UK IMO team leader's report

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This year the International Mathematical Olympiad was held in Chiang Mai, Thailand. The IMO is the world championship of secondary school mathematics, and is held each July in a host country somewhere in the world. A modern IMO involves more than 100 countries, representing over 90% of the world's population. The competition was founded in 1959. Each participating country may send up to six team members, who must be under 20 years of age and not have entered university.

The UK Deputy Leader was Dominic Yeo of the University of Oxford, and our Observer C was Jill Parker, formerly of the University of Bath. Here is the UK IMO team of 2015.

Joe Benton	St Paul's School, Barnes, London
Lawrence Hollom	Churcher's College, Petersfield, Hampshire
Sam Kittle	Simon Langton Boys' Grammar School, Canterbury, Kent
Warren Li	Eton College, Windsor
Neel Nanda	Latymer School, Edmonton, London
Harvey Yau	Ysgol Dyffryn Taf, Carmarthenshire, Wales

The reserves were Liam Hughes of Robert Smyth Academy and Harry Metrebian of Winchester College.

Here are the results obtained by the UK students this year.

Name	P1	P2	P3	P4	P5	P6	Σ	award
Joe Benton	7	2	1	7	1	1	19	Silver
Lawrence Hollom	7	1	0	1	1	0	10	Honourable Mention
Sam Kittle	7	2	0	7	3	0	19	Silver
Warren Li	7	7	1	7	3	0	25	Silver
Neel Nanda	7	1	0	7	2	0	17	Bronze
Harvey Yau	7	2	1	7	2	0	19	Silver

There are three problems to address on each of two consecutive days. Each exam lasts 4 hours 30 minutes. The cut-offs were 14 for bronze, 19 for silver and 26 for gold. The current IMO marks format became stable in 1981. This is the

lowest gold cut, and the equal lowest silver cut, since then. This is evidence of the exceptional difficulty of this IMO, perhaps because of the technical complexity of the medium problems, numbers 2 and 5.

There were 104 teams participating at IMO 2015. Hearty congratulations to the USA for finishing ranked 1st, the first time that they have achieved this since 1994. However, this is the 15th time that they have achieved a top three result in that period, so this is an event which has been waiting to happen. It is very hard to beat a modern Chinese team in a fair fight, and the USA joins only the Republic of Korea and Russia in achieving this.

Here are a few of the leading scores (the nations gathering at least 80 points). 1 USA (185), 2 China (181), 3 Korea (161), 4 DPR Korea (156), 5 Vietnam (151), 6 Australia (148), 7 Iran (145), 8 Russia (141), 9 Canada (140), 10 Singapore (139), 11 Ukraine (135), 12 Thailand (134), 13 Romania (132), 14 France (120), 15 Croatia (119), 16 Peru (118), 17 Poland (117), 18 Taiwan (115), 19 Mexico (114), 20 Hungary, Turkey (113), 22 Brazil, Japan, United Kingdom (109), 25 Kazakhstan (105), 26 Armenia (104), 27 Germany (102), 28 Hong Kong (101), 29 Bulgaria, Indonesia, Italy, Serbia (100), 33 Bangladesh, Slovakia (97), 35 Macao (88), 36 Philippines (87), 37 India (86), 38 Moldova (85), 39 Belarus (84), 40 Israel (83), 41 Saudi Arabia (81), 42 Georgia (80)

Anglophone and Commonwealth interest in other scores might include 49 New Zealand (72), 55 South Africa (68), 57 Malaysia (66), 63 Cyprus (58), 70 Sri Lanka (51), 77 Ireland (37), 82 Trinidad and Tobago (26), 85 Pakistan (25), 88 Nigeria (22).

The inexperienced teams of Botswana, Ghana, Tanzania and Uganda also participated, and as one would expect, did not score heavily. Uganda were only one mark short of getting an honourable mention.

Here are the unusual prizewinners for 2015. The first country to have its rank higher than its score was Algeria. This very creditable performance included a silver medal, and left them only 8 marks behind South Africa. Thus South Africa's position as the traditional champion of Africa may be under threat in the next few years.

It has been a very good year for monarchies, with Australia leading the way in an astonishing 6th place, with Canada in 9th and Thailand in 12th. Australia's result is impressive, especially given their performance when training with the UK at our pre-IMO camp in Malaysia. The teams tied for the Mathematical Ashes, and seemed well-matched. However, Australia had a great IMO.

Luxembourg managed to retain the Grand Duchy title, and will keep their firm grip unless Finland or Lithuania revisits its constitutional heritage, or Baden, Mecklenburg-Strelitz or Holstein-Oldenburg breaks away from the Federal Republic of Germany.

Romania was the top member state of the European Union, one spot ahead of France which is the leading country which uses the euro (behind two countries which put Queen Elizabeth on their money: Australia and Canada). France is to be congratulated on finishing ranked above the UK for the time since 2002.

Syria achieved its first silver medal, and Montenegro its first bronze medal.

Trinidad and Tobago obtained only its second ever silver medal. My apologies if I have overlooked other singular achievements.

The Papers

Contestants have 4 hours 30 minutes to sit each paper. The three problems on each paper are each marked out of 7. It is intended that the three problems should be in increasing order of difficulty on each day.

Day 1

1. We say that a finite set $\mathcal{S}$ of points in the plane is *balanced* if, for any two different points A and B in $\mathcal{S}$, there is a point C in $\mathcal{S}$ such that $AC = BC$. We say that $\mathcal{S}$ is *centre-free* if for any three different points A, B and C in $\mathcal{S}$, there is no point P in $\mathcal{S}$ such that $PA = PB = PC$.

   (a) Show that for all integers $n \geqslant 3$, there exists a balanced set consisting of n points.

   (b) Determine all integers $n \geqslant 3$ for which there exists a balanced centre-free set consisting of n points.

2. Determine all triples (a, b, c) of positive integers such that each of the numbers
   $$ab - c, \quad bc - a, \quad ca - b$$
   is a power of 2.

   (*A power of 2 is an integer of the form 2^n, where n is a non-negative integer.*)

3. Let ABC be an acute triangle with $AB > AC$. Let Γ be its circumcircle, H its orthocentre, and F the foot of the altitude from A. Let M be the midpoint of BC. Let Q be the point on Γ such that $\angle HQA = 90°$, and let K be the point on Γ such that $\angle HKQ = 90°$. Assume that the points A, B, C, K and Q are all different, and lie on Γ in this order.

   Prove that the circumcircles of triangles KQH and FKM are tangent to each other.

Day 2

4. Triangle ABC has circumcircle Ω and circumcentre O. A circle Γ with centre A intersects the segment BC at points D and E, such that B, D, E and C are all different and lie on line BC in this order. Let F and G be the points of intersection of Γ and Ω, such that A, F, B, C and G lie on Ω in this order. Let K be the second point of intersection of the circumcircle of triangle BDF and the segment AB. Let L be the second

point of intersection of the circumcircle of triangle CGE and the segment CA.

Suppose that the lines FK and GL are different and intersect at the point X. Prove that X lies on the line AO.

5. Let $\mathbb{R}$ be the set of real numbers. Determine all functions $f \colon \mathbb{R} \to \mathbb{R}$ satisfying the equation

$$f(x + f(x + y)) + f(xy) \;=\; x + f(x + y) + yf(x)$$

for all real numbers x and y.

6. The sequence $a_1, a_2, \ldots$ of integers satisfies the following conditions:

   (i) $1 \leqslant a_j \leqslant 2015$ for all $j \geqslant 1$;
   (ii) $k + a_k \neq \ell + a_\ell$ for all $1 \leqslant k < \ell$.

Prove that there exist two positive integers b and N such that

$$\left| \sum_{j=m+1}^{n} (a_j - b) \right| \leqslant 1007^2$$

for all integers m and n satisfying $n > m \geqslant N$.

These questions were proposed to the IMO by (1) the Netherlands (Merlijn Staps), (2) Serbia (Dusan Djukic), (3) Ukraine (Danylo Khilko and Mykhailo Plotnikov), (4) Greece (Vaggelis Psychas and Silouanos Brazitikos), (5) Albania (Dorlir Ahmeti) and (6) Australia (Ivan Guo and Ross Atkins).

Forthcoming International Events

This is a summary of the events which are relevant for the UK. Of course there are many other competitions going on in other parts of the world.

The next few IMOs will be held in Hong Kong 2016, Brazil 2017, Romania 2018 and the United Kingdom 2019. Forthcoming editions of the European Girls' Mathematical Olympiad will be in Romania in 2016 and Switzerland in 2017. The Balkan Mathematical Olympiad will be held in Albania in 2016, and the Romanian Master of Mathematics will be in late February 2016.

Diary

This diary is a partly frivolous summary of my personal experience at the IMO, and is rarely fair, balanced or accurate. Bits of it are. Dominic Yeo's report as

deputy leader contains far more information about the activities of the students, and of course there are students' reports too. The team leader does not see the the students very much at the IMO, being busy with other things. Jill Parker plays a huge role on the students' side, but again our paths hardly cross at the the IMO.

I thank the Thai organization for putting on an excellent IMO. It was exceptionally well staffed, and that certainly helped to make things run very smoothly. The people who were my window on the Thai organization were the always helpful Rachaya Srisurichan from the Secretariat and jury chair Soontorn Oraintara who showed unfailing courtesy, excellent judgement and great energy.

However, I am acutely aware that I never even had the chance to meet most of the huge army of organizers who worked harmoniously to create this truly excellent IMO, and it is their triumph that the rest of us enjoyed. Thank you so much!

I also want to draw attention to the unsung heroes of the IMO, the Ethics Committee. Rafael Sanchez of Venezuela, Paul Vaderlind of Sweden, Roberto Dvornicich of Italy and Dávid Kunszenti-Kovács of Norway who do a huge amount of work behind the scenes to make sure that everything is fair and above board.

Finally, note that this is the last year of support for the IMO by *Google*. They generously donated a million euros to support us for five years back in 2011. This was an exceptionally timely gift, since the world was still in shock from the economic disaster of 2008, and we were not at all sure that IMO host nations could be found. The *Google* donation got us through an exceptionally difficult period. Tip your hat.

A Plea to other team leaders

Now that I have become chair of the IMO Advisory Board, I have become the recipient of gifts from generous people who come from cultures where this is deemed appropriate. I am grateful for these items of course, but there is a problem. My suitcase is finite. Large, fragile and heavy gifts are not very convenient.

Let me emphasize, there is absolutely no need to give me a present. A smile and a handshake are more than enough. However, if you feel that you really must make a gift, then please change your mind. Finally, if you can't change your mind, then please make the gift small and light. Thanks! I am sure that similar remarks apply to the gifts which leaders and students exchange with one another.

June 30th

A taxi containing Jill Parker, our pastoral specialist, calls in at my home to pick up me and my suitcase. I have failed to pack my phone charger. Since no-one really wants to speak to me anyway, this is not a problem. I will manage to nurse the phone for quite a while, only using it as nature intended, as an alarm clock.

Our rail journey was not quite on time, and we missed our bus connection at Reading Station. We catch the next service, and the motorway traffic conditions

are not helpful. Tension is just starting to build when we break free, and arrive at Heathrow Terminal 5 fashionably but not worryingly late. Dominic Yeo has everything in hand, and forges ahead with the team while Jill and I check in.

After the usual process rituals with immigration and security, we meet up to find that Dominic is keen on *Wagamama* dining. I cannot resist a Japanese *Ramen*. Time is passing, and there is concern that we might not arrive at the gate on time. There is much frantic shopping en route to the shuttle, but happily we all arrive at the departure gate in good order, and in time to enjoy some queueing.

We depart soon after 9pm, and each adopt our coping strategies. I watch a film called *Kingsman: The Secret Service (2014)* which is a parody of the spy genre. It panders to under-achievers everywhere (possibly its target audience) by railing against the social injustice of it all, and exploring the comedic possibilities of violent death. It did pass the time on an intercontinental flight, and so it is fit for purpose, if not for small children.

July 1st

Flying East means that days and nights are compressed, so the schedule is dinner, sleep, breakfast, land. However, the journey ends in the afternoon by local time, so it doesn't quite work. We are in Kuala Lumpur airport, because we are having a pre-IMO camp in Malaysia with our Australian friends.

We will be staying at Nexus International School in Putrajaya, between Kuala Lumpur and its airport. The school has kindly offered to send a minibus. The driver is in the arrivals hall, and we are escorted through thick tropical air to the bus.

Now there is a problem, because we are 9 strong, we all have suitcases, and the *Tardis* feature on the bus is broken. We use a form of three-dimensional *tetris* to box me in behind a wall of baggage, and set off for the school. My dodgy knee is cramped, folded and is causing me acute pain, but fortunately no-one else cares.

Putrajaya is Malaysia's answer to Canberra. It is the administrative centre of government, and we chose to go there because of what it does not have: pollution, noise and big city life. The school turns out to be very well suited to our needs. It has vigorous air-conditioning, lots of space for lounging around and being a teenager (if you are), and excellent showers which are cleaned continuously throughout the hours of daylight.

It is the holy month of Ramadan, so some care must be taken to plan for meals. The school has helpfully made arrangements for an evening adventure.

July 2nd

The Australians are due in the afternoon. In the morning we take a boat trip on the artificial Putrajaya Lake. Attempts to follow this with a visit to mosques were foiled by the presence of worshippers. How could we be expected to foresee that? We adjourned to a Chinese Restaurant next to some botanical gardens, and let the passage of time do its gentle work on our jet lag.

We return to the school and soon we are joined by most of the Australians including their dazzling team leader, Angelo di Pasquale. We go out to dinner, and as planned, we are intercepted there by Australian Maths Trust royalty, Mike Clapper and Jo Cockwill.

July 3rd

The teams go to work on their first practice exam, but before they finish I leave for the airport and fly to IMO Chiang Mai. At the airport I see a backpacker being given a hard time by an immigration official. The Thais welcome short term visitors, but understandably have little time for impecunious travellers who seek to take up semi-permanent residence.

I am met by the efficient IMO organization, and am transported to the hotel. The traffic near the airport is jammed, but after that things loosen up. The city is bustling and thoroughly Asian. The leaders' hotel is a Holiday Inn, and very luxurious. I have a room on floor 14 which overlooks the river Ping. People are fishing in the river which is a very good sign. The advantage of a swish hotel is the personal comfort. The disadvantage is that hotel bars are very expensive, and this is not convenient in the evenings since leaders from less developed countries will shy away from prices which they must regard as absurd.

Strangely, the IMO shortlist is not yet available, and we will have to wait until tomorrow morning. This seems very odd, since some leaders have travelled a day early in order to start their work as soon as possible. Future IMO hosts please note: if you are not issuing the shortlist to early arrivers, then tell them in advance, and then they probably won't come.

July 4th

This is the normal arrival day for leaders, but I am busy at the annual IMO Advisory Board meeting. We have no formal offers to host IMOs beyond 2019, but even so there is a lot of business. In particular, we have a plan to make the selection of the medal cut-offs in a more sensible way. This will involve displaying the various options as bar charts, with the actual marks removed. This will, we hope, lead to more rational decision making, as leaders will not be sure of the consequences of the chosen cuts for their own students. There are all sorts of other matters to discuss too.

July 5th

Work on the shortlist. This is not very entertaining for the reader, so I will tell you about my adventures with journalism instead. Before leaving the UK, there had been a nice piece on the IMO and EGMO (European Girls' Mathematical Olympiad) in *The Guardian*, written by Sally Weale, and the paper was keen to do follow-up stories. Their stringer in Thailand is Oliver Holmes, and he will visit us in Chiang Mai on the day of the closing ceremony.

There are all sorts of possibilities for a story, as well as covering the results of IMO 2015. He seems very interested in the possibility of getting people to disagree with one another about the wisdom of having a separate maths competition for girls. I can see that this sort of dispute will go down very well with *The Guardian*'s target demographic. I suggest various people to put the pros and cons, and he eventually talks with Kirsten Rosenkilde of Denmark and Jana Madjarova of Sweden. That story has yet to surface, so we await a quiet news day in the UK.

July 6th

It is time to choose the papers. The jury has voted heavily in favour of the protocol I proposed in 2013. This protocol has the advantage that each of the main subject areas gets represented among problems 1, 2, 4 and 5, and every problem used is deemed the best of its type. The case against the protocol is that the jury loves to choose G1, the easiest geometry problem, and unless the jury can exercise more self-control than usual, there will never be a medium level geometry problem in the papers. My view is that the jury needs to get a grip on itself, and sometimes not select G1. That way we can sometimes have some medium geometry.

We choose the paper using a smooth application of the protocol, and the jury chair Soontorn did a great job.

July 7th

In the morning the English language version of the paper was burnished and eventually approved after lunch. The rest of the day was spent creating versions in other languages. In the evening I read that our Mathematical Ashes contest against the Australians has been a draw. Given that the Australians will go on to perform brilliantly at this IMO, the UK can count itself lucky to retain the Ashes. Fortunately for us, Australia peaked a little too late.

July 8th

Student arrival day. The jury has worked speedily, and you might think that they have nothing to do. However, after approving the different language versions, the *fourth law of thermodynamics* kicks into action. This is better known as *Parkinson's law: work expands to fill the time available for its completion.* The phase where problem captains and the jury negotiate the mark schemes normally lasts a couple of hours. However, there is no need for such unwarranted efficiency, and the process goes on all day. I take an hour off for a nap in the afternoon, but when I return the same leaders are saying the same things. You know who you are.

July 9th

Today we have the opening ceremony, and we have the honour that HRH Crown Princess Sirindhorn will be presiding. Our Thai hosts take Royal matters very seriously, and so we do too. European Royalty is a very relaxed business these days, and protocol is established with a very light touch. I remember being told before meeting the British Princess Royal "if you wish to use the traditional form of address, this is how you do it". This is not the case with Thai protocol, which is prescriptive, theatrical and serious.

The students have to be in place in the ceremonial hall very early, and the leaders are lucky that they only have to arrive an hour before the Royal Party. We go through airport-style weapons scans, and also have our temperatures taken (so as not to risk the health of the Princess). I get to sit at the front because as Advisory Board chair, I am to make a speech.

As I sit there, a Thai official in a *Top Gun* style white uniform walks towards me. He leans forward, smiles, and says "you don't remember me do you?" and then walks away. It turns out that he is the master of ceremonies, and speaks excellent English.

My speech has been through a few iterations, following exchanges with the royal household. I have submitted it, and was told I would get a version to use in the ceremony. I have a spare copy in my inside pocket just in case. I need not have worried, for a lady-in-waiting approaches me with a beautifully bound folder which contains the speech. She also gives me a tutorial in bowing. It must be from the waist, and slow. I am to bow twice on the way in, and twice on the way back from the podium. I decide to regard it as conjugation, so I am to bow, walk, bow, speak, bow inverse, walk inverse and finally bow inverse again.

The speech goes as well as I could hope. It is not really MLK's "I have a dream" nor Kennedy's "ask not what your country can do for you", but when I look up in mid speech, the Princess is smiling broadly. She must have to sit through a lot of formalities, so I admire her professionalism.

Part of the speech consists of administering the IMO oath, exhorting participants to play fair. The oath is an important reminder of the IMO spirit. We have an Ethics Committee translating and scrutinizing scripts between IMOs. To quote another US President, "trust but verify".

After my speech I introspect, trying to work out where I have met the master of ceremonies before, and I realise that he was a student at the University of Bath a long time ago. After the ceremony is over, I go over and find out the details. He is Natee Tongsiri, and in time of yore he was a postgraduate student in my university when I was the Conference Director of *Groups St Andrews in Bath 1997*, and he played the important role of minibus driver. It is wonderful to see him again after all this time.

In the afternoon the jury spends hours discussing self-denying ordinances. The jury is sovereign and supreme, but the jury is naughty, and the jury feels guilty about being naughty. The jury sometimes breaks its own rules. So, the IMO AB has a cunning plan to make the jury obey its own rules. How? More

rules of course. Anyway, it is worth a try, and perhaps at the final jury meeting the medals really will be given to at most half the contestants, and the ratio of gold:silver:bronze really will be an excellent approximation to 1:2:3.

July 10th

First Contest Day. This begins innocently enough. The leaders take a bus to the students' hotel where they are sitting the paper. This device simplifies the Question and Answer session during the first half hour of the exam. Students are allowed to ask questions of clarification, and the jury entertains itself by splitting into a helpful faction and a hard-as-nails group. At least, that is the traditional entertainment. This year there are lots of noisy observers and poor acoustics, so it is very hard to hear what is going on.

After the Q&A we are taken by bus to an elephant park. Just as I settle in to see elephants paint, miss penalty kicks and drag logs, news comes through of a possible IMO irregularity. The Russian leader Nazar Agakhanov has had a phone call telling him that some deputies have been given copies of the day 2 paper (on day 1). Since the deputies mix with the students, this is an irregularity. I consult with Advisory Board Secretary Gregor Dolinar, and contact the jury chair Soontorn Oraintara. Information about what has happened is sketchy, and the phone signal at the elephant camp is poor. We consult the elected members of the IMO AB as best we can, and quickly decide that we have to take emergency action. IMO AB people and the Problem Selection Committee are put on a bus, and return to the jury hotel, leaving everyone else to engage in elephant related activities. We also bundle Joseph Myers onto the bus, because he sits in the jury and makes exhaustive notes of everything that happens. We will need him to reconstruct the jury's discussions.

We decide that, in case the jury wants to reset the Day 2 paper, we have to facilitate this. We therefore construct various candidate replacement Day 2 papers, using both the opinions of the Problem Selection Committee, and the previously established opinions of the jury concerning the merits of the problems. Finally we realise that there are two good choices, and we have those ready.

When the jury returns, we have a meeting before dinner. The evidence about the scale of the irregularity is not conclusive, so the jury sensibly decides to be very careful, and chooses to reset the paper. Time is very short, because after dinner the new paper will have to be translated, approved and printed. The jury chooses the paper with little fuss. The jury, the co-ordinators and the Thai organizers worked very hard that evening, and by the start of Day 2, the situation was recovered.

In the end it turned out that a sequence of apparently minor mistakes and suboptimal decisions compounded to cause the problem. The people involved are loyal and hardworking friends of the IMO, so let us draw a veil of discretion over precisely what happened. Of course those mistakes will not happen again, we will make sure of that.

July 11th

The day of the second exam. I detect a little nervousness, given the amazing speed at which the selection and translation was made. Have we forgotten something? However, everything runs very smoothly. We have a joint IMO AB and jury meeting, and remember IMO friends who have died during the previous year with short speeches and a silence. There is a brief opportunity to meet deputies, but mine is half way up a mountain as usual. However, I am able to snatch a chat with Jill and she reassures me that the team members are OK.

The jury has a mid-morning lunch at the students' hotel, and then piles back to the leaders' hotel to agree the marking schemes for the new Day 2 problems. We need to do this in a hurry because the students will finish the paper soon. Therefore the leaders are not present to greet the students as they leave the second exam. It is often annoying when this happens, but this time there was a very good reason for the arrangement.

I finally meet the UK students in the late afternoon, and they are not really jubilant. It has been a demanding paper, and many scores will be low, but that is little comfort.

July 12th

The first day of co-ordination begins with a morning off. Our Thai hosts have arranged a generous schedule, so there is plenty of time to work on the scripts. Dominic and I have divided the responsibilities. I will handle the three problems with geometric content (including Problem 1), and Dominic will handle the others. As it happens, that means that Dominic will fight for scraps whereas I will harvest marks. I quickly dispose of Problem 3 in the afternoon. We ask for 100101 and get the marks easily enough. This question is a tribute to the nine-point circle, and as always happens with well-known configurations, there will be grief concerning "obvious" properties of the diagram. In this case it was Hungarian unhappiness.

July 13th

We are supposed to co-ordinate four questions today, but in fact we finish everything. Co-ordination is very straightforward because the hosts have prepared very well and there are more tables than usual, so much less queueing is needed.

Luckily we begin first thing in the morning, and are among the first to co-ordinate Problem 6. This gives Dominic an excellent opportunity to persuade the co-ordinators to vary their marking scheme, because Joe has made non-trivial progress on the problem, and his ideas can be completed to a full solution. The existing mark scheme would have him score 0, but by deploying the natural justice argument, he gets 1 mark. This only works because we are on first, and the co-ordinators have not had the chance to build the "this is the way we have treated all other scripts" into an unvarying mantra.

The other co-ordinations are less fraught, and we are pleased that we do not feel the victim of an injustice at any table. The easiest session was for Problem 1,

when the co-ordinators started to congratulate us on our excellent scripts even before we sat down. That is the civilized way to bag 42 marks. Problem 1 is a play on the Sylvester-Gallai theorem, the result that states that if you have n points in the plane, and every line through two of these points contains a third, then all the points must be on a line. The *balanced* condition replaces a line through two points by their perpendicular bisector. In fact parts of Problem 1 turn out to be a known, but the jury decided several years ago that with easy problems, the requirement for complete originality is not realistic. People who demand complete originality should take up problem composition as a hobby.

In general, we have not done as well as usual on the medium problem, and only Warren has scored full marks in the category on Day 1, and no-one on Day 2. By scheduling an extra meeting, we complete co-ordination a day early.

In the evening it turns out that Joseph Myers, the UKMT volunteer who is here as a co-ordinator is free, so we jump in one of the surprisingly unprecarious 3-wheeled taxis, with a plan to join the students for dinner. The driver gives every sign of knowing where the restaurant is to be found, but this turns out to be false. He lets us out in the general vicinity of the correct restaurant, close to a nearby junction. There is a sleazy joint filled with bar girls (or similar). I am not experienced in such situations, so I send in Joseph to use his urbane charm and easy manner to extract information. This fails for some reason. I take charge, and decide to use racism to solve the problem. We walk around the junction until I see a European face. I then use the subtle "excuse me, do you speak any English" line, and we are directed straight to the restaurant.

We have a happy time with the students, Jill and Dominic. I ask for extra heat in my soup, and end up in tears. It was excellent.

July 14th

The UK leaders are now on vacation, but co-ordination continues in the morning for some countries. These are the countries with difficult scripts to handle, together with those countries with vexatiously argumentative leaders. In the afternoon there is an excursion, but I elect for the indoor horizontal option.

We have the final jury meeting in the evening. There is one appeal to the jury concerning marking practice, but it is rejected. I have been told of the death of another former IMO team leader, and am moments away from making an announcement and calling for a silence. I check the exact pronunciation of his surname with that country's current team leader, only to be informed that the person concerned has not died. I am delighted to have been misinformed. Welcome back.

The new bar chart method of displaying the results works extremely well, and it is completely clear where the bronze and silver cuts should be. The jury is not being naughty! The IMO AB recommended reforms are working. There is room to debate where the gold cut should be. Remember that the jury does not know the cut it is making; it only knows that there are two rational choices and they are one mark apart. I assume that the jury will err on the side of generosity,

but no. The jury is now intoxicated with its own virtue, and is determined to implement the ratio rules as best it can. There is a close vote, because there is room for honest disagreement here, and finally the jury chooses. After this, the actual cuts are revealed; 14, 19 and 26, and suddenly we see the consequences of our actions.

UK student Warren Li is one mark short of a gold medal. This is painful, but at least no marks were left in the co-ordination room, and he got every mark that he earned. Three British students Joe Benton, Sam Kittle and Harvey Yau have snuck silver medals by scoring 19. Neel Nanda has a very safe bronze on 17, and finally Lawrence Hollom has an Honourable Mention for solving Problem 1 perfectly.

Alex Song, a Canadian student, has the only perfect score, and this takes him to the top of the IMO hall of fame. The Americans have edged out the Chinese, and it seems quite possible that Po-Shen Loh, the US leader, will explode with joy. The UK has four silver medals for the second year running, and 11 in the past three years.

July 15th

In the early afternoon the closing ceremony begins, of which there are a very large number of photographs on the internet. The video for the forthcoming Hong Kong IMO of 2016 is particularly clever, and the whole thing is done with class and efficiency.

Afterwards we walk to the site of a superb buffet banquet. The *Guardian* journalist is around, and I hope that he is picking up some good stories. I am taken to sit at the front with the dignitaries. There is entertainment on stage, and after a while a procession of Thai dancers enters the hall from the back. They are carrying lights, and the lead dancer is being carried on a platform. She appears to be modelled on Audrey Hepburn, but is covered in a layer of metallic sheen in the manner of Shirley Eaton in the Bond film *Goldfinger*. She presents me with a jasmine bracelet, but I decide to read nothing personal into this.

This front table has the advantage that people bring you food, and so you don't have to forage. Eventually most of the key figures from the Thai local organization drift away, and I return to join the UK students. The music is a touch loud for my tastes, especially since I have been down the front near the speakers.

The UK IMO gift this year consists of IMO logo stickers. These circular objects were designed so that people could use them to decorate their luggage, and thereby recognize suitcases on airport carousels more easily. These are now leaking into the hands of students, and unsurprisingly they start to use them in unexpected ways, mainly as fashion accessories, decorating their clothes and faces with IMO symbols. This could become a habit.

I share an open back red Thai taxi with Australians leaders. Angelo di Pasquale entertains us with some background information about Problem 6. The authors were Ivan Guo and Ross Atkins. It is a problem inspired by the math-

ematics of juggling. Imagine that you have just one hand, and can throw balls in the air so that their flight time is an integer number of seconds. You have a supply of balls, and you must arrange that you never have two balls landing in your hand at the same moment. Now Problem 6 looks completely natural, and b stands for the final number of balls in play.

July 16th

In the morning Dominic and I board a bus to Chiang Mai airport at 06:30. Traffic is very light, and now it is much more obvious how close we have been staying to the airport. For logistical reason too tedious to explain, I am bringing an extra suitcase home. AirAsia have an economic model which may be familiar to readers from other parts of the world. The flights themselves are very cheap, but unless you do everything correctly in advance and on-line, there are punitive charges waiting for you at the airport. This policy works in conjunction with a web site of such a poor (or malicious) design that the user is tempted to give up and pay the airport fine, or possibly to walk to the destination instead.

Various people have done battle with this site on behalf of UKMT, and and in fact Jill Parker has heroically checked in almost all the luggage except mine. The problem here is the extra suitcase, and we can't work out how to do that. The only solution is to pay the airport charge (ouch). However, this charge underscores how well she has done in checking in the rest, since we saved the best part of £1000 that way.

The UK party flies to Kuala Lumpur where we must pass about eight hours. We have asked my undergraduate friend and KL resident, Dave Bobker, to find a civilized way to pass the time. Using his high level administrative skills, he has passed the job to Mrs Bobker, the excellent Maria. Maria has hatched a plan to have a long slow meal in the Hilton Hotel, handily situated next to KL railway station.

At the airport the UK party follows instructions, and takes the fast train into KL, keeping the Bobkers informed of our schedule. The train is impressive and modern, and affords interesting views of the state of Malaysian urban development. In summary, it is mixed.

Dave and Maria meet us at the station and escort us to the hotel and the banquet. One of the UK students is not feeling too bright and we are in a hotel, so we get him a bedroom to rest.

At length we make our way back to the airport. The rest of the party check in easily enough, but although I know for certain that Bev Detoeuf in the UKMT office has booked me to take two suitcases, British Airways are in denial. They have to poke their software with sticks and hit their terminals with rocks but eventually they discover that UKMT has indeed booked two suitcases for me. I am glad to get through that, but am alarmed when my boarding card causes the machine to flash red at the gate. I assume that there must be another problem with the luggage, but instead it turns out that BA have decided to upgrade me to *Business Class*, presumably as an apology for all the trouble about the suitcase.

I find it hard to look the other UKMT passengers in the eye.

July 17th

We arrive safely at T5 Heathrow at about 05:00. The correct number of parents turn up. There is some emoting but of course I will have no part in this. It is far too early in the morning. The IMO excursion is over for another year.

Acknowledgements

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http://www.ukmt.org.uk/about-us/

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