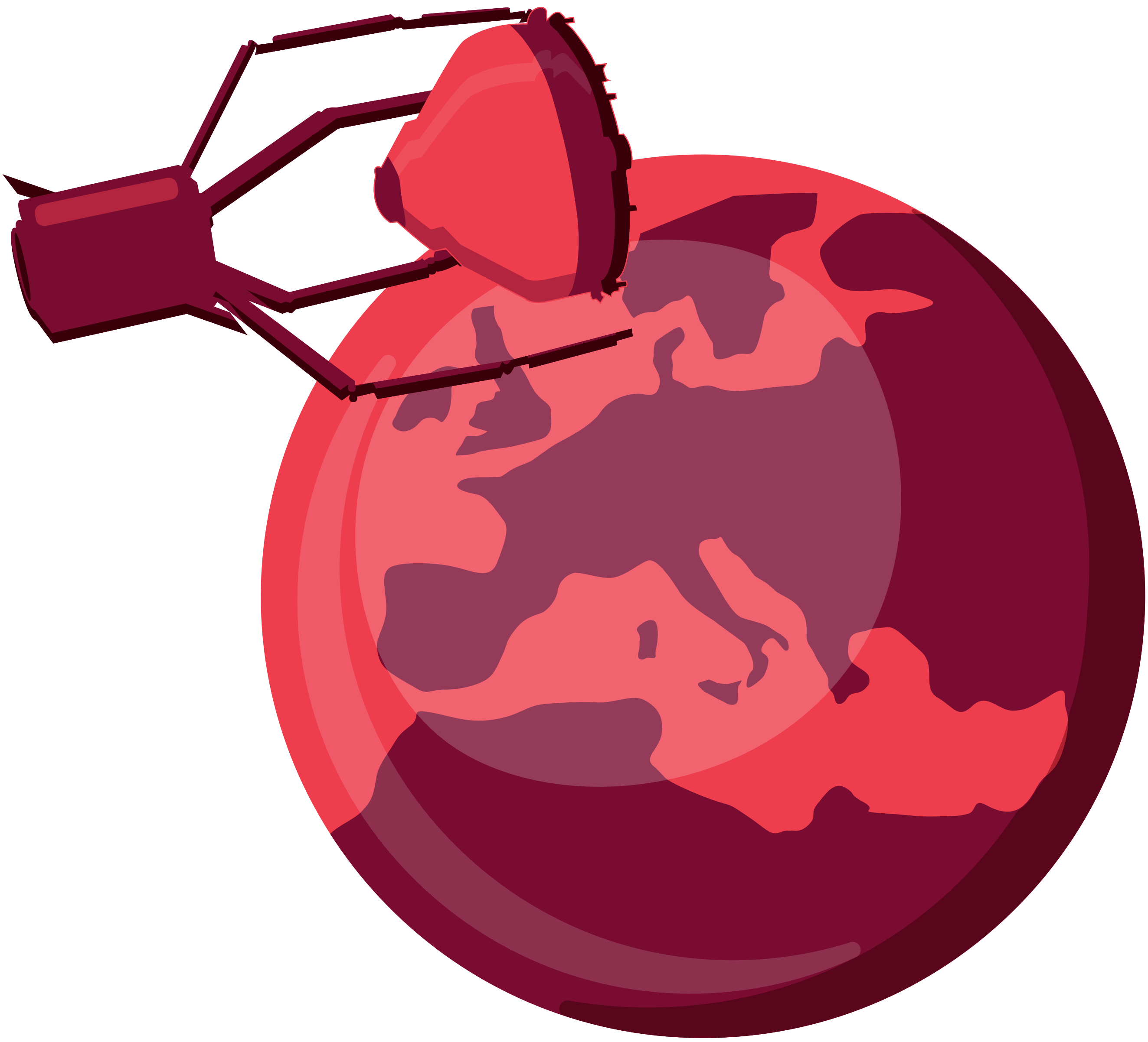
teach with space

→ CLEANING UP SPACE



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CLEANING UP SPACE

Fast facts

Subject: Engineering, Design, Technology, Science

Age range: 7-11

Type: student activity

Complexity: easy

Lesson time required: 5.5 hour

Cost: low

Location: Classroom

Includes the use of: computers or iPads (optional), sticky materials, glues

Curriculum area/keywords: Design Technology, Science: Earth and Space

Vocab: satellite, orbit, forces, spin, contact, grab, capture, debris

Brief description

In this set of activities, students will start by discussing their initial ideas for helping ESA and Paxi to remove space debris; then go on to plan initial designs for a debris capturing tool. They will investigate the implementation of unfurling 'tentacles', as well as comparing the effectiveness of various sticky materials. The students will then amend and enrich their designs, based on what they have learned.

Activities 1-3 can be done individually or as part of a set. Activity 4 is designed to build upon the knowledge gained in Activities 1-3.

Learning objectives

Having completed these activities, students will now...

- Understand what satellites are and how they help life on Earth
- Be familiar with different methods of debris removal, and have a basic understanding of their mechanisms
- Be able to draw inspiration from the world around them to approach scientific problems
- Be able to recognise when and how to set up comparative and fair tests, and explain which variables need to be controlled and why
- Understand that there can be multiple ways to approach the same problem, and that each method should be tested before implementation

Success Criteria

During these activities, students will demonstrate their ability to...

- Choose appropriate materials to design tools to tackle a specific problem, and explain their reasoning
- Use relevant scientific language and illustrations to discuss, communicate and justify their scientific ideas
- Design and build a prototype tool with a specific purpose
- Take repeated measurements where appropriate
- Decide how to record data and results of increasing complexity from a choice of familiar approaches: scientific diagrams and labels, tables and graphs

Activities 2 and 3 of these classroom resource are illustrated in the "Grab the space junk" video.

Summary of activities

Title	Description	Outcome	Requirements	Time
1. Grab that Space junk!	Students will model collisions between debris and satellites, and observe that one collision can lead to several more.	Students will learn that collisions between objects in Earth's orbit can lead to several more collisions, and that satellites burn up upon re-entry to Earth's atmosphere.	None	1 hour
2. Reaching the debris: Unfurling Tentacles	In this activity, students will explore the concept of unfurling tentacles, and how these might be utilised for space debris retrieval. They will first consider how such a mechanism might work, and will then go on to build their own unfurling tool.	Students will become familiar with different methods of debris removal, and have a basic understanding of their mechanisms.	None	1.5 hours
3. Grabbing the debris: Sticky Surfaces	In this activity, the students take on the role of space scientists to compare the effectiveness of various materials, sticky surfaces and glues in attracting and collecting 'space debris' represented by pieces of Lego.	Students will develop their ability to draw inspiration from the world around them to approach scientific problems, recognise when and how to set up comparative and fair tests and explain which variables need to be controlled and why.	None	1.5 hours
4. Design your own debris removal tool	In this activity, the students incorporate their experiences from all the activities to amend or improve their original designs. They go on to build a simple debris grabbing tool.	Understand that there can be multiple ways to approach the same problem, and that each method should be tested before implementation.	Designs from Activity 1, knowledge from Activities 2&3	1.5 hours

INTRODUCTION

A satellite is an object that orbits (circles around) a planet. There are several hundred natural satellites, or moons, in our Solar System. Thousands of artificial (human-made) satellites have also been launched since 1957. These have many different uses, including taking pictures of the Sun, Earth, and other planets, and looking deep into space at black holes, distant stars and galaxies. There are also communications satellites, weather satellites, and the International Space Station.

However, when satellites are no longer useful there is no simple way to retrieve or dispose of them, so they stay in orbit around Earth. This means that there is a buildup of space 'junk' around Earth, and this buildup is becoming an increasingly concerning issue – the more debris that accumulates, the more likely a collision is. Scientists and engineers are designing and testing technology to actively capture and remove space debris in search of the best ways to clean up space.

ESA is currently working on ideas to capture non-functioning satellites, using various capture methods including robotic arms, nets and harpoons. One of ESA's active debris removal projects involves using tentacle-like mechanical arms to capture dead satellites and drag them out from their orbits. The device would then plummet back towards Earth, and both will burn up when re-entering the atmosphere. Scientists are also taking inspiration from the world around them to develop debris-grabbing tools.

Grabbing things in space can be very difficult but a new robot that uses grippers, based on an amazing method inspired by gecko feet, might just be the solution to the problem. The robot can manoeuvre around in the microgravity of space, gripping and holding onto objects that have flat, smooth surfaces and even those that are curved.

Any concepts that scientists come up with need to be tested in various ways to judge their effectiveness and ensure they will work in microgravity. This set of activities challenges students to complete these tests, and use their findings to design their own debris-grabbing tool.

ACTIVITY 1 – GRAB THAT SPACE JUNK!

In this activity, students will discuss and describe the features of an active debris removal tool; they will go on to plan initial designs for a debris capturing tool.

Equipment

- Sheets of drawing paper
- Pens
- Pencils
- Felt tip pens
- Photos of satellites
- Access to computers or IPads if wished

Exercise

In this exercise, we will ask the students to draw what they think a tool to remove debris should look like.

In order to motivate them with this challenge, show the students the following Paxi animation: We see Paxi trying to help the satellite that appeared come back to Earth. Paxi asks the children of Earth to help him create a tool in order to grab this dangerous satellite and bring it back. Can the children think of any way to help Paxi?

Show the students the image of a satellite on **Activity sheet 1** and describe some of the important types of satellites and how they help us. Make a note of their shape and the materials from which they are made.

Ask the class:

- *What sort of tool do they think would be needed to capture a satellite?*
- *What would the tool be made from? Why?*
- *How might it work?*

Debris removal tools should be made from durable materials that can withstand high and low temperatures in space. It is also desirable for the materials to be lightweight because the heavier the load, the more fuel would be needed to carry the device into orbit by the launch vehicle. Satellites are usually made of a shiny metal (often even gold-plated) to reflect sunlight.

Allow time for discussion and designs. The students could use a design program on computer or iPad if available.

ACTIVITY 2 – REACHING THE DEBRIS: UNFURLING TENTACLES

Equipment per group of four

- Straws
- Crafts paper
- Sticky tape
- Scissors
- Ruler
- Elastic bands
- Lego blocks

Preparation

Introduce the lesson by showing this short gif that shows the unfurling of Clean Space tentacle-like arms.

1. *Ask the pupils if they can think of other examples of things that are coiled or curled that can be uncurled?* They might suggest examples from nature, such as the tongues of frogs, geckos or chameleons, octopus arms, a fern uncurling or a butterfly proboscis. See the Useful Links section for videos showing the above examples.

2. Split the class into groups and provide each group with party blowers. Encourage the pupils to discuss how party blowers work. Ask them to test the party blowers and explain the principle of inflation by air: when they blow into the party blower, the air will fill the paper causing it to straighten; when they stop blowing, there is no longer any force straightening the party blower, so it returns to its curled shape. Explain that the unfurling of the blower represents the uncurling of the debris capture tentacles shown in the video clip.

3. Challenge the students to follow the instructions on Activity Sheet 2 to construct their unfurling tentacle device. Their goal should be to create an unfurling arm to reach the debris, though it need not grab the debris at this stage. They can use photos, video or diagrams to record ideas and final design.

Discussion

The groups should demonstrate the effectiveness of their space debris 'tentacle' devices. Each group should describe their design and explore the following points:

- *What worked well?*
- *What did they find most difficult?*
- *What would they change to improve their prototype?*

Explain that space engineers would design, test, improve and retest their models many times before being satisfied with the final product – some designs may work well, some designs may not work at all, it is all part of the process.

ACTIVITY 3 – GRABBING THE DEBRIS: STICKY SURFACES

In this activity, the students take on the role of space scientists to compare the effectiveness of various materials, sticky surfaces and glues in attracting and collecting 'space debris' represented by pieces of Lego.

Equipment per group of four

- Glue sticks
- Sticky tape, duct tape, masking tape, double sided tape
- Magnetic Tape
- Velcro
- Lego pieces
- Activity Sheet 3

Introduction

Today the students will be space scientists, testing suitable materials or surfaces that could be used to capture space debris. They will be using Lego pieces rather than real space debris.

Exercise

Ask students to follow the instructions in activity sheet 3 (cardboard device) to make their own testing devices (one per sticky surface) in order to grab the debris. Once they have build their grabbing device, ask them to test the glue sticks, sticky tape, duct tape, masking tape, magnetic tape, and velcro to try to grab the lego pieces that represent the debris. Ask the students to annotate their findings (how sticky the materials are) in the table below in activity sheet 3.

Discussion

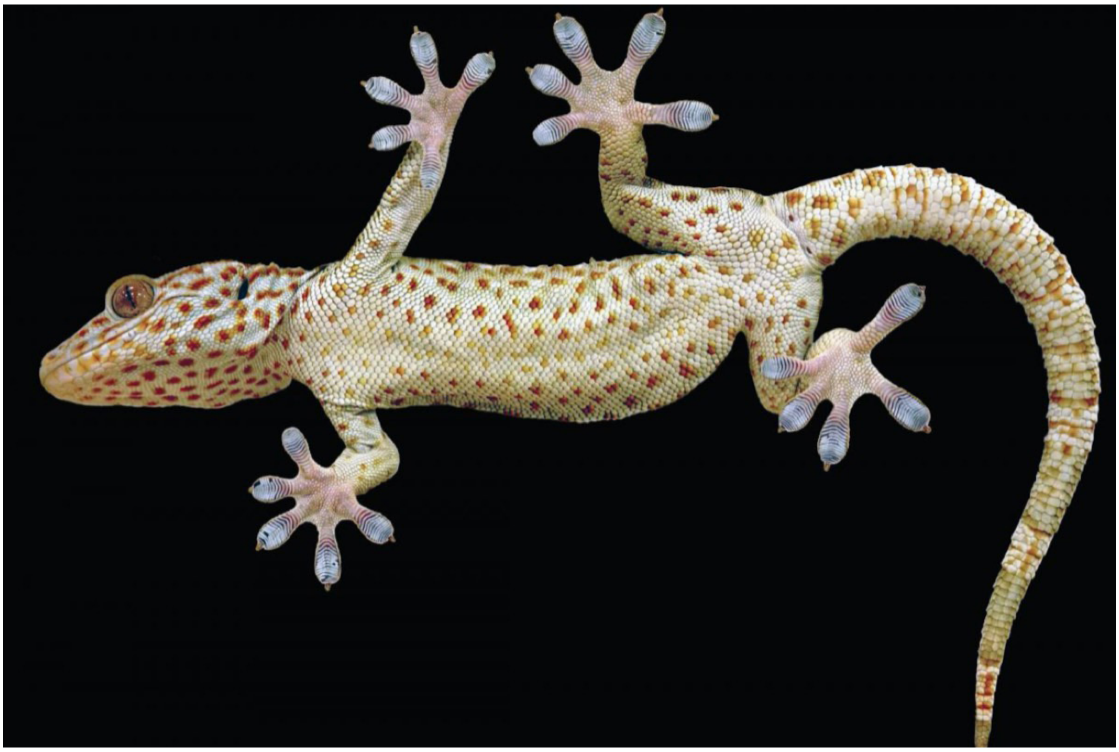
Collate the investigation results from each group and display them for the class to see. Ask the groups:

- Which coating or surface did they find most effective at capturing the debris? Which was the least effective? Can they put the materials into order of stickiness?
- Which materials would they recommend?
- How would they improve their test next time?
- Explain that sticky materials can behave very differently in space. Can they think why?
- Which of their testing materials do they think would work best in space?

Explain that methods used on Earth to grab things don't work in space. Normal adhesives stop being sticky in the cold vacuum of space, and even sticking down a piece of tape requires enough force to make the object you're adhering it to float away! Scientists can test how materials behave in space in planes being flown by trained pilots at high speed and performing parabolic flights.

DID YOU KNOW?

- Scientists have tested sticky surfaces inspired by geckos feet for collecting space debris. Geckos have lot of tiny hairs on the soles of their feet – these provide grip because there are so many of them in contact with the surface of the wall.



ACTIVITY 4 – DESIGN YOUR OWN DEBRIS REMOVAL TOOL

This activity builds upon Activity 1-3 that challenged the students to use their creativity to design a tool to capture space junk. Here, the students incorporate their experiences from all the activities to create their original designs. They go on to build a simple debris grabbing tool.

Equipment

- Thick/thin cardboard
- Paper
- Cardboard tubing
- Straws
- Glue
- Brass fasteners
- Paper clips
- Sticky tape
- Stapler
- Activity sheet 4A and 4B

Exercise

After reading the letter, ask the students to prototype their own reaching and grabbing debris device, which should have both functions (reaching and sticking the lego piece). Points to consider may include:

- What changes, if any, would they make to their designs using information learned from latest space debris capturing missions or techniques tried in activities 2 and 3?
- Would they like to combine aspects of their designs?

Explain that they are going to take on the role of space engineers. Challenge them to work together to build a space junk grabbing device. They should amend and enrich their designs and consider the materials they will need. Allow time for the students to build and test their prototypes. Encourage the students to take photographs or videos of their work at different stages of construction.

Discussion

Gather the students and ask them to describe and demonstrate their prototypes. Some points to consider during the discussion may include:

- *How does their device work? Is it able to capture a piece of space debris represented by pieces of Lego or other suitable objects?*

- *Show the class images of ESA's ClearSpace mission designs, what are the basic differences between their designs and ESA designs?*

Remind the students that engineers expect to test and improve a prototype many times before a final product is agreed; this is called the engineering process. End the lesson by encouraging the students to upload their designs and models onto the ESAKids website.

Useful links

ESA resources:

ESA classroom resources: www.esa.int/Education/Classroom_resources ESA Kids homepage: www.esa.int/kids

Useful information about satellites and their uses can be found on ESAKids website here: https://www.esa.int/kids/en/learn/Technology/Useful_space/Satellites

Videos of unfurling tentacles in nature:
Gecko tongue unfurling: https://www.youtube.com/watch?v=E76YBF3PoKo

Octopus moving: https://www.bbc.co.uk/newsround/32335519

Fern timelapse: https://www.youtube.com/watch?v=9c9Zi3WFVRc

Read more:
https://www.newscientist.com/article/2139071-gecko-inspired-robot-has- grippers-that-could-clean-up-space-junk/#ixzz6Ar1Ghx44

STUDENT WORKSHEETS:

ACTIVITY SHEET 1

Paxi needs your help to create a tool to grab the dangerous inactive satellites orbiting Earth. Consider the artist's impression of the Envisat satellite above. After discussing ideas with your classmates, use the box below to draw your idea for a satellite grabbing tool.

ACTIVITY SHEET 2

Complete the following steps, using the graphic to help you. You will need a piece of paper measuring 7x30cm.

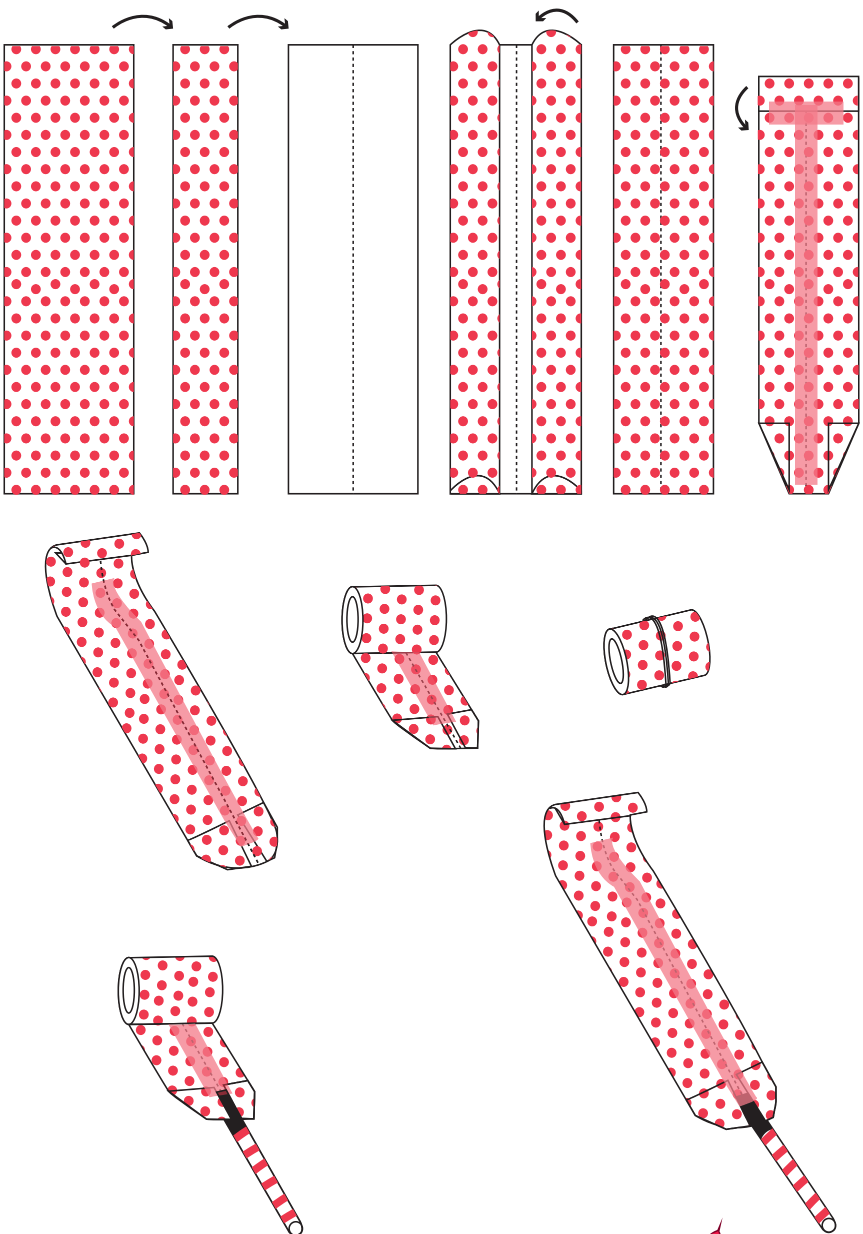
1. Fold the paper in half lengthways.

2. Unfold the paper then fold the edges into the crease in the middle.

3. Fold over about 1cm at one end and tape down.

4. Tightly roll up the paper starting at the taped end, secure with an elastic band and leave for a few hours.

5. Insert the straw into the device and secure it with tape.



ACTIVITY SHEET 3

Prepare a testing device from a rectangle of thick cardboard with a handle stapled in the centre. The example shown in the Teacher Information measures 10cm x 15 cm, its handle 15cm x 2cm. Make four per group, each with a different sticky surface.


1


2


3

Images show 1.an example of a space debris grabbing device, 2.its sticky surface and Lego debris before and after capture

Hint: start with the setup as in the photos above with 20 lego pieces laid out. Press your sticky surface on the lego then lift to see how many lego pieces were collected. Record your results in the table below and repeat 2 more times.

Stickiness (number of lego pieces collected out of 20)				
Testing Material	1st test	2nd test	3rd test	Average

ACTIVITY SHEET 4A

Email from European Space Agency

To: Pupil Space scientists
From: ESA

Subject: We need help to remove the debris!

Dear Space Scientists

We are a team of engineers and scientists working for the European Space Agency. As you know, there are lots of satellites spinning around in space, orbiting our planet Earth. They are very important and help us here on Earth in many ways, such as helping us to use our mobile phones or in weather forecasting. Unfortunately, when satellites stop working, they can become a danger to other satellites and spacecraft.
We think that it might be possible to grab the old or broken satellites in some way but we are not sure which tools would be most effective. We have heard that you are excellent scientists and we are writing to ask whether you would like to help us by doing some investigations.
Would you design a debris grabbing tool so you can help us design our tools to remove space debris?
We look forward to receiving your recommendations. Thank you for your help.

The European Space Agency

ACTIVITY SHEET 4B

You could use this to help you plan your investigation of debris removal tool.

Group Name
These are our ideas
This is our chosen design
We will use these materials
How well did it work?
We could improve our design if we...