A Martin Lewis image of the ISS in good seeing on 20 May 2009, revealing solar panels and habitable modules

CHASING THE ISS

Astrophotographer Martin Lewis achieves amazing detail in his images of the International Space Station. Here he tells us how he does it

MARTIN LEWIS

WORDS: MARTIN LEWIS

Since work began on constructing the International Space Station (ISS) in 1998, a huge amount of structure has been added to it. The first module, Zarya, was an un-screwed unit just 12.6m long and 4.1m wide. Now, 13 years later and 97 per cent complete, the ISS is a very substantial spacecraft, with habitable modules 51m in length and a solar array truss 109m long. Its large size and low-Earth orbit, at an altitude of around 320km, make it an ideal imaging target.

With an angular size that can be larger than Jupiter and an orbit that regularly brings it over the UK, the ISS is a splendid naked-eye sight to us on the ground. It is also highly reflective as it rises in the west and arcs silently across the skies. For these reasons it's relatively easy to take simple photos with a standard compact camera, leaving the shutter open for a few minutes (if your camera has that function) so that the space station trails across the frame.

Images showing details of the craft itself, however, need to be taken through a telescope. While small aperture telescopes will capture the ISS, the larger your telescope's aperture, the more detail you'll be able to make out. For my ISS imaging sessions I use a home-built Dobsonian telescope with an aperture of 222mm (8.6 inches) and a focal ratio of f/5.8, as well as an Imaging Source DMK21F04AS monochrome CCD camera that records video. I also use an infrared-ultraviolet (IR-UV) blocking filter and a 2x Barlow lens.

It's relatively easy to take simple photos of the ISS with a standard compact camera

Every target in astrophotography has its own challenges, and with the ISS the main difficulty is following it as it travels across the sky at angular speeds of up to 1° a second. I had at first assumed that the only way to take detailed images was to use sophisticated pre-programmed mounts, or optical lock-on systems similar to those in missile systems. But in 2007, I discovered a much lower-tech method of following the ISS that worked better than I could have hoped for – hand-guiding. Its simplicity is very appealing and I have been using it ever since.

A helping hand

Rather than mounting the telescope on a tracking equatorial platform, I follow the ISS solely by guiding the telescope manually on an altaz mount. I do this while looking through the scope's 8x50 finder, trying to keep the ISS lined up on its cross-wires. This is fairly easy in the first stages of an ISS pass, when it is distant and slow-moving, but when it is a useful size and travelling much faster, hand-guiding takes a lot of concentration.

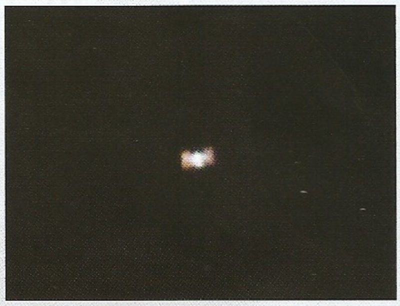
To record details on the ISS using this method, a fine balance has to be struck. Too large a magnification and the field of view is too small, making it hard to keep the ISS in the frame; too small, and there will be too few pixels across the target to capture detail. ▸

CAPTURING THE ISS

Three ways to image the space station as it passes overhead

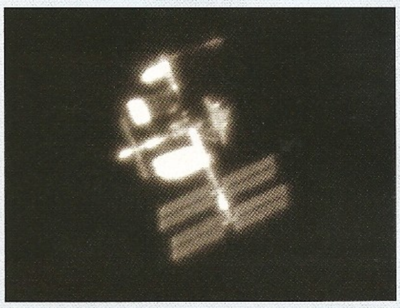
DIGITAL CAMERA AND TRIPOD

This simple image shows the ISS rising over Penzance in August 2011. It was taken using a tripod-mounted Canon 500D DSLR camera with an 18mm f/3.5 lens. The 3-minute exposure meant the ISS trailed across the frame and introduced some trailing to the background stars. Any camera can be used to take this sort of shot, provided it has a long-exposure 'bulb' setting.



DIGITAL CAMERA AND TELESCOPE

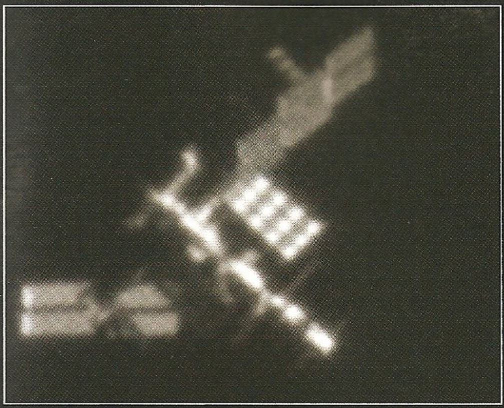
You can capture more detail using a hand-guided telescope with a camera attached and set on self-timer to take a burst of shots or a single shot. Digital cameras often have a larger chip than a webcam, so the ISS is more likely to be within any single frame. However, the camera's filters may necessitate smaller image scales to keep exposures short in order to minimise blurring.



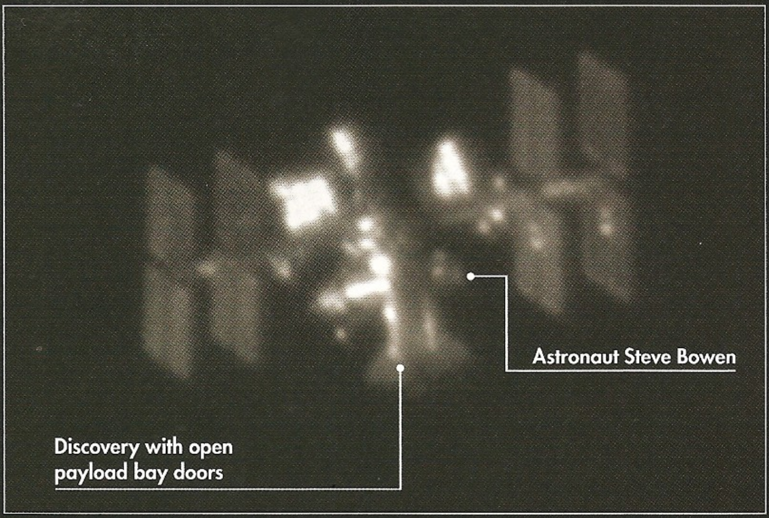
CCD CAMERA AND TELESCOPE

CCD cameras can record several thousand frames during a pass; with hand-guiding up to 10 per cent of them will show the ISS. Image scales are often larger than with a DSLR, which allows more detail to be seen. Often, only short sequences of useful frames are recorded, with lots of empty frames in between so you have to stack the frames to bring out more detail.

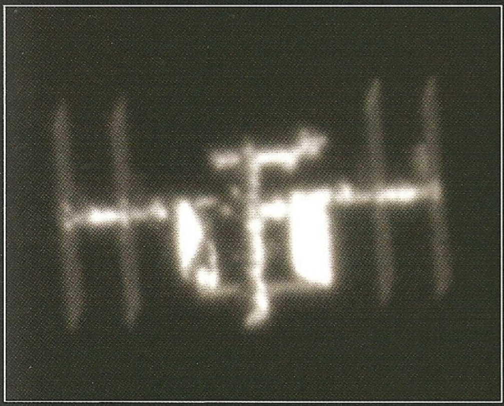
MARTIN LEWIS X 6, WILL GATER, NASA/ESA



▲ Detailed view of the ISS taken on 29 July 2008. Only two sets of solar panels have been fitted

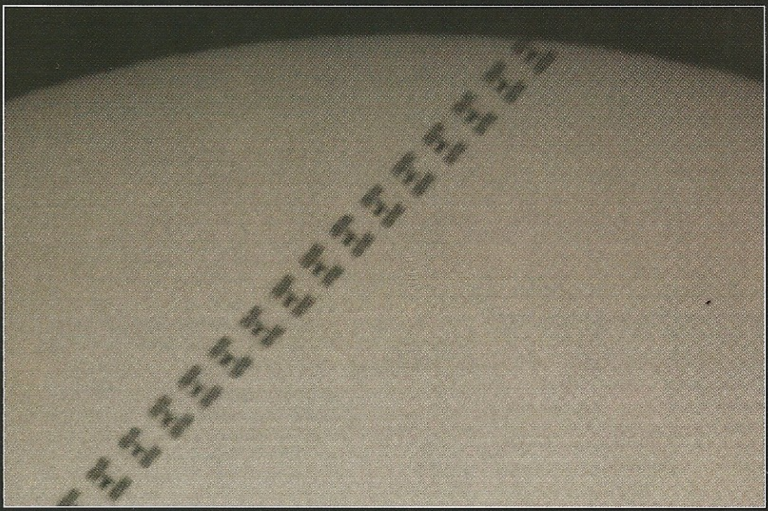


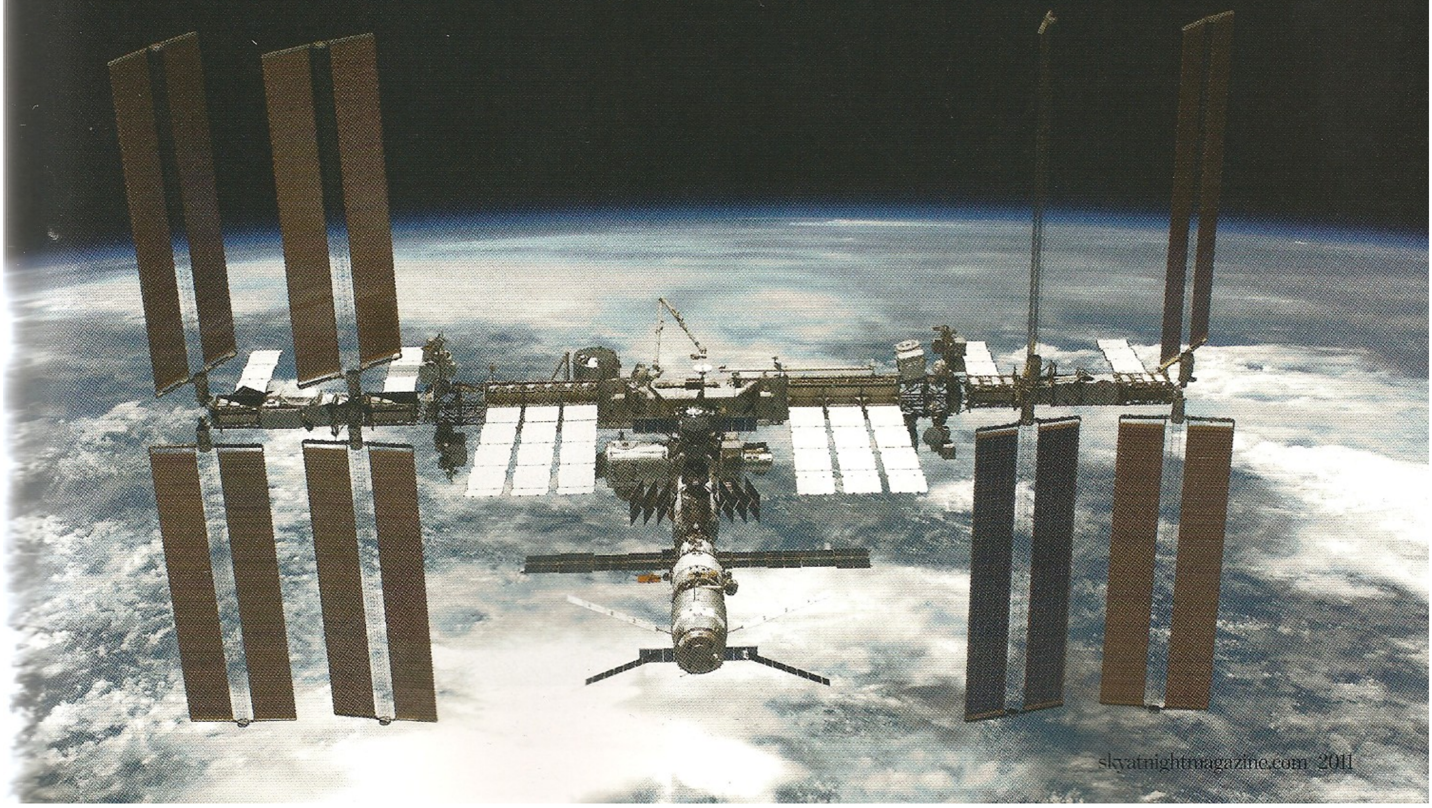
▲ A unique image taken on 2 March 2011, showing the Space Shuttle Discovery docked with the ISS and astronaut Steve Bowen on the second spacewalk of mission STS-133



▲ Face-on view of the ISS taken on 2 September 2009. Martin's image clearly shows an expanded structure

► Silhouette of the ISS against the Sun taken on 25 July 2009. Images were taken every 1/60th for this transit montage, which shows the ISS with Shuttle Endeavour attached





▲ Martin's imaging setup with a home-built 222mm Dobsonian telescope, manual altaz mount, CCD and laptop

▸ Hand-guiding is by its nature shaky and erratic, and the image of the ISS will dance on and off the camera's chip. Very short exposure times are essential to freeze the position and reduce motion blur. The brightness of the ISS helps here – provided the magnification is not too high.

My telescope and Barlow lens give an effective focal length of 3.2m, which gives a decent image scale while still allowing a sufficiently short exposure of 1/1,200s. Inevitably, a period of trial and error will be needed to find the best settings for your setup.

The ISS has some very bright areas where sunlight bounces off reflective metal

Camera considerations

Other high frame-rate CCD cameras can, of course, be used with the hand-guiding method, but the 640x480-pixel monochrome CCD cameras from DMK and Lumenera are particularly recommended. They don't have colour filters that can block light and they allow uncompressed videos to be captured at frame rates of up to 60fps, maximising the chances of useful frames containing the ISS.

General-use colour webcams like the Philips SPC900NC or planetary cameras like the Celestron NexImage will give decent images of the ISS, but won't provide as much detail. This is because they run at lower frame rates and their built-in colour filters block too much light. This means they have to be run at lower magnifications to increase the image brightness and the size of the image area and so improve the number of useful frames.

In the run-up to an ISS imaging session, I use the websites CalSky and Heavens Above to get details of ISS passes. South of latitude 51.5°N (Greenwich), overhead passes are quite common, and this is when the ISS gets as close as it can – around 320km above us. Near the zenith, however, altaz mounts have problems following the spacecraft, so equatorial mounts with both axes loosened off would probably be superior for these passes. Using an altaz setup, I've found that the best passes are when the ISS reaches an altitude of around 70°; here, the space station is large but still relatively easy to follow.

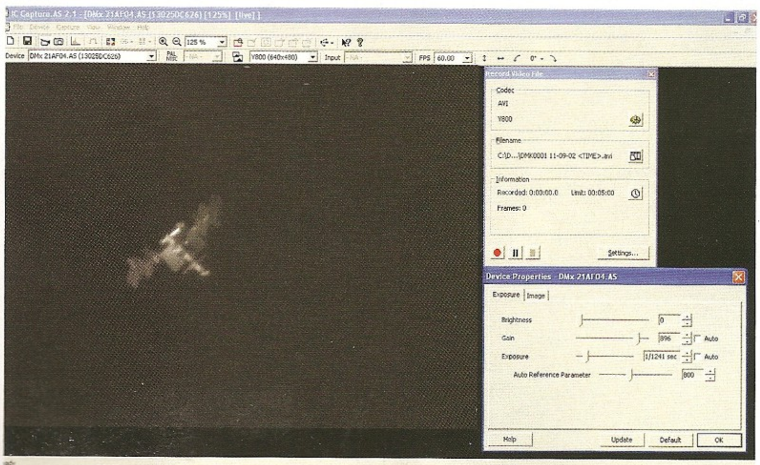
Just as for planetary imaging, nights of good seeing yield the best images. The telescope also needs to be properly collimated and allowed to cool fully for at least an hour to minimise tube currents. Hand-tracking also requires the finderscope to be accurately aligned and for the camera to be accurately focused prior to the pass. Polaris is a great focus target as it is virtually stationary in the field of my undriven telescope. You can also use a Bahtinov mask to find an accurate focus quickly.

The chase is on

During the 'chase', my laptop computer records a stream of video frames generated by the camera. Later, when I sift through the recorded video I generally find most of the frames are blank. However, if the guiding is good, then about 10 per cent of them will show part or all of the ISS. The best of these can then be used to generate the final image of the pass. To capture the video I use The Imaging Source's proprietary IC Capture software as my camera interface program; different cameras will come with their own.

The ISS has some very bright areas where sunlight bounces off metal, and some much darker areas in shadow. To record faint details without overexposing the brighter parts, there are some settings that can be adjusted in many camera interface programs. It's important to set the gamma value for the camera to a high value – I use 2.2. I also set the camera's frame rate to 60fps and its gain to about 80 per cent. Once all is ready, I wait patiently for the ISS to appear; once I see it, I hit the record button and start manually tracking it.

▼ ISS imaging in progress. Martin's camera interface screen during an ISS chase



MARTIN LEWIS X 8

Once the chase is over, the 2-3 minute video that's been recorded is saved as an AVI file. I have a quick look to check isn't a dud, then go through it frame-by-frame using the freeware program VirtualDub to pick promising sequences of frames. I then save useful sections of the video as sequences of frames in bitmap (BMP) format. Each sequence needs to be examined to pick the best frames from each, which are then aligned and stacked in Registax6.

The view of the ISS changes rapidly at its closest approach and it's only really useful to pick frames that are all within a period of about half a second, when the space station is nearly overhead. Once stacked, RegiStax's wavelet processing can be applied to bring out finer details, but since a typical final image is composed of between five to 30 frames, background noise is always an issue and the processing can only be at a low level.

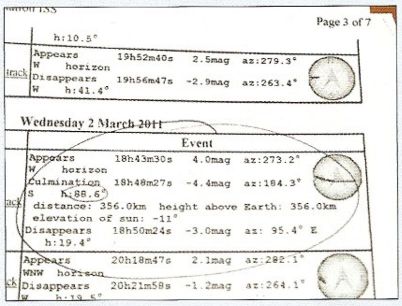
FIND OUT MORE

Calsky – www.calsky.com
Heavens Above – www.heavens-above.com
Make your own Bahtinov mask – www.skyatnightmagazine.com/bahtinov-mask
Martin Lewis's website – www.skyinspector.co.uk
Registax 6 – www.astronomie.be/registax
Virtual Dub – www.virtualdub.org

Using these methods I have taken many of the images in this feature. It's simple and effective. Using different methods – keeping the ISS within the field of the camera for the whole pass, for instance – would create even more possibilities, such as higher magnifications and longer exposures. It would also be possible to use IR-pass filters, bringing significant benefits to image quality as the atmosphere is much steadier at infrared wavelengths. You could also record videos showing the changing perspective of the ISS over a pass.

These benefits, however, come at a cost – and that is simplicity. Creating a tracking method that would fix the ISS in a camera's field of view for a whole pass is a very big jump in complexity from the hand-guiding method. It is the simplicity of this technique that I hope will encourage you to have a go at imaging the ISS for yourself. **S**

IMAGING THE ISS: A STEP-BY-STEP GUIDE



Page 3 of 7

h:10.5°
Appears 19h52m40s 2.5mag az:279.3°
W horizon
Disappears 19h56m47s -2.9mag az:263.4°
W h:41.4°

Wednesday 2 March 2011

Event
Appears 18h43m30s 4.0mag az:273.2°
W horizon
Culmination 18h48m27s -4.4mag az:184.3°
S h:88.6°
distance: 356.0km height above Earth: 356.0km
elevation of sun: -11°
Disappears 18h50m24s -3.0mag az: 95.4° E
h:19.4°
Appears 20h18m47s 2.1mag az:282.1°
WNW horizon
Disappears 20h21m58s -1.2mag az:264.1°

STEP 1

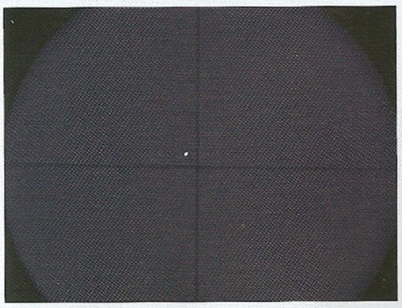
Consult the Heavens Above or CalSky website to find out where in the sky the ISS will first appear, reach its maximum altitude and disappear from your location. Set up your telescope in a spot that will allow a clear view of the ISS pass, especially when it's at its highest point.

STEP 2

Connect everything up and do a trial sweep along the estimated path. Check for smoothness of movement and cable snagging, and that your body won't get too contorted, which would affect concentration. For an equatorial mount, check your sweep won't be constricted by the polar axis.

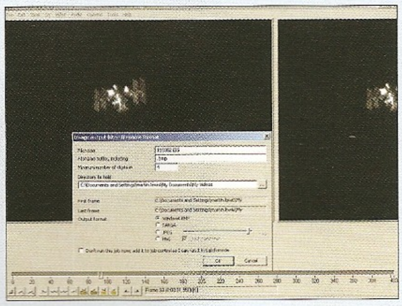
STEP 3

Use a bright star to carefully adjust the finderscope so its cross wires and the centre of the camera's field are aligned, then use the star to carefully optimise the camera's focus. A Bahtinov mask, pictured, will help with focusing, too – just don't forget to remove it afterwards!



STEP 4

Set the camera's frame rate, exposure, gain and gamma. Record a short video of a bright star to check it's all ready. When the ISS appears, hit record and start chasing it, doing your best to keep it aligned on the cross wires as you follow it across the sky manually.



STEP 5

Review the AVI video in VirtualDub, then go through it much more slowly in the same program, making a note of the best quality ISS frames. Use the File/Export/Image Sequence command to save promising sections of the AVI as sequences of frames in bitmap (BMP) format.

STEP 6

In Registax6, select short BMP sequences in which the perspective hardly changes. Use the program's default multipoint Align to align the ISS images. Stack them and follow this with a small amount of wavelet processing to bring out detail; be careful not to overdo the processing.