# L2 - Unit 2 - The Understanding and Application of Microsatellites

# Relevant LINKS

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Handbook home page **[2]**

# Overview

**Understanding and application of microsatellites** at Gold Level requires the candidate to show a good understanding of the market place for microsatellites and similar technology.  This can include some of the main countries that develop or manage them.  Candidates will need to demonstrate that they know why satellites are made, and how they are made, such that they could propose a possible design and purpose for one.  They will demonstrate a knowledge and application of the factors which affect these devices since they will be deployed in space, as well as how they move around while up their and how they can be controlled.  They also need to explore some of the issues relating to satellites, such as who controls the data created and for what purposes as well as what happens when they return to earth.

**A work activity will typically be 'non-routine or unfamiliar' because** the task or context is likely to require some preparation, clarification or research to separate the components and to identify what factors need to be considered. For example, time available, audience needs, accessibility of source, types of content, message and meaning, before an approach can be planned; and the techniques required will involve a number of steps and at times be non-routine or unfamiliar.

**Example of context** – using some design software and hardware (i.e. a 3D printer) to design and/or build a part for a satellite.  Research and report for a company to build a satellite.

# Example of work at this level (coming soon)

## Assessor's guide to interpreting the criteria

***General Information***

**RQF general description for Level 2 qualifications**

- Achievement at RQF level 2 (EQF Level 3) reflects the ability to select and use relevant knowledge, ideas, skills and procedures to complete well-defined tasks and address straightforward problems. It includes taking responsibility for completing tasks and procedures and exercising autonomy and judgement subject to overall direction or guidance.

- Use understanding of facts, procedures and ideas to complete well-defined tasks and address straightforward problems. Interpret relevant information and ideas. Be aware of the types of information that are relevant to the area of study or work.

- Complete well-defined, generally routine tasks and address straightforward problems. Select

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and use relevant skills and procedures. Identify, gather and use relevant information to inform actions. Identify how effective actions have been.

- Take responsibility for completing tasks and procedures subject to direction or guidance as needed.

***Requirements***

- Standards must be confirmed by a trained Gold Level Assessor or higher
- Assessors must at a minimum record assessment judgements as entries in the on-line mark book on the INGOTs.org certification site.
- Routine evidence of work used for judging assessment outcomes in the candidates' records of their day to day work will be available from their e-portfolios and on-line work. Assessors should ensure that relevant web pages are available to their Account Manager on request by supply of the URL.
- When the candidate provides evidence of matching all the criteria to the specification subject to the guidance below, the assessor can request the award using the link on the certification site. The Account Manager will request a random sample of evidence from candidates' work that verifies the assessor's judgement.
- When the Account Manager is satisfied that the evidence is sufficient to safely make an award, the candidate's success will be confirmed and the unit certificate will be printable from the web site.
- This unit should take an average level 2 learner 40 hours of work to complete.

***Assessment Method***

Assessors can score each of the criteria N, L, S or H. N indicates no evidence. L indicates some capability but some help still required. S indicates that the candidate can match the criterion to its required specification. H indicates performance that goes beyond the expected in at least some aspects. Candidates are required to achieve at least a S on all the criteria to achieve the full award.

***Expansion of the assessment criteria***

## 1. Candidates will show an understanding the current place in the market of microsatellites.

### 1.1 I can review the current status of microsatellites in terms of global production and main countries involved .

Candidates should be able to show they understand the most current state of the market for microsatellites.

**Evidence:** Documentation in portfolios, assessor observations.

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### Additional information and guidance

From 2000-2015, there were about 20-30 launches per year, on average, of microsatellites, but it is estimated that there will be 500+ launches in the next 5 years.
[https://en.wikipedia.org/wiki/Miniaturized_satellite#Microsatellites](https://en.wikipedia.org/wiki/Miniaturized_satellite#Microsatellites) [3]

Though the satellites themselves do not have to be hugely expensive, some of the equipment on them and the fact that they are required to be launched into space (which is expensive, most launches cost upward of £6,000,000 per device) means that the countries involved tend to be the more developed and wealthy nations. The above wiki page cites a small number of countries involved in the deployment, The main countries are the USA, UK, Spain, Germany, Japan, Canada and Mexico, though there are others. Candidates can explore a particular country and gather some information about how many devices are launched by the country. They can contact the companies to get some first hand data. If all students work on different countries, they can compile all the data for the group and have a better collective understanding. Candidates do not need a detailed understanding of the market, but should be able to show that they appreciate the key players and have a sense of specialisation from each.

### 1.2 I can list and define the key uses of microsatellites.

Candidates should be able to demonstrate they understand the range of microsatellite use.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

The primary use of most satellites is for the purpose of communication and we are increasingly dependent on them for things such as GPS tracking. Many candidates will be familiar with the use of GPS in cars and also that their smartphones can tell them exactly where they are. All of this information is possible because satellites are circling the earth and bouncing data back and forth. Candidates will also use tools such as Google Maps to look at locations. The detailed maps are a combination of GPS data, satellite images and images taken by driverless cars from the ground. This data makes travel much easier and more consistent as you can explore a new venue before ever being there. The other key driver of satellite usage is for research. Large and powerful satellites are used by national weather services to track the weather as it has a huge impact on a country's economy, such as knowing if the harvesting of food will be damaged by Summer storms or tracking hurricanes to minimise damage and loss of life. These types of systems can also be used on a smaller scale for something like University departments. Most Universities could not afford to build or launch low earth orbit microsatellites in order to carry out investigations about something like pollution levels or checking for different particle elements in different layers of the atmosphere, however, since the research is so important, national government tend to pay the bills.

Candidates can explore this area and find a number of different uses for microsatellites and as with the previous criterion, if they work in teams in different areas, they can share and compile their findings.

### 1.3 I can describe the main launch vehicles used for deployment and their characteristics .

Candidates should be able to describe a number of launch vehicles.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

Microsatellites are sometimes launched as secondary devices in main satellite deployments, but this does not always address the need for specialised orbit levels and flight paths, so increasingly there is a need to develop launch vehicles specialised for small satellites. The companies that are currently

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working on this are from the UK, US, Switzerland and Spain.

UK - Virgin Galactic
US - DARPA, Garvey and Boing
Switzerland - Swiss Space Systems
Spain - PLD Space

Each of these companies has a different approach to getting devices into LEO (Low Earth Orbit) and are possible trying to make themselves special in the market place.

Candidates can investigate these different companies and describe some of the USP (Unique Selling Points) of each of their launch solutions. They can list some of the characteristics such as: what height or range of heights do they operate in; what is their payload; what is their general cost etc.

**1.4 I can define the main versions of microsatellites including nanosatellites, picosatellites and femtosatellites .**

Candidates should be able to show they understand the basic differences between the main microsatellites.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

The most obvious difference between these devices is in their weight. Candidates will know from earlier units on rocketry that the more weight involved in a launch, the more expensive it becomes in terms of the fuel needed to get into orbit. Due to their weights and size, they should be capable of different tasks and carry a range of equipment. As technology evolves and more miniaturisation occurs, these may become blurred. It does not seem like much technology can be packed into a 100g femtosatellite, but when you consider that a Raspberry Pi Zero only weighs 31g and is a full blown computer, it does give some sense of the possibilities.

Candidates need to list the main characteristics of each device and give some broad examples of the type of equipment they might carry, perhaps with some images and descriptions.

**1.5 I can assess the current market in microsatellites.**

Candidates should be able to show they can appreciate the reasons behind some of the market information.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

The microsatellite market is an extremely exclusive one as it is very expensive to enter. As t is difficult to enter and expensive, it means that there is a lot of money to be had and not really enough people to understand it well enough. This criterion will allow candidates to use a more critical eye to look at the market place of microsatellites. Most companies that are advertising the ability to launch microsatellites are basing the ability to do this on future orders. The tell customers they “should” be able to do it, so customers give them some money in advance for it to happen, but that does not mean it will happen. As the launches and technology to launch are based on a great deal of theory, there is no guarantee involved. Virgin’s launch vehicle had a setback as the first test flight ended in tragedy which would have caused some customers to cancel their orders and these orders will have been used to borrow money in order to build and test the launch vehicles. Many companies said they could launch for a certain amount, i.e. £6,000,000 for a 100kg device, but when it comes close to the actual launch time it turns out to be closer to £10,000,000 because of factors such as increasing fuel or development costs that they were unable to predict. Many of the pieces of information
saying this industry is worth millions of pounds are coming from the very companies that stand to

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make all of the money. How much can we believe?

Candidates don't need to be shrewd market traders, but should be able to get enough information, with guidance, to be able to see what is hype and what is possible in this volatile and fast moving market.

**2. Review and define the key issues in making a microsatellite.**

**2.1 I can understand the need for size reduction in satellite technology .**

Candidates should be able to show they understand the implications of size and weight on the success of satellite technology.

**Evidence:** Documentation in portfolios, assessor observations.

**Additional information and guidance**

Candidates may already have explored issues about size and weight in the unit on rocketry and should appreciate the relationship between some of the forces involved. The energy required to get a 100 kg satellite into orbit is considerably more than a 1 kg one. Some of this need for size and weight reduction is driven by improvements in technology and miniturisation of components, but also by the drive for efficiency. The cost of launch will always be relatively expensive so manufacturers will always be trying to save weight and therefore cost. It might also mean additional business as companies that do have the capability to launch a 100kg payload can launch several smaller satellites and therefore make more money as they can charge each company and the sum of all companies may well be more than the total of the one.

Candidates need to show, with examples, that they understand some of these issues and that they have a good understanding of how and why manufacturing companies and designers of satellite technology will try to go for smaller systems and designs.

**2.2 I can describe some of the key materials used in construction and say why they are used .**

Candidates should be able to list and describe a number of the main construction materials used, giving reasons for their choice.

**Evidence:** Documentation in portfolios, assessor observations.

**Additional information and guidance**

Demonstrate the various forces and pressures on devices as they pass through different layers of the atmosphere and in their journey there will determine some of the material needs required. Once the devices are in orbit, there will be different forces and pressures on their components. As they accelerate through the atmosphere there will be gravitational forces and pressures as well as temperature changes working on them. Each material will need to be capable of withstanding some of these extremes. The temperature at launch will probably be 20-30 o C, this will increase to 100s or 1000s of degrees during flight, but by the time it is in orbit this could be as low as -269 o C. Candidates should appreciate that this range of temperatures will cause large extremes of expansion and contraction of materials. Materials need to be considered for this range of extremes. The other issue, once the satellites are in orbit, is they are no longer protected by the Earth's magnetic field or atmosphere and will be subject to higher levels of solar radiation. Many scientists are working on ways to reduce the damage and disruption caused to satellite technology due to these.
What materials might be used to reduce or deflect these damaging waves?

**2.3 I can describe the main forces acting on satellites in their life-cycle and how this affects their manufacture .**

Candidates should be able to show they understand the basic forces that satellites need to endure.

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**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

This criterion ties in with the previous one in looking at the forces working on satellites from “cradle to grave”. What materials can be used to not buckle and warps at temperature extremes. How can engineers choose materials that will not be damaged beyond repair once they are bombarded with different types of radiation. If the satellite is at the end of its life and reenters the atmosphere, what materials need to be used that will disintegrate and not fall back to earth to cause other issues. These are some of the issues that candidates need to explore and think about solving.

### 2.4 I can describe the main forms of communication used in microsatellites and give examples of their usage .

Candidates should be able to show they understand the ways that engineers control their devices.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

Depending on the purpose of the satellite, it will doubtless have a range of functions and these will need to be controlled from Earth. Some of the functions will relate to how the satellite works in the environment, so moving and adjusting its flight, perhaps twisting to keep facing the sun or down towards Earth etc. The instructions required to keep the satellite functioning effectively will need to be sent to the device and it will need to be able to send back signals that it has acted on these or not. As with any computerised system, if there are any problems, or potential problems, it needs to transmit these so that some action can be taken. Once it is in orbit, there is little that can be done, but there are likely to be some self- healing functions to try and make sure it can carry out the tasks it needs to. If the satellite is constantly transmitting information, the engineers need to work out the best way to do this. Transmissions of any description will require a transfer of power, albeit this may be small, so how might this be managed efficiently? What are some of the limitations of different communication and transmission system in terms of distance and data volume that can be carried? How can these be used effectively?

### 2.5 I can develop a list of requirements in the manufacture of a microsatellite .

Candidates should be able to use their knowledge and understanding to put together a simple shopping list of requirements.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

The candidates have explored some of the key ideas in microsatellite design and manufacture and considered carefully the impact of forces and the environment on their devices. They should not be able to put together some of their findings in terms of a list of possible elements. This will include some of the manufacturing materials required, some of the communication devices and types etc. This is bringing together all of their findings from earlier sections of this unit. In the case of materials, they should evidence some of the characteristics that have informed their choice, so for example, they would recommend a certain alloy for the frame
of the device because it does not distort with extremes of temperature, or some type of plastic shielding for the communications elements as the material is not as badly affected by gamma rays.

### 2.6 I can devise my own basic design for a microsatellite and define its purpose .

Candidates should be able to construct a basic diagram of their microsatellite with labels for key components.

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**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

The candidates can draw their designs on paper or use some computer assisted design software if they are able. They should use their acquired skills and knowledge to put together a basic design of their own microsatellite and label some of the main parts. The labelling will reflect what they understand about materials and if they want to, though it is by no means a requirement, they could write a detailed summary of the main parts with some descriptions of the materials used and why. This is likely to cover other criteria in this unit. In order to differentiate their satellite purpose from more general purpose satellites, they might include a short description of what data the device will collect and how that might be used. This information could be part of another criterion in the qualification.

Some guidance may be necessary from other subject areas, such as some explanation of the use of GPS data or temperature fluctuations as used in modelling such as weather or travel issues.

If their device is for high resolution photographs for a specific purpose, they may include the dimensions and specifications of the camera to be used.

At this level, it is not expected that candidates are experts in their field, but should be able to demonstrate a good depth of understanding around their chosen topic and show that they understand how the equipment used, such as a camera, will impact on how the device is made and any weight considerations.

The following site lists a number of uses for a specific satellite, showing some of the range.

http://www.nesdis.noaa.gov/jason-3/spacecraft.html [4]

## 3. Understand the key issues in space deployment.

### 3.1 I can appreciate the cost implications of getting equipment to space.

Candidates should be able to show they understand the relationships between weight and size and cost of deployment.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

The science behind this is quite complex to explain, but a basic understanding of power to weight ratios should be enough here.

Candidates can use the Kerbal program to test out their theories as it will output some data to tell them how much power is being used and they can see if they can get into space with a certain weight of object. It might be worth searching the Kerbal forums or posting a question there.

http://forum.kerbalspaceprogram.com [5]

Current estimates (using quora.com) are that a payload of 454g (1 pound) would cost £7,600 ($10,000). This is the total cost of the rocket and the fuel. The rocket is the expensive bit and the fuel is about 1/10th of the cost.

More details might be available through sites such as NASA’s resources for schools.

http://www.nasa.gov/education/resources [6]

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The criterion only states an “appreciation”, so there is no need, unless interested, to go into huge amounts of detail.

**3.2 I can describe key terms such as “piggy back” in terms of deployment and gives examples of how it is used .**

Candidates should be able to show they understand some key terms used and show their understanding with clear examples.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

The above criteria should demonstrate that getting stuff into space is not a cheap undertaking. Different ways of minimising the cost need to be explored, though as the criterion suggests, the most common is probably the use of a piggy back. This is a straightforward criterion to allow candidates to explore the different methods and give examples of how they work and why.

Given the cost of deployment and the increasing need of devices, there is not enough capacity so there are many satellites waiting to be launched but can’t be for several years. This might not be too big of an issue, but what happens if an important satellite suddenly malfunctions and needs replacing?

One possible solution here is to use jet aircraft to at least get some launcher close to space so that the energy needed to make the final step is not huge. This is not quite a piggy back in the traditional sense of being on the “back”, but is the same idea. The jet travels as high as possible and then launches a device like a rocket from its undercarriage. Like all of these ideas, there is an acronym for it, which is ALASA (Airborne Launch Assist Space Access).

https://youtu.be/BOaJWoVLhAc [7]

A more well known example of this might be the US Shuttle which used to be launched on top of a rocket.

Candidates can explore this technology and possibly comment on how effective they think it might be.

**3.3 I can list and define the main propellants used by microsatellites .**

Candidates should be able to document some of the propellants used in satellites and their characteristics.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

This will tie in with the rocketry unit to some degree, but the propellants used for getting devices into orbit may not be the same as the ones used once there. In most cases a device will not need to move around that much once it has achieved its orbital place, and most of its direction and placement can be controlled through the use of solar panels delivering energy supplies. However, there may be occasions when the device needs to adjust more radially or move to a different location and for this it needs slightly more power. Most devices will be built with small thrusters, depending on overall size and purpose, and most of these thrusters will be propelled by some chemical based on Hydrazine. There are various compounds based on this base product, depending on the requirements and other factors. The main characteristic is that it breaks down in a reliable way and produces energy which means that it can be used reliably and predictably in space devices. Small amounts can create large amounts of thrust which means a small payload on a microsatellite could help it maneuver for many decades without any problems.

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Students can produce basic tables listing the elements and giving some of their basic characteristics such as:

| Propellant name | Main chemical (s) | Type | Comments |
|---|---|---|---|
| Anhydrous Hydrazine | Nitrogen and hydrogen ($N_2H_4$) | Liquid | Absorbs a lot of water from the air (hygroscopic), so hard to handle |
| Monomethyl Hydrazine | Carbon, hydrogen, nitrogen ($CH_3NHNH_2$) | Liquid | Absorbs a lot of water from the air (hygroscopic), so hard to handle. Strong hydrogen bonding. |
| ALICE | Aluminium | Powder | Small particles of aluminium that react with H and O in water to create energy. Can be made on moon and Mars |

It is not expected that candidates understand the complexities of the chemical, but should have a good overview that there are liquid and solid variants and some of the elements involved.

Other propellants can be discovered and commented on.

**3.4 I can describe the main strengths and weaknesses of the main propellants used in space.**

Candidates should be able to show they understand some of the characteristics of propellants.

**Evidence:** Documentation in portfolios, assessor observations.

**Additional information and guidance**

The key thing about propellants is that they are stores of energy and therefore, quite dangerous. The main ones used in space are also, as observed in the previous criterion, hygroscopic which means they would leach water from anything they come in contact with, including our hands. This criterion and the previous one can be combined so that candidates can gather information about the main propellants, but also offer some descriptions of their merits. They should be able to demonstrate that one propellant might be more useful as a fuel to get into space as it works more safely in our atmosphere, but would be unsuitable in space because of the freezing temperatures there, or conversely, one works in space, but not on Earth so well. The assessors will be looking for a good overview of how
candidates judge what is useful and why.

**3.5 I can describe the different levels of orbit used in microsatellite systems.**

Candidates should be able to show they understand the different orbits in terms of their distance and characteristics.

**Evidence:** Documentation in portfolios, assessor observations.

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### Additional information and guidance

Most satellites and microsatellites are positioned at a certain point away from the planet in order to maximise their functionality. Some stay in a fixed position and distance, while others circle around the planet. Each of these takes a different set of equipment to manage. The closer the device is to the Earth, due to gravity, the faster it will move.

There are 3 different types of orbit that are generally used.

### High Earth Orbit

Satellites in this orbit are designed to match the Earth's rotation so they can map specific areas over long periods of time. An example here is a weather satellite that would be used by a specific country to know the weather for the country every day. In order to be in this position the satellite needs to be 36,000km from the surface. Although “stationary” in relation to earth, they are still travelling at 11,100km per hour, as is the Earth. As noted earlier, any closer and the device would begin to speed up and not be synchronous with a spot on the Earth. Since they are quite a distance away from the Earth, they can also be used to monitor the Sun’s activity, particularly measuring the burst of radiation that come from the Sun from solar flares as these are damaging for radio equipment on the planet.

### Medium Earth Orbit

Satellites in this orbit will take 12 hours to pass around the Earth and will be positioned at 2,000-20,200km from the surface. The most common use for devices at this altitude are GPS (Global Positioning System). The orbit is very predictable and constant which makes it ideal for GPS systems so they can be constantly updated on their position and speed, such as in car navigation.

### Low Earth Orbit

The satellites are generally used for very specific purposes, such as specific weather checking. For this purpose, a satellite will be launched to monitor a very small region, such as the one launched to monitor only the rainfall in the tropics. Since the tropics is a specific section of the Earth either side of the equator, the satellite needs to stay in this region above the earth. The altitude for this will vary, but will generally be between 180-2,000km from the surface.

There are quite a lot of objects now in LEO, though most of them are “junk” such as debris from launches or disabled satellites. The following image is from a NASA web site that tracks the pieces.

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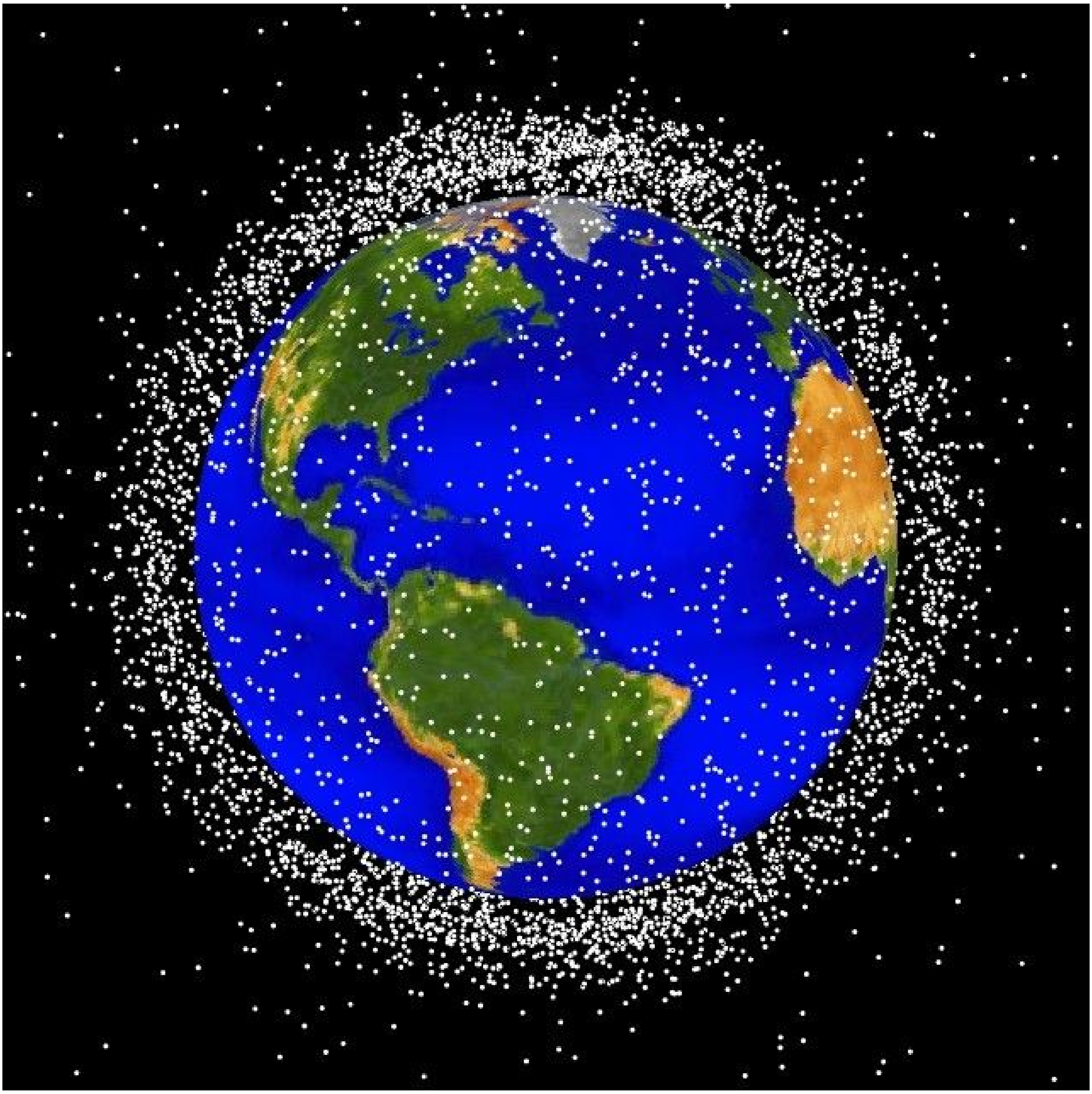

http://orbitaldebris.jsc.nasa.gov/Photo-Gallery.html [8]

Clearly there is a lot out there just above us.

Candidates need to show an appreciation of some of these numbers and give some examples to show their overall understanding.

**3.6 I can describe the main legal issues relating to microsatellites.**

Candidates should be able to show they understand some legal issues.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

The main considerations about microsatellites is perhaps related to ownership. Who actually "owns" space and how can it be managed?

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There are a number of potential legal issues that can be investigated including the following.

**Space Activity**

Anything that goes into space needs to be managed by someone, but only a certain number of countries have the resources to put objects into orbit. The US has the most objects in space, but can also put satellites up for other countries using their rocket systems, as can Europe, Russia, Japan etc. Who gives the authority to do all of this?

**Telecommunications**

Most countries now use satellites for their mobile phone systems and they will have a license to operate a satellite in their own country. However, many people travel to different countries and want to use their phones or other devices in those countries which means some international cooperation. How is this controlled and who is in charge if there is a problem.

**Observation**

At present, the governments are the only organisations that can afford to put satellites in space with advanced imaging capabilities. They can then share this image data with other organisations. However, they may only share information that is not going to cause them problems or embarrassment. With the cost of microsatellites and launches going down all the time, it could be possible that organisations like newspapers can have their own equipment and they might then be able to contradict the government, especially where governments are misleading people about military activities.

**Debris**

The amount of hardware in space is quite staggering. Some it will fall to Earth and some of it might cause damage to people or property. If an American device falls to Earth in the UK and damages people, how will damage compensation be retrieved. What happens if a satellite loses control and crashes into a UK communications satellite and all of the customers lose their signal for many days. Who will fix the issue and pay for the customer’s inconvenience?

Some satellite uses are listed here with discussions.

https://quizlet.com/3838036/satellites-correction-legal-and-ethical-issu... [9]

These are some of the issues that can be explored and candidates are encouraged to think of their own examples to explore. There is likely to be a great deal of work in space jurisprudence in the years to come.

## 4. Investigate the control, data use and end of life issues related to microsatellites.

### 4.1 I can describe how microsatellites are controlled from earth.

Candidates should be able to describe some basic control mechanisms used in satellite deployment.

**Evidence:** Documentation in portfolios, assessor observations.

**Additional information and guidance**

Once microsatellites are up in space, they tend to be control through radio transmissions or other means as discussed in the next criterion. Most companies will have computer based control centres which will monitor the devices to make sure they are collecting the right kind of data and that they are not in danger of being damaged by other space junk. As with the control centres seen in TV

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broadcasts of US space flights, companies will have several computers and monitors looking at different aspects of the devices needs. Some computers will be controlling the movement of the device, while others will be making adjustments to the onboard sensors to make sure they are collecting the right kind of data. In some cases, they may need to recalibrate the collection equipment to make sure the data
being collected is fit for purpose. Other pieces of equipment might run basic checks on the collected data to look for problems before processing and releasing the results.

This Inmarsat infomertial shows some of the equipment in operation:

https://youtu.be/FCE27vAPd6I [10]

#### 4.2 I can describe how microsatellites are controlled while in space.

Candidates should be able to describe how these devices are controlled with some examples.

**Evidence:** Documentation in portfolios, assessor observations.

#### Additional information and guidance

The majority of microsatellites will be launched into a Low Earth Orbit, which candidates will have investigated earlier and will know to be 100-2,000km above the Earth. At these distances, the types of communication involved with talking to satellites and receiving their data are likely to be radio transmitter based systems. However, even this has some issues as different radio frequencies are absorbed or deflected by different parts of our atmosphere, so the usable frequencies for space are broadly 30MHz to 30GHz. This is not all usable however, since most countries use radio frequencies for various purposes on Earth, such as FM radio which operates between 88 and 108MHz. This would interfere with communications to satellites and vice versa.

http://www.spaceacademy.net.au/spacelink/radiospace.htm [11]

Candidates can explore this in as much detail as they are comfortable with, particularly if it overlaps with an interest in another subject, but the requirement is to show an understanding that microsatellites will be tuned to respond to some form of radio signal in this range and that this signal will send messages to the device to perform some operation and the device will use this frequency to transmit data, such as images, back to the control station on Earth.

The amount of control for LEO satellites will be higher as they are effectively being pulled back to Earth by gravity. The control systems will need to make adjustments to the device to make sure it stays at the correct heights and in the correct direction to carry out its functions.

There are 3 effects on LEO satellites that need to be adjusted to compensate for.

1. **Atmosphere** - the atmosphere, though thin, still drags on satellites so causing them to be more affected by gravity and being pulled closer and faster to Earth
2. **Solar Power** - when the Sun is hotter, it makes the air expand. The satellite is in a fixed orbit, so it is now moving through thicker air. Conversely, when the Sun is cooler, the air is thinner so the satellite needs to be adjusted more often.
3. **Crashes** - there is a lot of junk in space and all of it travelling at thousands of kilometres per hour, if there is a collision is creates a lot of extra junk. Satellites need to be adjusted to avoid this debris and not make more.

#### 4.3 I can review the types of data collected by microsatellites.

Candidates should be able to show they understand the different types of data available.

**Evidence:** Documentation in portfolios, assessor observations.

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### Additional information and guidance

This criterion can be combined with 3.5 above which is looking at where the satellites are placed in orbit, as this will determine what they can do. The candidates can extend the information in 3.5 to include more detailed examples of the different data that is collected. Some of this will be quite familiar to candidates if they watch the weather forecast on the morning news, then use GPS to get to school and then look at their school on a mapping program such as OpenStreetMap.

What other data could be collected?

https//www.ncdc.noaa.gov/data-access/satellite-data/satellite-data-access-datasets [12]

Candidates can explore the types of data available and give some examples of data that they find interesting or unusual.

### 4.4 I can review the dangers of microsatellites that return to earth when they finish their mission.

Candidates should be able to document some of the dangers of space debris.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

Candidates earlier explored the danger to objects in space, where 500,000 pieces are flying around at 28,000km/h. However, what if some of these objects manage to survive the burn up through the various layers of the atmosphere and come to Earth? In 2014 the amount of junk in space was estimated to be 5.5 million kilograms. Some of it can be quite big when it gets back to Earth.

Most objects will burn up and lose most of their velocity as they are quite small. It is estimated that if they do not burn up they will hit the Earth at about 100m/s (6,000km/h), though this is not as fast as their speed in space, it is still more than fast enough to kill someone and cause significant damage.

Candidates can explore as part of this ways to minimise this possibility. There are plans to build satellites in space that will destroy various junk. Other plans are for ground based lasers to destroy material as it enters the atmosphere and there are already instances where surface to air missiles have been used for large objects returning to Earth.

### 4.5 I can assess the impact of microsatellites and recommend a future use for them .

Candidates should be able to show they can think about the future of microsatellites and potential uses based on their understanding.

**Evidence:** Documentation in portfolios, assessor observations.

### Additional information and guidance

Having explored what satellites can do and what equipment they might be able to carry on board in previous criteria, what additional uses might there be? Candidates are encouraged to “think outside the box” and come up with their own ideas about what these devices might be used for. As part of this criteria, though it is not mandatory, they should be able to come up with a design of their own and specify what equipment it will carry and what data it will collect and transmit.

### Moderation/verification

The assessor should keep a record of assessment judgements made for each candidate guided by the above guidance. Criteria should be interpreted in the context of the general descriptors of QCF Level 1 qualifications.  They should make notes of any significant issues for any candidate and be in a position to advise candidates on suitable routes for progression. They must be prepared to enter

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into dialogue with their Account Manager and provide their assessment records to the Account Manager through the on-line mark book. They should be prepared to provide evidence as a basis for their judgements through reference to candidate e-portfolios. Before authorising certification, the Account Manager must be satisfied that the assessors judgements are sound. In the event of missing evidence, the assessor will be requested to gather appropriate information before the award can be made.

**Source URL:** https://theingots.org/community/osamtl2u2x

**Links**
[1] https://theingots.org/community/rocketry
[2] http://thelearningmachine.co.uk/tlm-l2-osamt-handbook/
[3] https://en.wikipedia.org/wiki/Miniaturized_satellite#Microsatellites
[4] http://www.nesdis.noaa.gov/jason-3/spacecraft.html
[5] http://forum.kerbalspaceprogram.com
[6] http://www.nasa.gov/education/resources
[7] https://youtu.be/BOaJWoVLhAc
[8] http://orbitaldebris.jsc.nasa.gov/Photo-Gallery.html
[9] https://quizlet.com/3838036/satellites-correction-legal-and-ethical-issues-computers-flash-cards/
[10] https://youtu.be/FCE27vAPd6I
[11] http://www.spaceacademy.net.au/spacelink/radiospace.htm
[12] http://www.ncdc.noaa.gov/data-access/satellite-data/satellite-data-access-datasets

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