Teacher notes – Glider Pilot Navigation Challenge KS3 Maths activity

- Essential prior knowledge:
- Speed, distance, time calculations
- Conversion of time between seconds, minutes and hours
- Knowledge of ratios
- Scaling ratios up and down
- Conversion between metres and kilometres

Introduction

Use the first section to establish what a glider is and what it can do. Elicit experiences from the class. Has anyone been gliding? Seen a glider in the air? Are there any gliding sites local to the school?

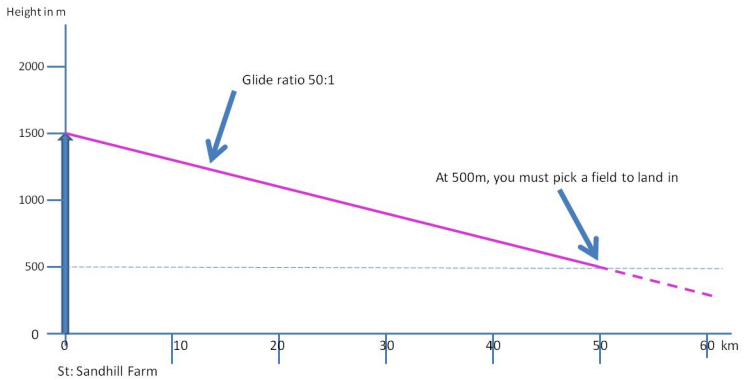
The video show how gliders get airborne. Winch launched gliders are attached to a cable. This cable is pulled in rapidly by a winch at the other end of the airfield. At the top of the launch the glider pilot releases the cable from inside the cockpit and is flying free. Aerotowed gliders get dragged behind a powered aircraft until they are at the height they want and then release the cable and fly free.

We show how gliders are able to stay airborne despite not having an engine. By turning in circles in columns of rising air called 'thermals' the glider can gain height. We fly from thermal to thermal using the lift we find to increase our height. Typical climb rates might be from 100-300m/min on a nice summer's day, sometimes more. Gliders generally climb up to cloudbase which is typically 1500 - 2000m.

Sometimes there are only weak thermals or no lift at all and we run out of height. In these scenarios we must head back to the airfield or, if we are not in range of the airfield, land in a farmer's field. This means you have to reserve some height to make sure you can get to a suitable field and to plan your landing - learning to land safely in a suitable field is part of our training and then we have to wait for someone to come and get us with a trailer.

We split the Challenge into two parts.

Part 1 - Glide Ratio – make sure students understand what this means. The higher the glide ratio the better as it means we can glide further. Pause the video at 'Over to you' and introduce the Challenge by handing out the first page of the student workbook. Q1 is about how far the glider can glide. Students should remember to save 500m to pick a field to land in!



Part 2 - Controlled Airspace

Students will be planning a cross country route between two airfields by using thermals. It won't be as straight forward as flying in a straight line though; we must avoid certain areas of sky known as 'controlled airspace'.

Watch and listen as our pilot explains these 'roads in the sky'. See how she flies through the gap between the forbidden areas of airspace.

INFORMATION BULLETIN - Controlled Airspace

There are a number of different types of controlled airspace which give protection to aircraft taking off and landing at airfields or travelling along the main routes between major airports. Some control areas are prohibited to any aircraft which is not flying under radar control with an air traffic controller. Some areas permit entry only when given permission by radio communication, and some require a transponder. As commercial airlines have become busier, more airspace has been created to ensure safe separation of commercial aircraft, however most of the sky outside the main airports remains as 'Class G' airspace, available to general aviation to fly without any need for air traffic control by simply maintaining a good lookout for other aircraft.

As aircraft fly all round the world, airspace design and standards around safety and efficiency are coordinated internationally by ICAO – the International Civil Aviation Organisation. For example, there is a standard barometric pressure setting of 1013mbs to ensure that instruments in a plane taking off from Tampa show the same height as one departing Oslo!

The next section explains the student challenge in more detail and sets out the route map. Draw students' attention to the start and end points, the blue direct route and the controlled airspace with their heights.

Discuss the competition rules with the students using the 'what you need to know' slide. Remind them that cloudbase at 1500m is as high as they can climb in each thermal, and In particular note the rule about planning to remain at least 100m above controlled airspace in case of sinking air that will make the glider descend quicker than your glide ratio suggests. Also important is the rule about staying above 500m – important to prevent having to make a field landing!

See example drawings in the Student notes – make sure your students understand that the baseline is the actual route you fly via thermals not a straight line to your goal airfield.

Pause the video at ' Good Luck' – there is some further information on finding out more once they have completed the Challenge. If time permits, please show our Inspiring People video of Heather, Air Cadet Gliding Instructor and Maths Teacher.

Whilst there is no single 'correct' answer, some key points on the challenge questions are as follows:

Navigation Challenge Questions:

1. If you glide from your start point at 1500m over Sandhill Farm, how far can you go before touching down?
   With a 50:1 glide ration, students might say 1500m * 50 = 75km BUT you need to save 500m to safely pick a field for a field landing, so 1000m*50 or 50km is a better answer

2. Given the airspace considerations, can you fly in a straight line along the track marked in blue on the map?
   No – you would descend below 1100m while crossing block A, and with a maximum height of 1500m, you certainly couldn't go through block E at 12,000m!

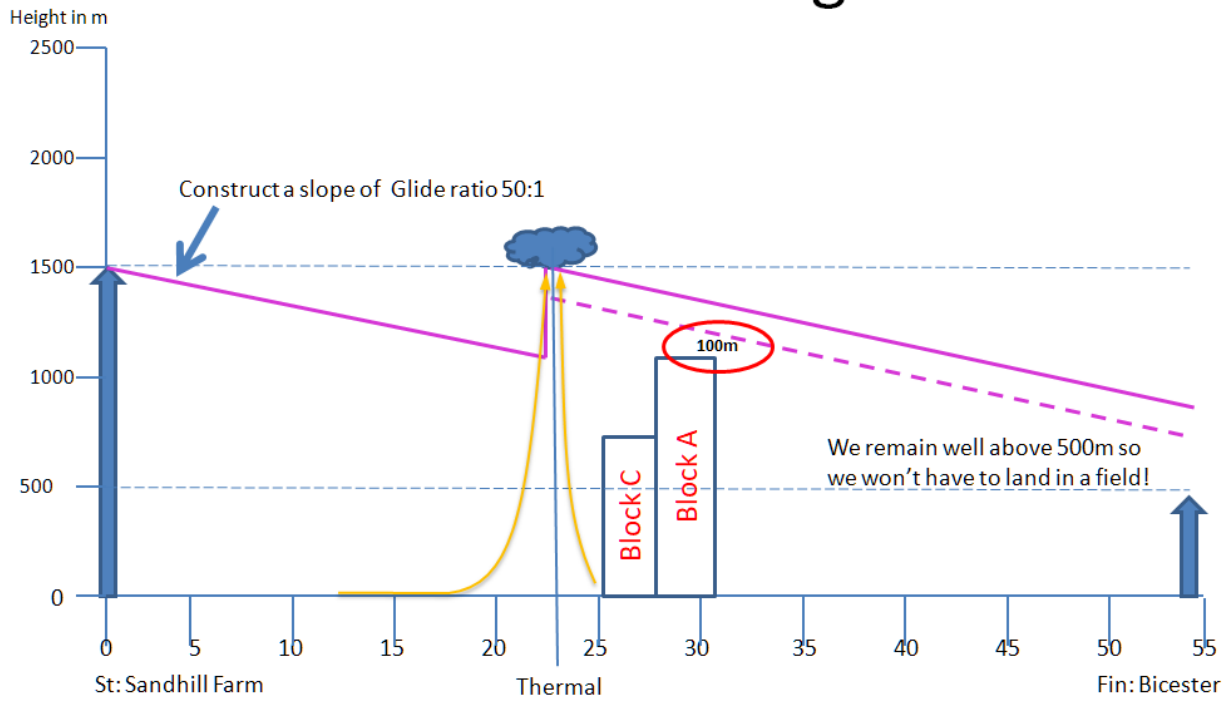
3. Work out a route that you can fly that will take you clear of forbidden airspace
   a. How far will you fly?
   b. How long will it take you to complete your course?

4. Construct a route diagram (like the example above) showing your height against your distance along the route and plot the airspace on the diagram

   An obvious route for 3 & 4 is via Thermal 6 at ~23km, climb to 1500m, then take a line that will just skirt the SE edge of block E (12,000m) – another ~31km. This route takes you across block C and block A, but you remain more than 100m above them. Your distance is 54km so calculate time en route based on 110kph PLUS the time you spend climbing in thermal 6 at 100m/minute. If you climb to 1500m in thermal 6 to be sure of getting to Bicester, you arrive at Bicester at around 880m – well above land-out height. So you can save time by only climbing high enough to clear Block A and remain above 500m at Bicester. These are all real-life en-route decisions every glider pilot has to take!

Starting at 1500m			Descent (m) @50:1	Height (m)	Minutes
Gliding a distance of km	23		460	1040	
climbing back to 1500m at 100m/min for				460	
will take					4.6
Flying 54km at 110kph will take				0.5	h
				29.5	minutes
So climb time plus glide time				**34.1**	**minutes**
But if you just climb to leave 100m margin above Block A, arrival Bicester is still >500m					
What height at 23 km will give you 1200m at 31km?				9	km glide
	9	km	180		
you must climb to				1380	
starting at 1040m climbing to 1380				340	
will take					3.4
Flying 54km at 110kph will take				0.5	h
				29.5	minutes
So climb time plus glide time				**32.9**	**minutes**

Vertical section along route



5. If you had been able to climb to 2000m in each thermal, would it have changed the course you are able to fly?
    a. If yes, what is the distance and how long will it take you to arrive at Bicester?

    Yes, you can fly across and remain above block A on a route just avoiding block E – it adds about 1km to the distance. You arrive at Bicester well above 500m. Time en route – 52km at 110kph, no time spent climbing en route.

Extension Task

6. Another pilot flies the route below and finds stronger thermals on her way, giving climbs of 150m/minute to 1500m – shown in purple.
    a. How long does she take to complete the course?
    b. Can you find a quicker route than she took?

    There are several answers! Try direct to thermal B – that gives enough height to get to Bicester.

We hope you found this useful and a fun way to encourage young people into the world of STEM and aviation. Girls in particular are under-represented in these areas and we are working to change this. Inspire them with videos of our STEM role models along with other exciting gliding-based STEM resources covering various elements of the National Curriculum on gogliding.uk and at www.gliding.co.uk/STEM.

Students can find out all about gliding at the British Gliding Association website www.gliding.co.uk and the Junior Gliding and Women Gliding communities at the links below. There's information about flying with and without an engine and all types of aviation at https://stem.caa.co.uk/ & www.airleague.co.uk – aviation is not just about being a pilot! The CAA STEM site is particularly good, showcasing the breadth of aviation and associated careers.

You can contact the Go Gliding team at gogliding@gliding.co.uk.

The student notes are overleaf.

As you progress through gliding, there are badges you collect to add to your qualifications. Today, you are going to attempt your first cross-country flight to gain your Silver Distance badge by flying 50km. Your challenge is to fly from your home gliding club at Sandhill Farm to Bicester – that's 50.9km in a straight line.

We'll explain in the video about two important concepts that you need to know before you can complete your Challenge:

- **glide ratio**, or how far the glider will travel for a given height loss
- **controlled airspace** – parts of the sky that you are not allowed to fly through, or are only allowed to enter under certain circumstances, for example when authorised by Air Traffic Control.

What you need to know:

- Your glider has a glide ratio of 50:1 at your flying speed of 110 kph
- You start directly overhead Sandhill Farm at 1500m and must arrive at Bicester at 500m
- You can climb in thermals whenever you find them – for today's exercise they are marked on the map as green stars. Each thermal gives a climb rate of 100m/minute to 1500m. While you are circling to climb, you stay in the same place.
- You don't have to take every thermal along your route but:
    - You must avoid forbidden controlled airspace – with a 100m vertical safety margin in case you find sinking air on your chosen route
    - You must stay higher than 500m – if you get down to 500m you must pick a suitable farmer's field and land! Challenge over!!!

Good luck with your Glider Pilot Navigation Challenge!!

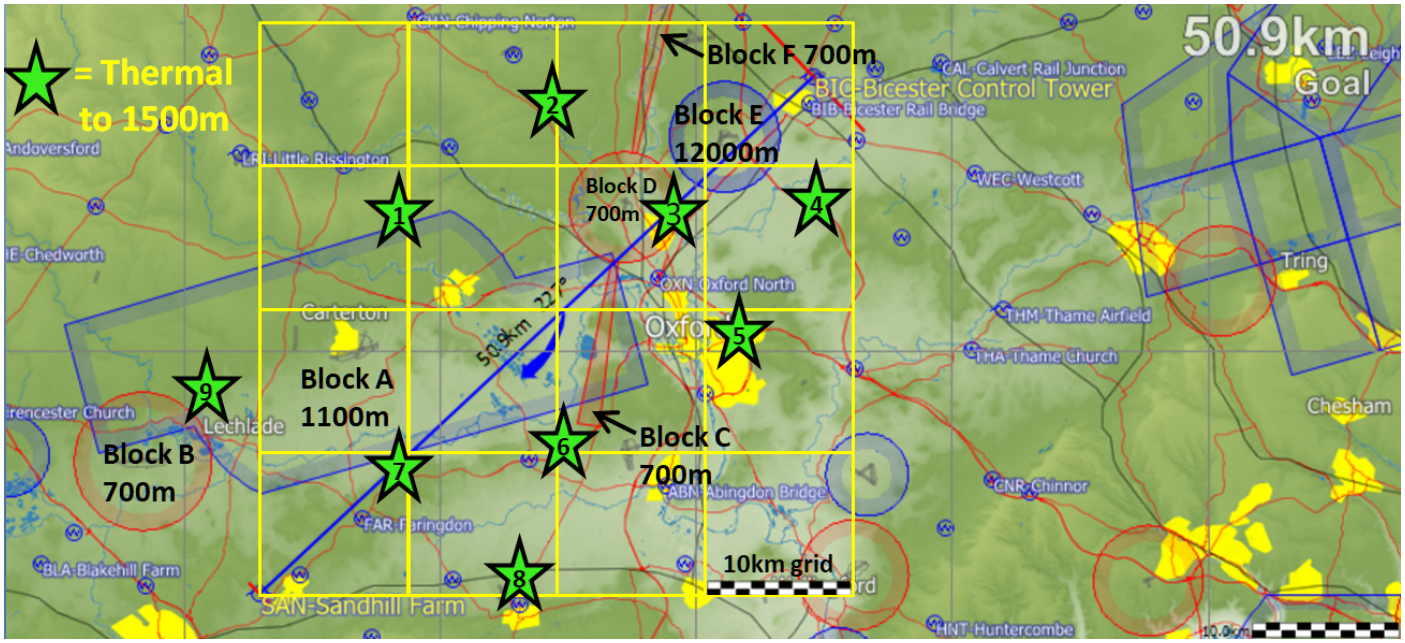
Navigation Challenge Section 1 - Glide ratio calculation

1. If you glide from your start point at 1500m over Sandhill Farm, how far can you go before touching down? Construct a chart showing this with height on the y axis and a start height of 1500m, distance in km as the x axis and a 50:1 glide angle.

>>> Now watch the second part of the video and learn about Controlled Airspace before going to section 2.

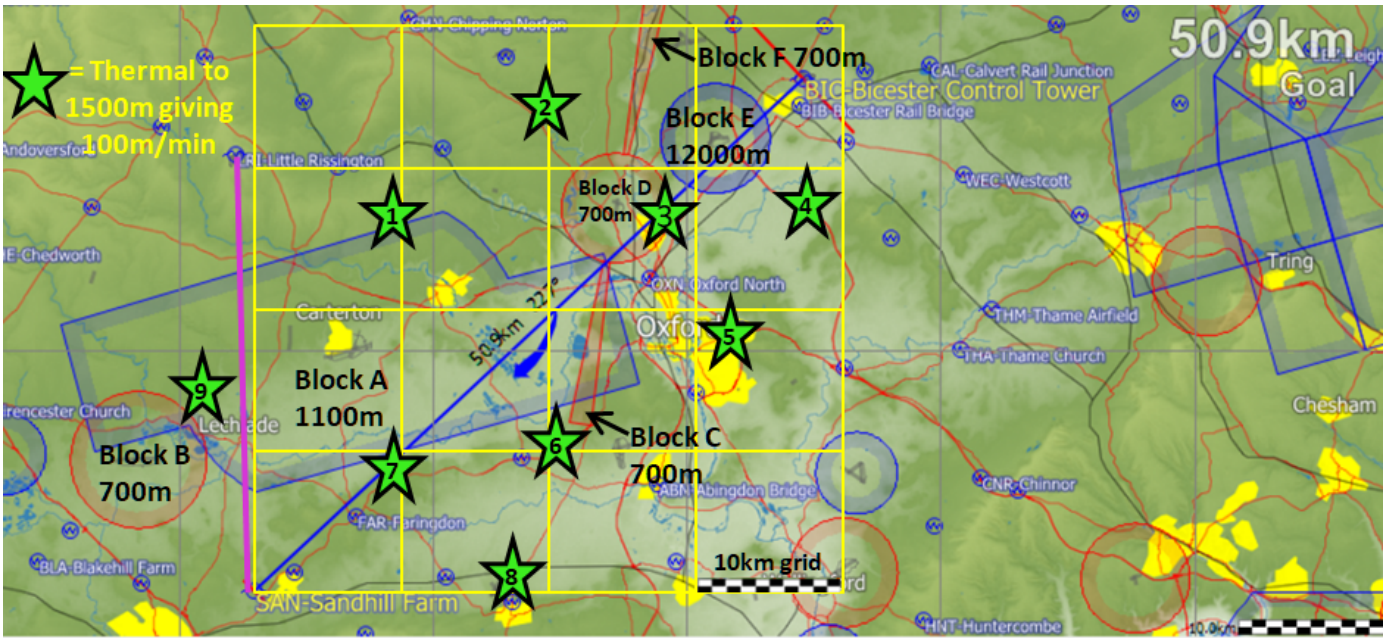
Navigation Challenge Section 2 – Avoiding airspace

Here's your air map with the task drawn on. You can scale distances from this map – the grid is 10km squares:



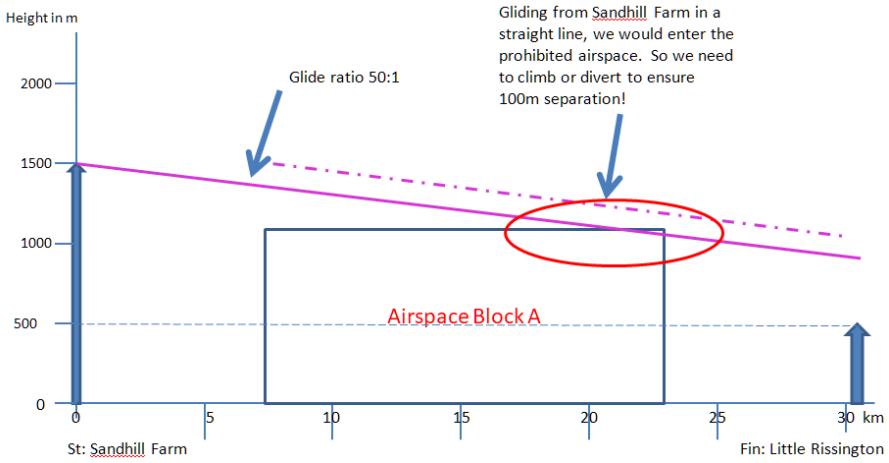
To help you answer the questions in this section, you'll need to interpret what your potential route would look like if you flew along it, bearing in mind the glide angle of your glider and where along that route you will encounter thermals and airspace.

For example, let's plot a route north from Sandhill Farm to another airfield, Little Rissington – along the pink line shown on the left below:



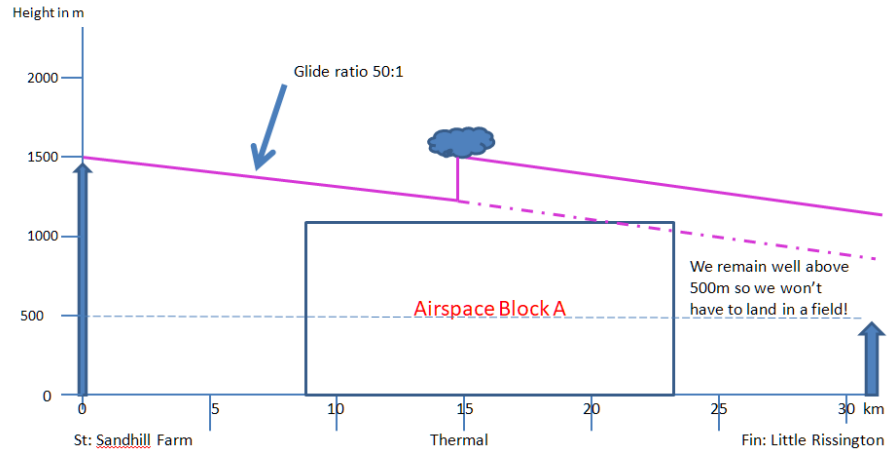
If we construct a vertical view along the route, what would that look like?

It would look like this:



Note that the diagram has **actual distance flown along your route on the X axis** whether or not your planned route is a straight line. Remember to stay at least 100m above any airspace you need to cross, and always above 500m to avoid having to land in a field. This diagram shows that we can't fly there direct – we certainly don't remain 100m clear shown by the dashed line, we actually go into the airspace.

So let's fly via Thermal 9. That gives us a plot like the one below – the distance is a little further so the baseline changes, and we meet the airspace at a different distance along our route:



Navigation Challenge Questions Section 2:

2. Given the airspace considerations, can you fly in a straight line along the track marked in blue on the map?
3. Work out a route that you can fly that will take you clear of forbidden airspace
    a. How far will you fly?
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4. Construct a route diagram (like the example above) showing your height against your distance along the route and plot the airspace on the diagram
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Extension Tasks

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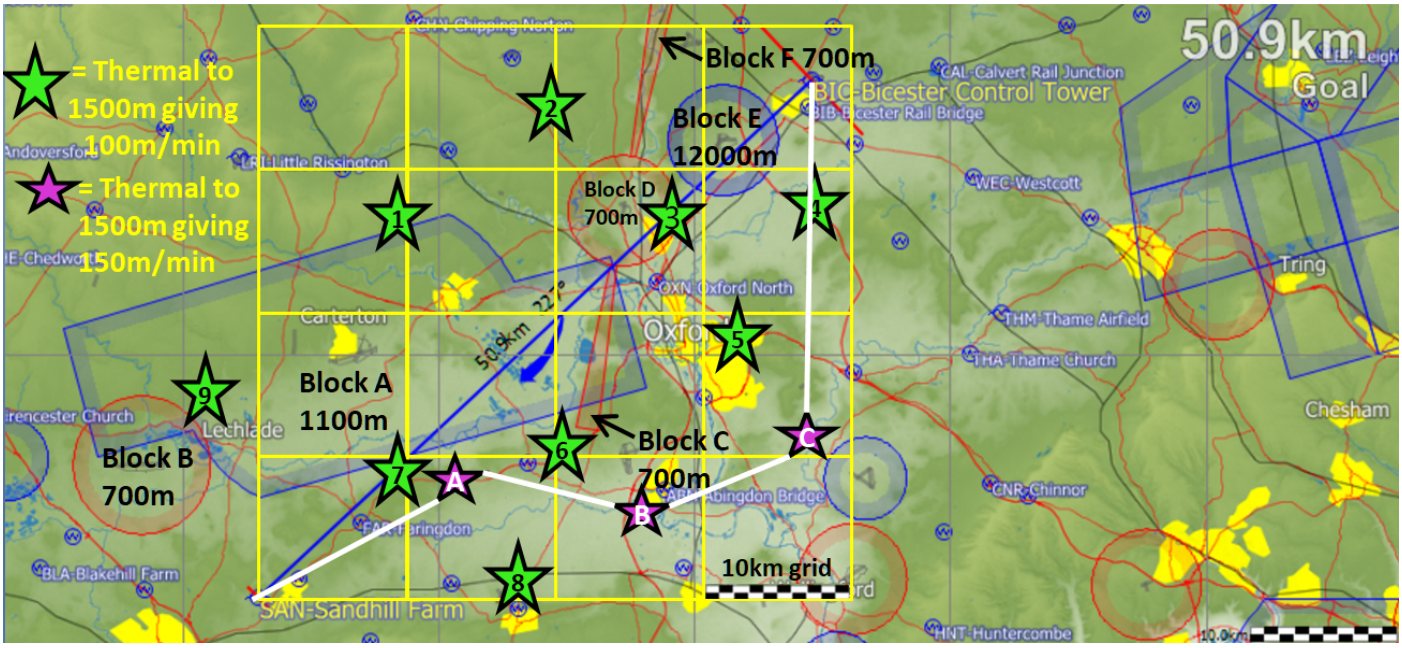

We hope you had fun learning about gliding and airspace!
Find out more about GLIDING at the links below, all types of AVIATION at airleague.co.uk & CAREERS at stem.caa.co.uk/careers-in-aviation-and-aerospace

Why not Go Gliding?
Find your nearest gliding club at https://www.gliding.co.uk/club-finder/

We hope to see you on an airfield soon!