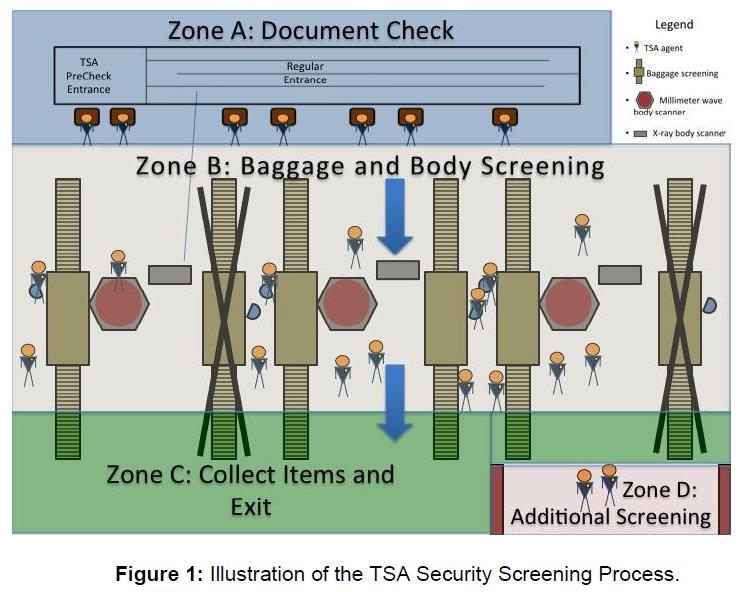


Figure 1: Illustration of the TSA Security Screening Process.

Approximately 45% of passengers enroll in a program called Pre-Check for trusted travelers. These passengers pay $85 to receive a background check and enjoy a separate screening process for five years. There is often one Pre-Check lane open for every three regular lanes, despite the fact that more passengers use the Pre-Check process. Pre-Check passengers and their bags go through the same screening process with a few modifications designed to expedite screening. Pre-Check passengers must still remove metal and electronic items for scanning as well as any liquids, but are not required to remove shoes, belts, or light jackets; they also do not need to remove their computers from their bags.

Data has been collected about how passengers proceed through each step of the security screening process. Click here to view the Excel data.

http://blog.sciencenet.cn/static/ueditor/dialogs/attachment/fileTypeImages/icon_default.png[2017\_ICM\_Problem\_D\_Data.xlsx](http://blog.sciencenet.cn/home.php?mod=attachment&filename=2017_ICM_Problem_D_Data.xlsx&id=94055)

Your specific tasks are:

a. Develop one or more model(s) that allow(s) you to explore the flow of passengers through a security check point and identify bottlenecks. Clearly identify where problem areas exist in the current process.

b. Develop two or more potential modifications to the current process to improve passenger throughput and reduce variance in wait time. Model these changes to demonstrate how your modifications impact the process.

c. It is well known that different parts of the world have their own cultural norms that shape the local rules of social interaction. Consider how these cultural norms might impact your model. For example, Americans are known for deeply respecting and prioritizing the personal space of others, and there is a social stigma against “cutting” in front of others. Meanwhile, the Swiss are known for their emphasis on collective efficiency, and the Chinese are known for prioritizing individual efficiency. Consider how cultural differences may impact the way in which passenger’s process through checkpoints as a sensitivity analysis. The cultural differences you apply to your sensitivity analysis can be based on real cultural differences, or you can simulate different traveler styles that are not associated with any particular culture (e.g., a slower traveler). How can the security system accommodate these differences in a manner that expedites passenger throughput and reduces variance?

d. Propose policy and procedural recommendations for the security managers based on your model. These policies may be globally applicable, or may be tailored for specific cultures and/or traveler types.

In addition to developing and implementing your model(s) to address this problem, your team should validate your model(s), assess strengths and weaknesses, and propose ideas for improvement (future work).

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] http://www.wsj.com/articles/why-tsa-security-lines-arent-as-bad-as-youd-feared-1469032116

[2] http://www.chicagotribune.com/news/ct-tsa-airport-security-lines-met-20160823-story.html

[3] http://www.cnn.com/2016/06/09/travel/tsa-security-line-wait-times-how-long/

[4] http://wgntv.com/2016/07/13/extremely-long-lines-reported-at-chicago-midway-airports-tsa-checkpoint/

[5] http://www.cnbc.com/2016/04/14/long-lines-and-missed-flights-fuel-criticism-of-tsa-screening.html

**D题中文翻译：**

问题D：在机场安全检查站优化乘客吞吐量

随着2001年9月11日美国恐怖袭击的发生，世界范围内的机场都极大地加强了安检力度。机场有安检口，用于扫描乘客以及他们的行李，检查是否有爆炸物及其他危险物品。这些安检措施的目标是为了防止乘客劫持或摧毁飞机，并保证所有乘客的旅途安全。但是，航空公司在通过最小化乘客排队安检以及等待飞机的时间使乘客拥有一个良好的飞行体验方面有着既定的利益。因此，加强安检的同时最小化给乘客带来不变的这个期望导致了一个紧张局面的产生。

2016年间，排长队的航线（尤其是在芝加哥奥黑尔国际机场的）受到了美国运输安全管理局（TSA)的强烈指责。随着公众关注度的提高，TSA投入了一定资金用于改进他们的安检设备及过程，并在更加拥挤的机场增派了员工。虽然这些改进有效地减少了等待时间，但是TSA执行这些新的措施、增加新员工付出的代价有多大仍未可知。除了奥黑尔机场的问题，其他机场（包括那些等待时间通常很短暂的机场）同样会产生原因不明、无法预测的长航线事故。排队安检队伍之间的差异对乘客来说代价可能会很大，因为他们不知道自己是到得过早了，还是很有可能错过自己的飞机。很多文章，包括[1和3,4,5]，都提到了与机场安检有关的问题。

TSA联系了你的内部控制管理团队（ICM)，为了确定分散客流量的可能瓶颈来审查机场安检口及员工。他们对既能增加安检口客流量又能减少等待时间之间的差异的创造性解决办法尤其感兴趣，这一切都在保证原有的安保标准的前提下进行。

美国安检口目前的流程如图1所示

• A区：

〇乘客随机抵达安检口并排队等待安检员检查他们的身份证与登机文件。

• B区：

〇乘客随机移动到下一个开放的检查队伍，根据机场的预计活动水平开放相应的队伍。

〇一旦乘客抵达队伍最前端，他们就要准备把自己的行李进行X光检查。乘客必须脱掉鞋子、皮带、夹克衫，拿出电子产品、液体容器并将他们放在一个箱子里进行单独的X光检查；手提电脑与某些医疗设备同样需要从包里拿出来并放在另一个箱子里。

〇乘客的所有物品，包括以上提到的放置在箱子里的物品，都由传送带移动通过一台X光仪器，某些物品被分拣出来另外检查或由安检员搜查。（D区）

〇与此同时乘客要经过一台微波扫描仪或是金属探测器。

〇未通过这一步骤的乘客会由安检员进行全身拍摸检查。

•C区：

将近45%的乘客注册了一个为可信赖乘客发起的称为预检的项目。这些乘客支付85美元接受背景调查，并享受为期五年的单独检查过程。一般每三个普通通道就会有一个预检通道，虽然使用预检流程的乘客较多。预检乘客和他们的行李通过的是一样的检查流程，只是在加快检查速度的设计上作出了一些改进。预检乘客同样需要移除电子与医疗设备及液体以待检查，但是无须脱下鞋子、皮带以及薄外套；他们同样不需要将电脑从包里取出来。

乘客通过安检流程的每一步的数据己经收集好了。点击此处查看Excel数据。你的具体任务是：

a.      研制一个或多个模型供你探讨通过安检口的客流量并确定瓶颈。清楚指出当前流程中存在哪些问题区域。

b. 为增大客流量、减少等待时间的差异研制出两个或多个可能的改进方法。将这些改变模型化以便说明你的改进是如何影响过程的。

c. 众所周知，世界上不同的地方具有不同的文化规范，塑造了社会互动的本地化规则。思考这些文化规范将会如何影响你的模型。比如，美国人以尊重及优先化他人的个人空间著称，并将插队视为社会耻辱。与此同时，瑞典人以对集体效率的强调著称，中国人以将个人效率置于首位著称。将文化差异可能会如何影响乘客安检的过程视为一个敏感性分析。在你的敏感性分析中使用的文化差异可以建立在真实的文化差异之上，你也可以不根据任何一个特定文化模拟不同旅行者的风格（例如，一个更慢的旅行者）。安检系统该如何在一定程度上适应这种不同，而且既能促进客流量又能减少时间差异呢？

d.基于你的模型对保安部经理提出与政策及过程相应的建议。这些政策既可以全球范围内适用的，也可以是为某种特定文化以及/或者某种类型的旅游者量身制定的。

除了研制与实施模型以解决这个问题，你的团队需要验证你们的模型，评估优势与劣势，并提出改进倡议（进一步的工作）。

您的ICM提交应包含1页的摘要表，您的解决方案不能超过20页，最多21页。注意：附录和参考文献不计入20页的限制。

**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。

您的ICM提交应包含1页的摘要表，您的解决方案不能超过20页，最多21页。注意：附录和参考文献不计入20页的限制。

**PROBLEM F: Migration to Mars: Utopian Workforce of the 2100 Urban Society**

The international agency, Laboratory of Interstellar Financial & Exploration Policy (LIFE), has recently (in this year of 2095) completed a series of short-term planned living experiments on our neighbor planet, Mars. New technologies, including personalized artificial augmentations units, will soon enable humans to inhabit manufactured cities on Mars by 2100. The first wave of migration, called Population Zero, will include 10,000 people.

The LIFE agency launched project UTOPIA: 2100, with the goal of creating an optimal workforce for the 22nd century to give all people the greatest quality of life with a vision of sustainability for the next 100 years. Over the last 20 years, several planned communities have been designed and built across Earth that tested several planned living conditions. These communities are driven by egalitarian principles in economics, government, workforce, and justice systems.

LIFE is seeking a set of mathematical and computational models that will inform the International Coalition on Mars (ICM) government on how to design an economic-workforce-education system that they can implement with Population Zero. In order to decide what procedure to follow, LIFE has hired the most qualified policy makers and data scientists with the goal to develop a set of policies to realize the migration to Mars. Your three-person policy modeling team is part of the group of advisors and policy makers. ICM has asked your group for a policy model and report that will result in a set of policy recommendations that will create a sustainable life-plan and will make the living experience on Mars in the year 2100 even better than the Earthly one in the current year of 2095.

New tools in network science, systems science, complex systems, organizational & industrial psychology, and other interdisciplinary fields provide new insights for understanding social and governmental systems, with important capabilities to deal with issues of scalability (relevant for both small and large populations and effects), modality (multiple layers), and dynamics (changes over time).

Population Zero aims to have optimal conditions in many workforce and social living factors (note that another team is being tasked with health policy, so ICM has asked that you exclude health care from your analysis). The mission of Population Zero is to create a sustainable society by maximizing both economic output (GDP) and happiness in the work place for its citizens. Of course, these two goals can be in opposition, so the policy recommendation has to consider balancing factors, such as:

● Income: Ensure adequate compensation so that all people can afford fundamental necessities (shelter, food, clothes).

● Education: Provide high quality education that prepares citizens for the needs and challenges of the 22nd Century.

● Equality: Improve the retention of women in the workforce, particularly in fields where they have been underrepresented or discriminated against on Earth.

Your ICM-directed tasks are:

1. Define parameters and specific outcomes related to the three priority factors (income, education, and social equality) in Population Zero. Some issues to consider are: a) minimum wage and salary distribution (income); b) skills required for an efficient workforce; types of governance and infrastructure needed to obtain these skills (education); and c) maternity and paternity leave, affordable childcare to ensure people can remain in the workforce (social equality).

a. Identify and define the specific outcomes that would indicate positive results across the three factors for the next decade (years 2100-2110). Consider what the goal is for each of these factors; for example, is the objective to improve the quality of living for all citizens or improve quantity of output of the system.

b. What are the major features of the population (eg. demographics, population size, and working conditions) that would contribute to these outcomes?

c. Create metrics that you will use to evaluate whether the system is meeting its objective by identifying and defining the critical parameters for each of the three factors.

2. You have been asked to generate a sample population of 10,000 people to emigrate to Mars. Extract data from a census dataset (link to one is provided below) or synthesize one.

a. From your data set, identify and analyze the demographic characteristics of this simulation of Population Zero. Analyze and describe demographic distributions, such as gender, ethnicity, age, and education levels.

b. Consider the distribution of citizens in terms of factors that will also help to meet goals of UTOPIA: 2100 – to build a peaceful, cooperative, egalitarian society. Are your data sufficient to determine these factors? For example, should the distribution of innovators versus producers be considered? Of skilled versus unskilled labor? Of families versus single people?

Link to PUMS data (if you desire to use this census data):

o PUMS data can be found via following links:

♣ http://www.census.gov/programs-surveys/acs/technical-documentation/pums.html

♣ http://www2.census.gov/programs-surveys/acs/data/pums/2015/1-Year/

o These links show how to extract the data in R:

♣ https://stat.ethz.ch/R-manual/R-devel/library/base/html/sample.html

♣ https://cran.r-project.org/web/packages/sampling/sampling.pdf

o This link show how to extract the data in MATLAB:

♣ https://www.mathworks.com/help/stats/datasample.html?requestedDomain=www.mathworks.com

3. Build a model that includes the three identified factors (income, education, & social equality). Using the parameters that you created in task 1, define the key elements of a successful society for the next 10 years. When integrating these three factors, what are the critical interdependencies among the parameters? Are there additional constraints required to preserve the outcomes over the 10 year period? How often should the model be evaluated to ensure the goals of UTOPIA 2100 continue to be met? What might be economic, social, cultural, and other global factors that might affect the viability of the model over that period? Based on these factors and constraints, answer the following:

a. Determine the optimal minimum wage and salary distribution to best manage the tension between wellbeing (higher quality of life) and support for those less equipped to provide labor services.

b. Identify terms in your model that can be most improved through contribution of new ideas. Describe the incentives to motivate contribution of those new ideas.

c. What is the best childcare and paternity/maternity leave strategies?

4. Now that you have created models for the three factors, proceed to merge these models into a global model. In task 3, you designed a model to provide optimal outcomes for society, at large. Now, consider how the model will function for different groups?

a. Identify the major subgroups of your workforce, and identify their main priorities. For example, unskilled labor force might be concerned with work hours, disability care, child care, and minimum wage, while the priorities of the professional workforce may be time off, training, and parental leave. Your model will dictate which subgroups you consider. You might have to develop new parameters to adequately evaluate each groups’ priorities.

b. With the understanding that each group will have a different set of needs, perspectives, and criteria for success, analyze how closely their needs are met in terms of income, education, and equality. For example, does your model function differently across educational levels? Different ages? Different cultural values? Does your model function better for women or men? How are families affected?

c. With the consideration of the subgroups that you have identified, your previous model may no longer produce optimal outcomes. Adjust the model by adding new constraints or parameters to optimize the needs of the different subgroups. The goal is to maximize the priority outcomes of the subgroups without significantly reducing the global outcomes.

5. LIFE has planned additional migration phased over the next 100-years.

a. How sensitive is your model to the population selection for various migration phases? Does the demographic distribution of this population significantly change the outcomes? How does your sampling procedure affect your model? If migration and growth in future years will be similar to Population Zero (10,000 people in a new manufactured city at a time), how would you change your model for the next few migrations? How sustainable are your recruitment and selection processes?

b. Is this long-term plan substantially different than the 10-year plan? Are there elements in your 10-year vision and recommendations that are not sustainable for the 100 year vision? Identify any new parameters or constraints that will ensure your model continues to be effective for the entire 22nd century.

6. In shocking news, scientists discover a threat of a collision of Earth with a planet sized comet. We need to evacuate planet Earth and move as many people as possible to Mars to live in enlarged manufactured cities.

a. Is your model still functional? Would it make a difference if migrations occurred in phases?

b. Study the robustness of your model and comment on its general sensitivity to a much larger scale migration.

c. State the strengths and weaknesses of your model relative to a major migration.

7. Write a policy recommendation addressed to the director of LIFE that includes the factors of income, education, equality policies based on your model and according to the directions of ICM. Will your recommendations change depending on the composition and size of the Population Zero? Explain the reasoning that led you to your recommendations and analyze the results you are expecting to achieve.

Your ICM submission should consist of a 1 page Summary Sheet, a 1-2 page policy recommendation, 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.

References:

https://www.kansascityfed.org/publications/community/transformworkforce

https://www.kansascityfed.org/~/media/files/publicat/community/workforce/transformingworkforcedevelopment/book/transformingworkforcedevelopmentpolicies.pdf

http://www.economist.com/blogs/freeexchange/2012/01/chinas-labour-force

**F题中文翻译：**

问题F：迁移到火星：2100城市社会的乌托邦劳动力

国际机构，星际金融与勘探政策实验室（LIFE），最近（在今年的2095年）完成了一系列短期计划的生活实验我们的邻居星球，火星。新技术，包括个性化人工增强单元，将很快使人类能够在2100年之前在火星上居住制造的城市。第一波移民潮叫做人口零，将包括10,000人。

LIFE代理机构启动了UTOPIA：2100项目，旨在为22世纪创造最佳员工队伍，为所有人提供最高质量的生活，并在未来100年实现可持续发展愿景。在过去20年里，几个计划的社区已经在地球上设计和建造，测试了几个计划的生活条件。这些社区由经济学，政府，劳动力和司法系统中的平等主义原则驱动。

LIFE正在寻求一套数学和计算模型，通知国际火星联盟（ICM）政府如何设计一个他们可以用零人口实施的经济劳动力教育系统。为了决定采用什么程序，LIFE聘请了最合格的决策者和数据科学家，目的是制定一套政策，实现向火星的迁移。您的三人政策建模小组是顾问和决策者小组的一部分。 ICM已要求您的小组制定一个政策模式和报告，这将产生一套政策建议，将创造一个可持续的生活计划，并将使火星在2100年的生活经验甚至比地球上的一年更好的2095。

网络科学，系统科学，复杂系统，组织和工业心理学以及其他跨学科领域的新工具为理解社会和政府系统提供了新的见解，具有处理可扩展性问题的重要能力（与小群体和大群体相关），模态（多层）和动态（随时间的变化）。

人口零旨在在许多劳动力和社会生活因素中获得最佳条件（注意另一个团队正在负责健康政策，因此ICM要求您从您的分析中排除医疗保健）。人口零的使命是通过最大限度地提高经济产出（GDP）和幸福来创造一个可持续的社会在其公民的工作地点。当然，这两个目标可能是相反的，因此政策建议必须考虑平衡因素，如：

●收入：确保适当的补偿，使所有人都能负担得起基本必需品（住所，食物，衣服）。

●教育：提供高质量的教育，使公民为22世纪的需要和挑战做好准备。

●平等：改善妇女在劳动力中的保留，特别是在她们在地球上代表不足或受到歧视的领域。

您的ICM定向任务是：

1.定义与人口零三个优先因素（收入，教育和社会平等）相关的参数和具体结果。需要考虑的一些问题是：a）最低工资和工资分配（收入）; b）高效劳动力所需的技能;获得这些技能所需的治理类型和基础设施（教育）;和c）产假和陪产假，负担得起的儿童保育，以确保人们能够留在劳动力（社会平等）。

一个。确定并定义将在未来十年（2100-2110年）的三个因素中显示出积极成果的具体结果。考虑每个因素的目标是什么;例如，目标是改善所有公民的生活质量或提高系统的产出数量。

b。人口的主要特征（例如人口统计，人口规模和工作条件）将有助于这些结果？

C。创建将用于通过识别和定义三个因素中的每一个的关键参数来评估系统是否满足其目标的度量。

2.你被要求生成一个10,000人的样本人口移民到火星。从人口普查数据集提取数据（链接到一个数据集在下面提供）或综合一个。

一个。从你的数据集中，识别和分析人口零模拟的人口统计特征。分析和描述人口分布，如性别，种族，年龄和教育水平。

b。考虑公民的因素分布，这也将有助于实现UTOPIA：2100 - 建立一个和平，合作，平等社会的目标。您的数据是否足以确定这些因素？例如，是否应考虑创新者与生产者的分配？熟练劳动与非熟练劳动？家庭与单身人士？

链接到PUMS数据（如果您希望使用此人口普查数据）：

o PUMS数据可以通过以下链接找到：

♣http://www.census.gov/programs-surveys/acs/technical-documentation/pums.html

♣http://www2.census.gov/programs-surveys/acs/data/pums/2015/1-Year/

o这些链接显示如何提取R中的数据：

♣https://stat.ethz.ch/R-manual/R-devel/library/base/html/sample.html

♣https://cran.r-project.org/web/packages/sampling/sampling.pdf

o此链接显示如何在MATLAB中提取数据：

♣https://www.mathworks.com/help/stats/datasample.html?requestedDomain=www.mathworks.com

3.建立一个包括三个确定因素（收入，教育和社会平等）的模型。使用您在任务1中创建的参数，定义未来10年成功社会的关键要素。当综合这三个因素时，参数之间的关键相互依存关系是什么？是否需要额外的限制来保持10年期间的结果？应该多久对模型进行评估，以确保继续满足UTOPIA 2100的目标？在这一时期可能影响模型的可行性的经济，社会，文化和其他全球性因素是什么？基于这些因素和约束，回答以下：

一个。确定最佳最低工资和工资分配，以最好地管理福利（更高的生活质量）和支持那些较不能提供劳动服务的人之间的紧张。

b。识别您的模型中可以通过新想法的贡献得到最大改进的术语。描述激励这些新想法的贡献的激励。

C。什么是最好的育儿和陪产假/产假策略？

4.现在您已经为三个因素创建了模型，继续将这些模型合并到全局模型中。在任务3中，您设计了一个模型，为整个社会提供最佳结果。现在，考虑该模型将如何为不同的组运行？

一个。确定你的员工的主要分组，并确定他们的主要优先事项。例如，非技术劳动力可能涉及工作时间，残疾照顾，儿童保育和最低工资，而专业人员的优先考虑可能是休假，培训和育儿假。您的模型将决定您考虑哪些子组。您可能需要开发新参数以充分评估每个组的优先级。

b。理解每个小组将有一套不同的需求，观点和成功标准，分析在收入，教育和平等方面满足他们的需求的程度。例如，您的模型在不同教育水平上的功能是否不同？不同年龄段？不同的文化价值观？你的模型对女性或男性是否更好？家庭如何受到影响？

C。考虑到您已确定的小组，您以前的模型可能不再产生最佳结果。通过添加新的约束或参数来调整模型，以优化不同子组的需求。目标是使子群体的优先成果最大化，而不会显着减少全球结果。

5. LIFE计划在未来100年内分阶段实施额外的迁移。

一个。您的模型对于各种迁移阶段的群体选择有多敏感？这个人口的人口分布是否会显着改变结果？你的抽样程序如何影响你的模型？如果未来几年的移民和增长将类似于人口零（一次在一个新的制造城市10,000人），你将如何改变您的模型为下几次迁移？你的招聘和选拔过程是否可持续？

b。这个长远计划与十年计划有很大不同吗？你的10年愿景和建议中有哪些元素对于100年愿景是不可持续的？识别任何新的参数或约束，以确保您的模型在整个22世纪继续有效。

6.在令人震惊的新闻中，科学家发现地球与行星尺寸彗星碰撞的威胁。我们需要疏散行星地球，并尽可能多的人移动到火星住在扩大的制造城市。

一个。您的模型是否仍然有效？如果迁移发生在阶段，它会有所不同吗？

b。研究您的模型的鲁棒性，并评论其对更大规模迁移的一般敏感性。

C。说明您的模型相对于主要迁移的优势和弱点。

7.写一份针对LIFE主任的政策建议，其中包括基于您的模型的收入，教育，平等政策等因素，并根据ICM的指示。你的建议会根据人口零的组成和规模而改变吗？解释推理，使您得到您的建议，并分析您期望实现的结果。

您的ICM提交应包括1页的摘要表，1-2页的政策建议和您的解决方案（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。