International Mathematical Olympiad 2013

UK leader's report: GCS

August 2013

The 54th International Mathematical Olympiad was held on the Caribbean coast of Colombia in July 2013. The students stayed in Santa Marta, and the leaders in Barranquilla, at the mouth of the Rio Magdalena. The UK Team Leader was Dr Geoff Smith of the University of Bath and the Deputy Leader was Dominic Yeo of Worcester College, Oxford. The person in charge of pastoral matters is our Observer C, Bev Detoeuf from the Leeds Office of UKMT.

The team was as follows:

Andrew Carlotti	Sir Roger Manwood's School, Kent
Gabriel Gendler	Queen Elizabeth's School, London
Daniel Hu	City of London School
Sahl Khan	St Paul's School, London
Warren Li	Fulford School, York
Matei Mandache	Loughborough Grammar School

The reserves were

Frank Han	Dulwich College, London
Maria Holdcroft	Willink School, Berkshire
Freddie Illingworth	Magdalen College School, Oxford

Andrew Carlotti was competing for the fourth time, and by securing a gold medal at IMO 2013, he now has the best IMO medal record of any British student. He has one bronze medal and three gold medals, won during 2010–13. This takes him above Simon Norton (3 gold medals, 2 special prizes) and the late John Rickard (3 gold medals, 3 special prizes).

The performance of the British team of 2013 is shown in the following table:

		$P1$	$P2$	$P3$	$P4$	$P5$	$P6$	Σ	Medal
UNK1	Andrew Carlotti	7	7	0	7	7	6	34	Gold
UNK2	Gabriel Gendler	7	5	0	7	6	0	25	Silver
UNK3	Daniel Hu	7	7	0	7	7	2	30	Silver
UNK4	Sahl Khan	7	0	0	7	7	0	21	Bronze
UNK5	Warren Li	7	7	0	7	7	0	28	Silver
UNK6	Matei Mandache	7	7	0	7	7	5	33	Gold

The cut-offs were 15 for bronze, 24 for silver and 31 for gold. There were 97 participating nations. The unofficial ranking of countries by total scores has the UK in 9th position overall, 2nd among European nations (behind Russia), and in 1st position among the nations of the European Union (by some margin). This represents the best team performance by a British side at an IMO since 1996 when we finished 5th.

Here are the top 30 places at IMO 2013. The full table can be found at

`http://www.imo-official.org/year_country_r.aspx?year=2013`

1. China (208), 2. South Korea (204), 3. USA (190), 4. Russia (187), 5. North Korea (184), 6. Singapore (182), 7. Vietnam (180), 8. Taiwan (176) 9. United Kingdom (171), 10. Iran (168), 11. Canada (163), 11. Japan (163), 13. Israel (161), 13. Thailand (161), 15. Australia (148), 16. Ukraine (146), 17. Mexico (139), 17. Turkey (139), 19. Indonesia (138), 20. Italy (137), 21. France (136), 22. Belarus (134), 22. Hungary (134), 22. Romania (134), 25. Netherlands (133), 26. Peru (132), 27. Germany (127), 28. Brazil (124), 29. India (122), 30. Croatia (119).

Of the remaining nations, Anglophone and Commonwealth scores include 31. Hong Kong (117), 31. Malaysia (117), 48. New Zealand (77), 56. Sri Lanka (65), 58. South Africa (64), 61. Bangladesh (60), 64. Cyprus (52), 76. Ireland (33), 79. Pakistan (25), 84. Nigeria (18), 86. Trinidad and Tobago (16), 95. Uganda (1).

Italy are to be congratulated for finishing top of the nations using the *Euro*. France finished above Germany, a singular event which had not happened since German re-unification. There seems to be a general trend that some of the countries of central and eastern Europe are getting lower IMO rankings, whereas the nations of the Far East are doing very well recently. Indonesia obtained an excellent result, a sharp improvement on their previous performances, and Israel secured their best ranking position since 2000. As

often happens, China sent a very strong team, and are to be congratulated for winning the event.

Problems of Day 1

1. Prove that for any pair of positive integers k and n, there exist k positive integers $m_1, m_2, \ldots, m_k$ (not necessarily different) such that

$$1 + \frac{2^k - 1}{n} = \left(1 + \frac{1}{m_1}\right)\left(1 + \frac{1}{m_2}\right) \cdots \left(1 + \frac{1}{m_k}\right).$$

2. A configuration of 4027 points in the plane is called *Colombian* if it consists of 2013 red points and 2014 blue points, and no three of the points of the configuration are collinear. By drawing some lines, the plane is divided into several regions. An arrangement of lines is *good* for a Colombian configuration if the following two conditions are satisfied:

   - no line passes through any point of the configuration;
   - no region contains points of both colours.

   Find the least value of k such that for any Colombian configuration of 4027 points, there is a good arrangement of k lines.

3. Let the excircle of triangle ABC opposite the vertex A be tangent to the side BC at the point A_1. Define the points B_1 on CA and C_1 on AB analogously, using the excircles opposite B and C, respectively. Suppose that the circumcentre of triangle $A_1 B_1 C_1$ lies on the circumcircle of triangle ABC. Prove that triangle ABC is right-angled.

   The excircle *of triangle ABC opposite the vertex A is the circle that is tangent to the line segment BC, to the ray AB beyond B, and to the ray AC beyond C. The excircles opposite B and C are similarly defined.*

Problems of Day 2

4. Let ABC be an acute-angled triangle with orthocentre H, and let W be a point on the side BC, lying strictly between B and C. The points

M and N are the feet of the altitudes from B and C, respectively. Denote by ω_1 the circumcircle of BWN, and let X be the point on ω_1 such that WX is a diameter of ω_1. Analogously, denote by ω_2 the circumcircle of CWM, and let Y be the point on ω_2 such that WY is a diameter of ω_2. Prove that X, Y and H are collinear.

5. Let $\mathbb{Q}_{>0}$ be the set of positive rational numbers. Let $f\colon \mathbb{Q}_{>0} \to \mathbb{R}$ be a function satisfying the following three conditions:

   (a) for all $x, y \in \mathbb{Q}_{>0}$, we have $f(x)f(y) \geq f(xy)$;
   (b) for all $x, y \in \mathbb{Q}_{>0}$, we have $f(x+y) \geq f(x) + f(y)$;
   (c) there exists a rational number $a > 1$ such that $f(a) = a$.

   Prove that $f(x) = x$ for all $x \in \mathbb{Q}_{>0}$.

6. Let $n \geq 3$ be an integer, and consider a circle with $n+1$ equally spaced points marked on it. Consider all labellings of these points with the numbers $0, 1, \ldots, n$ such that each label is used exactly once; two such labellings are considered to be the same if one can be obtained from the other by a rotation of the circle. A labelling is called *beautiful* if, for any four labels $a < b < c < d$ with $a + d = b + c$, the chord joining the points labelled a and d does not intersect the chord joining the points labelled b and c.

   Let M be the number of beautiful labellings, and let N be the number of ordered pairs (x, y) of positive integers such that $x + y \leq n$ and $\gcd(x, y) = 1$. Prove that

$$M = N + 1.$$

Diary

The Director of IMO 2013 was Maria Losada (not be confused with Maria Falk de Losada, her mother and the chair of the jury). Maria Losada was immensely helpful to the Australian and UK teams, facilitating our early arrival, monitoring our hotel bookings, and inviting the UK team guide Maria Ximena Rueda to join us for our pre-IMO camp. Maria Losada does not play a large role in this diary, but she orchestrated the IMO, and without her work, and that of her team, the IMO could not have happened.

Sunday July 14th We have an early flight tomorrow, so some of us gather at a *Holiday Inn* near Heathrow Airport. This involves meeting the flight of Daniel and Matei, silver medallists from the International Physics Olympiad in Denmark. They are having to miss the physics closing ceremony to join us for the journey to Colombia. Our International Olympiad in Informatics (Computing) silver medallist, Andrew Carlotti, will be making his way from the IOI in Brisbane in the company of the Australian IMO team. They have to travel via New Zealand and Chile, and Andrew should arrive in Santa Marta a few hours before we do.

Monday July 15th We have ordered a giant taxi, but a merely large one arrives. We quickly arrange for a more impressive vehicle, and make our way to Terminal 5. We find Sahl there, so the party is as ready as it is going to get until we reach Colombia.

We are delighted to discover that our Iberia/Avianca flights will take our checked-in luggage all the way to Santa Marta. The first hop to Madrid goes easily enough. In Madrid we have to change terminals, and we do so in the hope that our luggage will move as swiftly.

The long journey to Bogota involves trays of baby-food, mysterious pastes which were presumably obtained as surplus goods from NASA. I am the happy position of being moved to a row of seats with no other passengers. Ten hours later, or just four hours later if you are foolish enough to use local time, we find ourselves in Bogota. We are at a great altitude, so the conditions are not oppressive.

The students are hungry, and we quickly locate a traditional Colombian Japanese *sushi* and *sashimi* restaurant. The students spot a flight information board, and Gabriel convinces us that our flight to Santa Marta has been cancelled. I compound the error by taking him seriously. Eventually it turns out that we have been looking at the arrivals board.

The correct departure gate is unmarked, but by determined negotiation we eventually find ourselves waiting in the right place. At last there are a few maths T-shirts around, and it is clear that we are getting close to the IMO. Our Colombian guide Maria introduces herself, for she has kindly agreed to act as translator during the Australia-UK pre-IMO camp.

The flight to Santa Marta is in the dark, and when we arrive, we step off the aircraft into proper tropical air that you can chew. Our bags soon arrive, and we locate the minivan which has been sent to meet us from the *Santorini Hotel*. It has been a long day, and while people are not yet irritable, the *bonhomie* is getting a bit forced. The chap in charge of loading the bags

is of a certain age, and rather ponderous. Eventually we intervene and load the bags ourselves. We are then crammed into the van for the short journey to our hotel.

I can tell that we have arrived when I see the Australian leaders Angelo di Pasquale and Ivan Guo standing by the side of the road. There are various conflicting instructions as to what we should do with (a) our bags and (b) ourselves. Eventually we get out and Bev does battle with a UKMT credit card and the very confused check-in staff. After over half an hour (I kid you not) she succeeds in making the appropriate credit card payment, and leads the students off to the UK villa.

Then Dominic and I stroll up to the counter to collect our room keys, and are astonished when the staff explain that Bev has not paid for us, and we must pay before we are given our keys. We are exhausted, and not in the mood for a fight, so I pay using my UKMT credit card and we get our keys.

Dominic shoots down to the UK villa. He and Bev study our paperwork, and we discover that Bev had indeed paid for us. Dominic comes back to my room, takes my credit card, and gets the second payment reversed by the gentlemen in reception. Dominic is initially of the opinion that the receptionists are crooks, but having seen earlier events, I reassure him that they are just massively incompetent.

I am now drained after this prodigious journey, and am not best pleased when the clowns in the room next door decide to have loud conversations on their balcony until past 4am. As I drift off to sleep, someone sets off firecrackers to entertain the hotel at 5am. Things can only get better.

Tuesday July 16th The Australian and UK students each have their own villas, and we rearrange the social spaces to create exam rooms, borrowing furniture from the nearby pool area when necessary. While they sit the paper, I go to reception, and have my room changed to get away from the selfish idiots who were in room 511 last night.

We get bread, cold meats, cheese and tropical fruit drinks from a local supermarket, and have an improvised lunch when the exam is over.

The British students have bested the Australians on the first paper, but only by a narrow margin. I am impressed, because I know that the British side is very good. It seems that the Australians will not be a pushover this year, and that our continued possession of the *Mathematics Ashes* is in doubt. The contest is the final exam of the pre-IMO camp.

Wednesday July 17th After my first good night's sleep in Colombia, I am to be picked up by a minivan taxi for the transfer to the city of Barranquilla

while the students are sitting an exam. Checking out involves tangling once more with the characters in reception. To simplify matters, I take along an itemized list of my extras, so that settling up should be a straightforward process. They wave my list away, and start tapping at computer terminals. After the usual 30 minutes, they come up with a completely incorrect figure. I point out that they have failed to allow for the items associated with my second room. There is much slapping of palms on foreheads, and they decide simply to let me off those items, presumably because my taxi is due and it would take another 30 minutes to add two numbers together.

Mike Clapper of the Australian Maths Trust, together with his partner Jo, arrive from the airport just before my taxi turns up, and we exchange warm greetings. Their luggage has vanished somewhere between Brisbane and Santa Marta, but they seem happy enough just to have arrived.

My taxi parks outside, and I bid farewell. The van is cool and quick, and we drive to Barranquilla in under 2 hours. For much of the journey, the sea is on your right, and a large lake is on your left, and as your mind drifts, it is not clear which is which. It feels like you are travelling on a tropical *Afsluitdijk*, with pelicans and countless white herons for decoration. I am travelling with several other team leaders: Dieter Gronau from Germany, Raphael Steiner from Switzerland, Philipp Wirth from Liechtenstein and Bernd Kreussler from Ireland.

It is a curious feature of Colombian geography that it has cities and towns, but the villages are mostly missing. There is one small settlement in the middle of the journey, and there we could see the sharp disparities of wealth which bedevil Colombia and many other Ibero-American societies.

At length we arrive at the El Prado hotel in Barranquilla. This is not an ordinary modern hotel, but rather it dates from the 1930s, and is fit for Ernest Hemingway. The reception staff act as if they have never heard of the IMO, and give us room keys and the information that we will get free breakfast tomorrow. Since today's lunch is now overdue, this is disconcerting. I leave my luggage in my room, and conduct a random walk through the hotel. Eventually I spot IMO internet Tsar Matjaž Željko, and tail him until he leads me to the IMO office. I get the shortlist, and tokens that can be exchanged for meals.

Thursday July 18th

I enter an email exchange with my brother Pete, who lives in Dubai. After a couple of decades of making things happen, he has recently written a book (Project Management: All You Need is Love) and is developing a literary

bent. He sets himself the challenge of getting the British and Australian press interested in the Mathematics Ashes, and over the next few days he works on a blog with this purpose. We swap ideas during my night and his day, but the text is all his.

http://otherashes.wordpress.com/2013/07/19/and-so-it-begins/

The Mathematics Ashes has its origins in a hotel bar in IMO Vietnam, where, after several beers, the former Australian Mathematics Trust supremo Peter Taylor suggested this annual competition, and Peter Taylor is very much in on the gag. Joseph Myers keeps the Mathematics Ashes records in a more formal style.

http://www.bmoc.maths.org/home/ashes.shtml

Friday July 19th The jury has its first serious meeting. In my Observations of 2011 (http://www.imo-register.org.uk/2011-report-geoff.pdf) I made a "modest proposal" to reform IMO voting protocols, and the case for change was made more pressing by the unbalanced papers of 2012. The new protocol involves forcing problems 1, 2, 4 and 5 to involve all four subject areas, and then choosing the best two hard problems on merit alone, unconstrained by subject type except that they should not be from the same area as one another.

The mechanism for producing the balance in the easy and medium problems is to choose eight problems. For each of the areas algebra, combinatorics, geometry and number theory the jury can choose the best easy and the best medium problem. The easy and medium positions can then be filled in $\binom{4}{2} = 6$ ways. The jury pauses for reflection on the relative merits of the six choices, and then votes off possibilities one at a time. The idea is that each problem that appears on the paper must be the best available question in its category, and that the easy/medium problems, the ones which most students actually try to do, will be balanced.

There is an extended debate, and eventually the jury agrees to try the new protocol for one year as an experiment. Whether the new method is adopted again is a matter for future juries, and I suppose that will partly depend on how people judge the quality of the 2013 paper. Anyway, having lit the touchpaper, I sit back and wait for disaster.

The jury chair is Maria Falk de Losada, a formidable Colombian New Yorker who eats fools for breakfast. She wants us to discuss the merits of

the problems. This is an excellent idea, but it is too soon. It turns out that many leaders (me included) want to be left alone to struggle with the shortlist problems in their rooms, and we persuade the chair to give us more time.

Saturday July 20th At length we have the solutions to the shortlist problems, and we can start to make rational judgements about the merits of the of the harder problems. We implement the new protocol, and a paper is produced. One well-known jury figure is convinced that the paper is too easy, and that we have really messed it up this year. I am not so sure. We have chosen a purely conceptual problem in position 2, and our experience with the 2011 windmill was that many students find such questions very difficult.

Viewing the internet late in the evening, I discover that the UK has retained the Mathematical Ashes by 1 point. The Australians set an easy Ashes paper to compress the marks.

Sunday July 21th Today is student arrival day in Santa Marta, but this is of little import at the jury site. The jury begins the day by working on the notation that will be used in the problems. Having established that, the English Language Committee kicks into life, with its open door entry qualification. Chris Tuffley of New Zealand constructs the computer file, and after our deliberations we make our proposal to the jury, and after further discussion we have the English language versions of the papers. A few hours later we approve the other IMO official languages, and finally the leaders go to work to produce the papers in all necessary languages.

Monday July 22nd The jury approves the final versions of the papers, and then we travel to the opening ceremony. This is held in a very large university hall. There are short and welcome speeches from various members of the Losada family, and a political address from the mayor of Barranquilla which set everyone thinking.

We then entered the important phase of the ceremony, when the teams paraded one by one round the arena, accompanied by various grotesque figures from the Colombian carnival. The conception was brilliant. This bizarre procession was accompanied by carnival music: horns, drums and accordions. No review that I might give would do it justice.

The UK team members, dapper in shirts, ties and panama hats, take their turn. Sahl is carried round by Gabriel, while Andrew, Daniel, Matei and Warren stroll round while waving.

At the end of the ceremony, the leaders depart for Cartagena, a beautiful old Spanish port along the coast. The architecture is beautiful, and we have

a happy time wandering around the town. The city walls are intact, put there to protect Cartagena from English pirates. On the way back to our hotel, the driver gets lost in Barranquilla. This is no mean feat because the roads are set out and numbered on a grid system, American style. I wonder if he is related to the people working at reception in the Hotel Santorini?

Tuesday July 23rd Checking the internet in the morning, I discover that the baby who will become Prince George of Cambridge has been born. This is a disaster for my brother Pete's plan to get publicity for the Mathematics Ashes. The journalists who planned to give name checks to the team members in the British press have had their stories spiked. Their editors have given over space to the "woman gives birth to baby" story. As Pete put it, we were "bumped by the bump".

It is the morning of the first exam, and the jury convenes to answer questions of clarification from the students. There are one or two technical problems, one of which is resolved by turning a television screen upside down.

The co-ordinators present their marking schemes. Initially there are no paper copies, and that makes it very hard to view the schemes in the round. This is sorted out fairly quickly.

In the evening we attend the mayor's reception, and listen to more of that carnival music. The most impressive aspect of the event was the extraordinarily powerful amplification system. You can imagine how much we enjoyed that.

On returning to the hotel, we find that the students scripts are expected to arrive at about 11pm. I go to bed rather than wait.

Wednesday July 24th I pick up the UK scripts before breakfast. My initial reaction is that the jury has messed up very badly, and problems 1 and 2 must be far too easy, because the British students have demolished them. I prepare for the worst. No doubt the new voting protocol will be blamed, and I will lose all respect from my fellow jurors.

I ask other leaders how their students have done, and to my surprise it seems that many students have found problems 1 and 2 quite difficult. While I am sorry for the students personally, it is a relief that the paper has not been completely misjudged. The British students have done unusually well on paper 1. It is a shame that there is so little work on problem 3, not even many good diagrams.

We have a much more efficient Q & A session for the first 30 minutes of paper 2, and then listen to the well-presented marking schemes for the problems of day 2. We have lunch and then transfer to the students' site.

There has been little time to work on the scripts of day 1. This is not a problem for me, because the British solutions fall easily into two categories: completely right or total rubbish. Many leaders will have more subtle issues to resolve, and I feel for them.

The students' site, the *Irotama Resort*, is a wonder to behold. It is a huge resort complex set right on the beach. Many people are housed in beach bungalows, but I am in a tall apartment block. In my suite we have our own bedrooms, but I share a common social area with Dieter Gronau of Germany and Gregor Dolinar of Slovenia. The apartment is well equipped, with a chilled water dispenser and a washing machine.

It is delightful to meet the UK team, and both Bev and Dominic. Everyone is well, and the students are claiming to have done better on day 2 than day 1. If this is true, we are going to have our best performance for years. I ask other leaders, and while problem 4 is widely regarded as accessible, problem 5 is viewed as quite challenging and problem 6 as very hard indeed.

In particular, Andrew Carlotti is an extremely happy bunny, and he looks almost certain to pick up his third gold medal. It also seems certain that all our team will get medals, and that many of them will be strong.

We leave Bev to keep an eye on the team, and Dominic and I go into mark maximization mode. It is really only problems 3 and 6 where we are likely to have complicated co-ordinations. Dominic takes the combinatorial problem 6 and this leaves me with the geometric problem 3. It is a long evening, but not as long as it might have been.

Thursday July 25th On the first day of co-ordination we address problems 1, 5 and 4. The marks harvest is 125/126, but we know that day 2 will be a more testing experience.

The co-ordinators seem well prepared, and the co-ordination room is so well air-conditioned that there is an incentive to prolong discussion indefinitely. There are now ample opportunities to meet old friends among the deputies and observers, and of course to strike up new relationships.

Friday July 26th Our first co-ordination in on problem 3. One of our co-ordinators is Mark Saul, whom I have known for a long time. I lead. There are only two scripts of interest. Daniel Hu has not done the problem, but he has done the converse (that it is, he has proved the reverse of what is required). The marking scheme helpfully and explicitly states that there are no marks available for doing this, but I begin by asking if case law has developed allowing partial credit. It has not, and we move on.

Next we examine Andrew Carlotti's script. This is all rough work, but

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he has circled a piece of work on page 9 which is interesting. It is written in his characteristic stream of consciousness style, but if carefully read, it is an outline of part of the necessary proof, a part which is worth 3 marks.

I have seen co-ordinators give full marks for material like this, and I have also seen them give zero. The extreme perspectives are (i) "this is an essentially correct solution, but the student has written it up (probably under time pressure) very casually, but we are here to reward ideas, not neat and accurate presentation, so we allow this as a proof" and (ii) "you have supplied a very interesting way to interpret these jottings, and we commend your ingenuity, but we are here to mark the student's script, not the quality of your interpretation". Unfortunately the co-ordinators are firmly of the latter view, and though we obtain a second opinion from Jana Madjarova of Sweden, we cannot squeeze out a mark.

Dominic is to lead on the remaining two questions. Problem 2 is the geometric combinatorics problem proposed by Ivan Guo of Australia. We have four clear solutions, one clear non-solution, and an incomplete solution by Gabriel Gendler, written up against the clock. Dominic forecasts 5 points for Gabriel in advance, and that is exactly what we get, along with four 7s and a 0.

Finally we move to problem 6. After day 1, no student of any country had obtained a mark for this problem on the public display. We have three scripts with content. Andrew Carlotti gets 6, Matei Mandache gets 5 and Daniel Hu gets 2. This is roughly in line with Dominic's forecast, though he has to do some very hard work to convince the co-ordinators of our case. Dominic's mastery of his brief is excellent, and tries very hard to persuade the co-ordinators that Daniel's script is worth more than 2, but they will not budge. Since the gold medal cut-off seems likely to be about Daniel's score, this could be very important.

In the evening we had the joint IMOAB and jury meeting. We begin by remembering those who have, in the language of Erdős, "left". This includes my friend and co-author Christopher Bradley, and I give a short summary of his contributions and career. The jury stands in respect.

There is an announcement about the film, being made in the UK at the moment, provisionally entitled *X PLUS Y*. This is a love story, the main players being two young people from different IMO teams. The IMO Foundation should be in a position to make use of the publicity to try to garner support for the IMO, and for this reason it is being reconfigured.

The runners and riders for the IMOAB elections are announced, nomina-

tions having been gathered at IMO 2013. There are many candidates for the positions on the IMOAB, but only two candidates for the IMOAB chair. I happen to know that each of these two candidates nominated the other, so we can expect the usual extremely amicable election at IMO 2014.

Finally we study the mark distribution at IMO 2013, and decide upon the medal cut-offs: 15 for bronze, 24 for silver and 31 for gold.

Saturday July 27th There is a tourism opportunity in the morning, but all the UK participants take a rest. At 3pm we have a brief meeting of countries interested in EGMO (the European Girls' Mathematical Olympiad). The event will be held next year during April 10–16 in Antalya, Turkey, but thus far we have no host country for EGMO 2015.

In the afternoon we visit the Santa Marta botanical gardens, adjacent to the house where Simon Bolivar died in 1830. We are gathering for the medal ceremony. At this moment I am approached by the leaders of Belarus, Igor Voronovich and Sergei Mazanik. They have just received a message from the Belarus Ministry of Education that they are prepared to support an edition of EGMO. We pencil in Belarus as hosts of EGMO 2015. I am very excited about this excellent news.

There is a brief ceremony involving some ornately dressed soldiers, and IMO chair Nazar Agakhanov lays a memorial wreath. After that we have an outdoor medal ceremony, and finally return to the Irotama hotel for the farewell dinner round the pool (which was brilliantly planned) and the presentation of the *Microphone d'Or*. The competition for the most garrulous juror is organized by Rafael Sánchez of Venezuela. Rafael has asked me to make the speech, so I prepare some offensive remarks. Unfortunately Angelo is busy trying to check-in the Australian team for the flights home. We find his deputy, Ivan Guo, and he kindly agrees to substitute for his leader.

The usual characters crowd on stage for the ceremony, and speeches are translated into all official languages. Ivan accepts the golden microphone with a few well chosen insulting phrases about his leader, and honour is satisfied. Angelo beat me by one speech!

Sunday July 28th I wake up and check my email. There is a worrying message from Adam McBride that David Monk is in intensive care with heart problems. David has been a stalwart of UK IMO preparation since the 1960s, and he is known and loved internationally because of his beautiful problems. He is the most prolific author of IMO problems, having created no less than 13 over the years (he is sometimes given half a credit for another problem, but he repudiates this). He wrote the wonderful "New Problems in Euclidean

Geometry" a few years ago (published by UKMT). At breakfast I share this disturbing news with other leaders and it gives us all pause for thought. (As I write this report, the good news is that David is recovering well, and has just been allowed home.)

Indra Haraksingh from Trinidad and Tobago kindly tries to give me a T-shirt. I am flattered by the 2XL size label, but explain that this is not realistic. I look for the UK guide Maria and am disappointed to discover that she has already left for Bogota. Good luck to her at MIT.

The UK team catches the 10:30 am bus and arrives in good time at Santa Marta's *Simon Bolivar Airport*. We meet a Uruguayan contestant who is desperate for a hamburger. Presumably this is a form of homesickness. The airport, and subsequently our plane, fills up with IMO teams.

At Bogota we have little time to change planes, but the team are hungry so they demolish a quick meal. I go on ahead, and hear repeated calls for "Carlotti" over the tannoy. The whole team turns up oblivious to team member Andrew's new-found celebrity. My best guess is that he has dropped his passport in the loo, but no. It turns out that the Colombian customs authorities want to inspect his checked-in luggage. Bev and Andrew hurtle off to do the necessary. Fortunately they arrive back quickly, and we board as normal.

This time Bev has managed to persuade the airline not to ignore our food requirements, and people get the meals they want. This is an overnight flight, so we hope to sleep. I am initially disappointed to be trapped by an aisle seat passenger, but after inspecting her new neighbour, she magically disappears. It is a gift I have.

This means that I can spread sideways, leaving more space for my colleague Dominic. This is all very satisfactory. I insert earplugs which nearly, but not completely, cut out the loud conversation from the wretches behind who decide to flirt at volume while the rest of the plane is trying to sleep. Don't you just love attractive young people?

Saturday July 29th We arrive in Madrid a little after 9am local time. We have ample time to change planes and terminals and have a meal. We take a lunchtime flight to London. This turns out to be more exciting than we had planned. Just as we are about to touch down, the landing is aborted and the plane's engines scream at full power as we climb away at speed. When we are at a safe height, the captain explains that air traffic control called off the landing because the previous plane had failed to clear the runway in time. I looked up the statistics on this when I arrived home. It happens to about 1

landing in 400 at Heathrow.

The luggage comes through the excellent Terminal 5 system of belts and tubes in no time at all, and we go outside to be met by happy families. We distribute medal and participation certificates, and it is over for another year.

Thanks

Thanks to everyone who made this possible. Thanks to the the families and the Leeds Office of UKMT, and the small army of UKMT coaches and mentors and the organizers in Colombia. Thanks to James Cranch for having played such a key part in training over the past couple of years, and to my colleagues Dominic and Bev for countless kindnesses.

Finally I thank the students. Their behaviour was excellent throughout. They clearly enjoyed one another's company, and maintained an unceasing interest in working on mathematics problems before, during and after the IMO. Two are available for IMO 2014, and as for the other four, I give the University of Cambridge fair warning of what is coming.