RCEA
(SUSSEX)

An Association for Retired Professional Engineers

NEWSLETTER December 2019

President's Message

Welcome to the December Newsletter.

We have started our autumn series of talks with excellent speakers and very good attendances.

I am aware of the disappointment some of you had with the microphone and amplification arrangements at the November meeting. This was particularly a problem for those sitting towards the back of the room.

The arrangement we have with Field Place is a mixture of our microphones and their amplification equipment. Following our recent committee meeting when we discussed the problem, we agreed that Glyn and George would have a meeting with the staff at Field Place to discuss the issue and the options available to us.

We will endeavour to have some improvement for our talk on 10th December.

I wish you a very Merry Christmas and a Happy New Year

Derek Webb

December 2019

PROGRAMME OF EVENTS December 2019 – April 2020

10th Dec	**Tuesday**	**Talk – "National measurement standards for medical ultrasound and underwater acoustics"**
19th Dec	**Thursday**	**Coffee - at Spotted Cow, Angmering**
26th Dec	**Thursday**	**No coffee at Swallow's Return**
14st Jan	**Tuesday**	**Talk – "Operation Overlord, D-Day 6 June 1944"**
16st Jan	**Thursday**	**Coffee - at Spotted Cow, Angmering**
30th Jan	**Thursday**	**Coffee - with Partners at Swallow's Return**
11th Feb	**Tuesday**	**Talk – "Wealden Iron – the UK's First Industrial Centre"**
20st Feb	**Thursday**	**Coffee - at Spotted Cow, Angmering**
27th Feb	**Thursday**	**Coffee - with Partners at Swallow's Return**
10th Mar	**Tuesday**	**Talk – "The Evolution of Military Flight Simulators"**
19st Mar	**Thursday**	**Coffee - at Spotted Cow, Angmering**
26th Mar	**Thursday**	**Coffee - with Partners at Swallow's Return**
16th Apr	**Thursday**	**Coffee - at Spotted Cow, Angmering**
20th Apr	**Monday**	**Outing – Hassocks Garden Centre, including talk on "The history of lawnmowers"**
30th Apr	**Thursday**	**Coffee - with Partners at Swallow's Return**
14thMay	**Thursday**	**Visit – Ford Materials Recycling Facility (date to be confirmed)**
21st May	**Thursday**	**Coffee - at Spotted Cow, Angmering**
28thMay	**Thursday**	**Coffee - with Partners at Swallow's Return**

We are also planning another visit to the Centre for Fusion Energy at Culham. This will probably be on a Saturday in May.

All Talks and Meetings will commence at 2.30 pm and be held in the Chichester Room, Field Place, Worthing unless another venue or time is indicated.
Timings for visits and outings will be as printed in the detailed description of the activity. Reply slips for all visits and outings can be found at the end of this newsletter. Coffee mornings commence at 10.30 am.

We apologise for only being able to publish a short list of our forthcoming events. This is simply due to the difficulties we now face in booking speakers and visits far ahead. As you know we sometimes have to cancel/rearrange talks and visits, often at short notice. We suggest that members should increasingly rely upon our website for up to date details of events.

Membership Subscriptions 2019/2020

Our thanks go to all members who have renewed their subscriptions. Those members not renewing should note that their membership will cease on 1/1/2020.

Website of the RCEA

Our website, **www.rceasussex.org.uk** carries the very latest information on all of our events.

New Members and Speakers for Talks

The RCEA needs new members and speakers to ensure that we can continue as a thriving organisation. Please think of appropriate people you know and encourage them to come along to our talks and hopefully join the RCEA.
We also need more speakers to give talks to us on Tuesday afternoons from September to March. We are aware that many members have the knowledge from their working careers to provide interesting talks. If you are willing to give a talk please let us know. Speakers from outside organisations are increasingly harder to find and often seek payment for their services.

New Members

P Mason, B Sc (metallurgy) – Rustington

B Rawlings, C Eng, FIEE, FIET – Worthing

Latest Member's Handbook

Would all members please check their entry in the latest Members Handbook to ensure that it is correct in every detail i.e. address, telephone number, e-mail address, etc. Any errors or omissions should be communicated to Mike Wooldridge, Membership Secretary, so that the appropriate corrections can be made ready for printing the next Members Handbook.

Similarly, if members become aware that a fellow member no longer lives at the address that we publish in the handbook, we would be grateful for the information.

Members will be aware that we are now using the MemberMojo database. This is certainly making life easier for our Treasurer and for our Membership Secretary, but there are also benefits for members as you can now update your own personal details. Using your internet browser, you select the MemberMojo RCEA website, whereupon the site will send you an email, through which you will gain access to your personal record which you can then edit. You can also change your email address if required within MemberMojo. This will result in your receiving a rather abrupt email telling you that you have left RCEA and a new prompt advising you to sign in again using your new email address.
However, until such time as we have mastered how to get MemberMojo to produce the handbook directly, it is not easy for our membership secretary to spot every change that may be made by a member. Until further notice therefore, when making changes to your Membermojo details, would you kindly drop an email to mike.wooldridge1@btopenworld.com advising of the changes. Mike will collect all such emails into a file and use them to apply updates to next year's Handbook (2020-21) when the time comes. Hopefully this will all change when we can use Membermojo to automatically generate the handbook.

RCEA Insurance

Members need to be aware that the insurance policy that the Association holds is solely for the protection for the assets and liabilities for the Association as an entity. The policy does not provide cover for personal injury or loss to individual members. Members attend the Association's events at their own risk; although under some circumstances there may be some cover from the insurance arrangements of the venue owner.

Newsletter Entries

If you would like to provide an article for inclusion in a future newsletter it would be very welcome as we are always looking for new material in addition to reports on previous talks and visits/outings. From feedback from our members we know that the newsletter is particularly appreciated by those who are no longer able to get to our meetings and visits, so if you are able to contribute in this way it would be much appreciated. Articles should preferably be Microsoft Word documents, although we can usually convert both text and pictures (even photographs) into a suitable format. Accompanying pictures are best supplied as separate files which will be embedded within the text during editing.

Brief Detail – Talks, Outings and other activities December 2019 – March 2020

Talk
Tuesday 10th December - National measurement standards for medical ultrasound and underwater acoustics

Dr Roy C. Preston, retired Senior NPL Fellow
The UK National Physical Laboratory started work on establishing measurement standards for medical ultrasound in the late 1970's to meet the needs of clinicians and industry to ensure safety. Medical ultrasonic devices operate mainly in the frequency range 1 – 20 MHz, so measuring devices were developed such as radiation force balances to measure ultrasonic power and new types of hydrophone to measure acoustic pressure. Optical calibration methods directly traceable to the SI system were also developed. During the 1980's and 1990's NPL built an impressive capability that today leads the world. During the late 1990's opportunities were taken to address the need for traceable standards in underwater acoustics. New capabilities were established, including a 100 Tonne acoustic pressure vessel which is unique in Europe, and now these have also become world leaders. This talk will explain the background to these developments and achievements.

Talk.
Tuesday 14th January – Operation Overlord, D-Day 6 June 1944

Dudley Hooley, Director, Tangmere Military Aviation Museum

The talk inevitably can only skim the surface of what was the largest amphibious landing in the history of warfare.
After a brief introduction to the allied leaders, the talk covers Operation Fortitude, the great deception to persuade the German high command that the invasion would be centred on the Pas de Calais, the eccentric Gen Sir Percy Cleghorn Hobart and his 'Funnies' which played such a key role in the success of the invasion, Operation Deadstick, the attack on Pegasus Bridge, which signalled the opening shots of the invasion, a brief look at the German defences and role of the X-Craft, the landings at the Pointe de Hoc and the four invasion beaches.
Air support flown from local Sussex airfields includes the story of Spitfire ML 407, still flying today. Finally a few staggering statistics conclude what truly was the 'Longest Day'.

Talk.
Tuesday 11th February – "Wealden Iron – the UK's First Industrial Centre"

Dr Tim Smith, Hon Sec Wealden Iron Research Group

The Weald was the centre of the armaments industry for nearly 200 years, supplying cannon and shot to the Government and merchant ships.
The traditional Sussex rhyme:
'Master Huggett and his man John,
They did cast the first can-non'
dates from around 1574 in the reign of Queen Elizabeth I. The casting of shot and cannon continued until 1775 when the Industrial Revolution brought new, more accurate, methods of boring cannon to Northern England and Scotland which Wealden gun founders could not match.
This talk will first look at the earlier bloomery furnaces dating from the iron Age to the Medieval period and then follow the blast furnaces and forges which dominated iron production for over 300 years from 1490 to 1827.

Talk.
Tuesday 10th March – The Evolution of Military Digital Flight Simulators

Stewart Hilton, former Technical Director, ESS GmbH (Eurofighter Simulation Systems).

The talk will cover the needs and benefits that drove development and advancements over the decades (late 60s to present day) and the challenges faced in providing solutions to the training needs (requirements) and meeting the expectations of the customer (MoD).
Emphasise will be focused on the engineering challenges and how they were overcome.
The talk will use examples from the most demanding of military aircraft types, the fast jets, including the Jaguar, Tornado, and Typhoon.

The first simulator to be discussed will be the Jaguar. The aircraft was developed in the 1960. The SEPECAT Jaguar was a joint venture between Britain and France to produce a supersonic, low-level strike fighter**.** The maiden flight took place on 8th Sep 1968. The aircraft entered service with the RAF in 1973 and remained in service with the RAF until 2007.

The Second simulator to be discussed will be the Tornado. The Panavia Tornado is a family of twin-engine, variable-sweep wing multirole combat aircraft jointly developed and manufactured by Italy, the United Kingdom, and West Germany. The maiden flight was 14 August 1974. The aircraft entered service with the RAF in 1979 and remained in service with the RAF until April 2019.

If time permits the Third simulator to be discussed will be the Typhoon. The Eurofighter Typhoon is a twin-engine, canard–delta wing, multirole fighter. This again was a workshare program comprising UK, Germany, Spain and Italy.

The talk will look in detail at:

1. The introduction of the digital computer.
2. The critical importance of Cuing (visual, motion, sound and 'G')
3. The simulation of offensive and defensive weapon systems
4. The challenges posed by the design of full mission training systems
5. The future of military synthetic training.

Reports

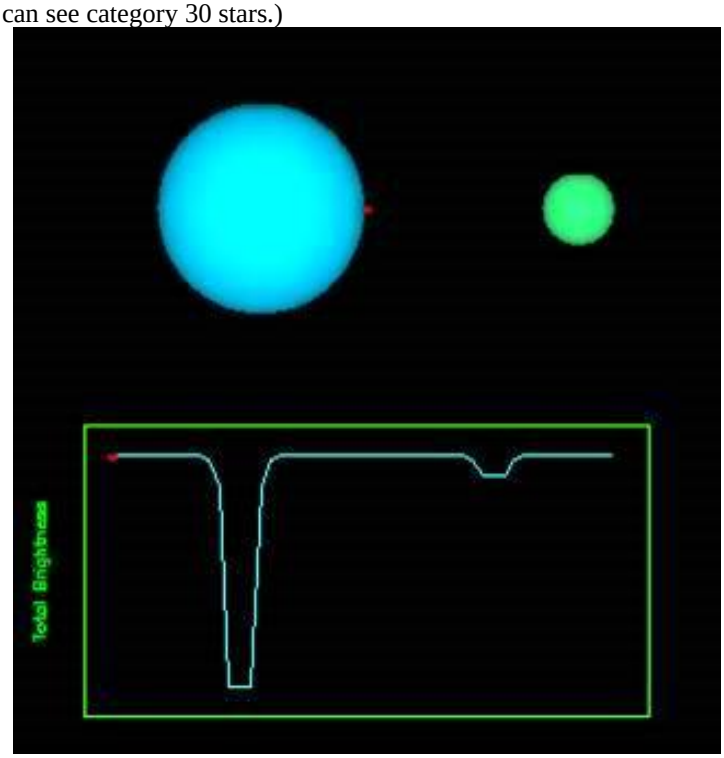
Talk

Tuesday, 17th September 2019 – "Technical Challenges of Capturing and Making Measurements in Astronomy".

John Mallett, FRAS

After John decided to retire, he bought himself a telescope and a digital SLR camera and started his involvement with astronomy by taking photographs. This resulted in a university (Oxford) spotting some of his work and asking if they could use his photographs. He was encouraged to receive their acknowledgement, and this led to him working with a team of colleagues, suggested by said university, to measure a binary star system and identify any planets associated with it. A binary star system is one in which two stars rotate about each other but appear as one when viewed from earth because of the effect of distance. They may also have planets rotating about each star.

The star system they decided to look at was not bright enough to be seen with the naked eye, but just observable to his sensitive camera, set to a 40 second exposure time. It has an 'apparent [logarithmic scale] magnitude' of 13-15, where 0 or -ve is the very brightest star, 6.5 is just visible to the naked eye, and 22 is about the visible limit through a telescope in our normal, light-polluted sky. (The Hubble telescope can see category 30 stars.)



The picture opposite shows the variation of brightness with time as the stars rotate about a vertical (in the diagram) axis between them, with the result that they eclipse each other at intervals causing associated changes in observed brightness. NB The two stars, being some 100,000 light years away appear as a single, dim, dot. The graph shows how the total brightness changes with the eclipses. The length of the flat bases of the curves can be used to calculate the relative size of the stars. Further information can be deduced from the slope of the curves, as well as changes in period.

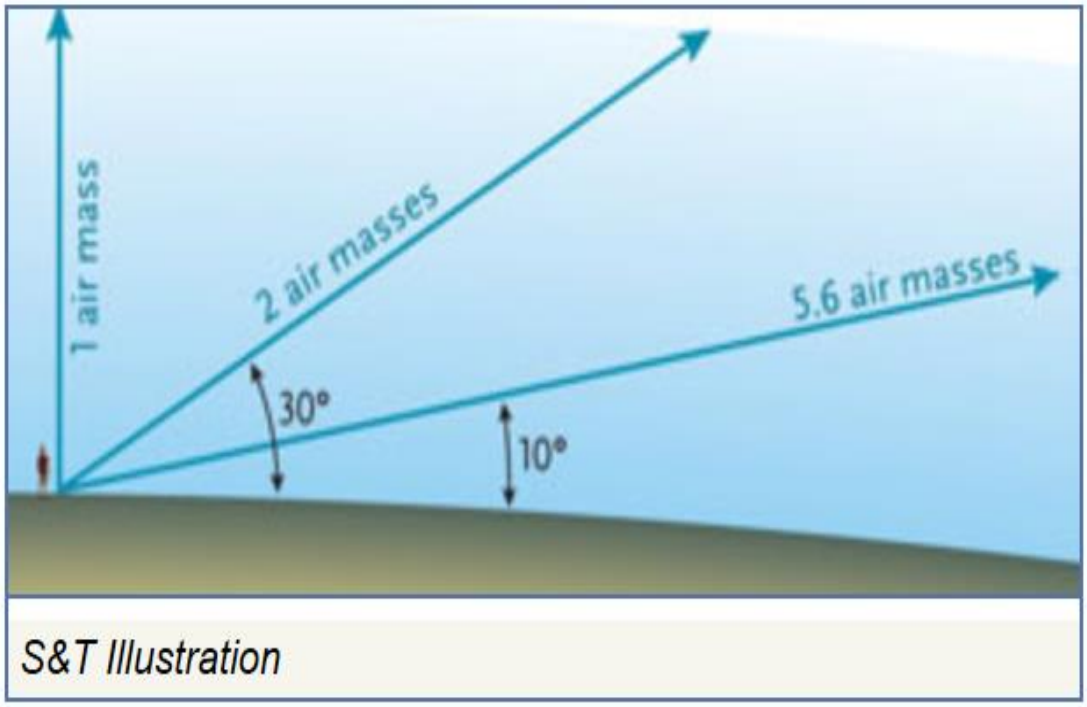
To investigate this system effectively, John needed:

- a telescope that can collect enough light for this magnitude of star at minimum cost: an 8" reflecting telescope gives this capability (about £2500);
- a sensitive camera that has low noise (about £1000);
- a means of keeping the telescope pointed at the star for some hours (about £1500);
- the ability to take a rapid series of images, which are used to detect the exact time of a primary eclipse.

There are a number of problems which need to be overcome in order to make accurate measurements, which John discussed.

A special mount (known as an equatorial mount) is needed to compensate for the rotation of the earth. This provides a platform for the telescope that has one axis pointing at the pole star (the only near-stationary star in the sky), thus requiring only one axis to track the rotation of the stars 360 degrees in 24 hours or about 15 degrees/hour. John uses a German Equatorial Mount which has a resolution of c. 0.14 arc-seconds, which is good. However, gear errors, backlash, etc are all much greater than the resolution. They result in an overall pointing accuracy of 5 arc minutes. This needs to be improved to match the accuracy of the camera – the best that John can afford, which includes cooling to minimise the noise, is 0.6 arc-seconds per pixel. This is a monochrome camera as it has better resolution than a colour equivalent. The camera is produced by a British company, intriguingly named 'Starlight Xpress'. The cooling is obtained by 4-stages of Peltier effect thermocouples, which gives -40 degrees C.

'Plate solving' software such as AstroArt 7.0 matches the image from the telescope to a star atlas database in order to centre the telescope on the desired star image. While perfect alignment is never possible, it goes some way to compensate for the inaccuracies in the pointing of the equatorial mount. Software also enables the mechanism of the mount to track the star to within 0.4 arc-seconds as it moves.



The star image also changes with time because of atmospheric distortion. The diagram opposite shows the effect of telescope inclination on atmospheric distortion. To minimise this, the telescope needs to be used at an inclination of at least 30^0.

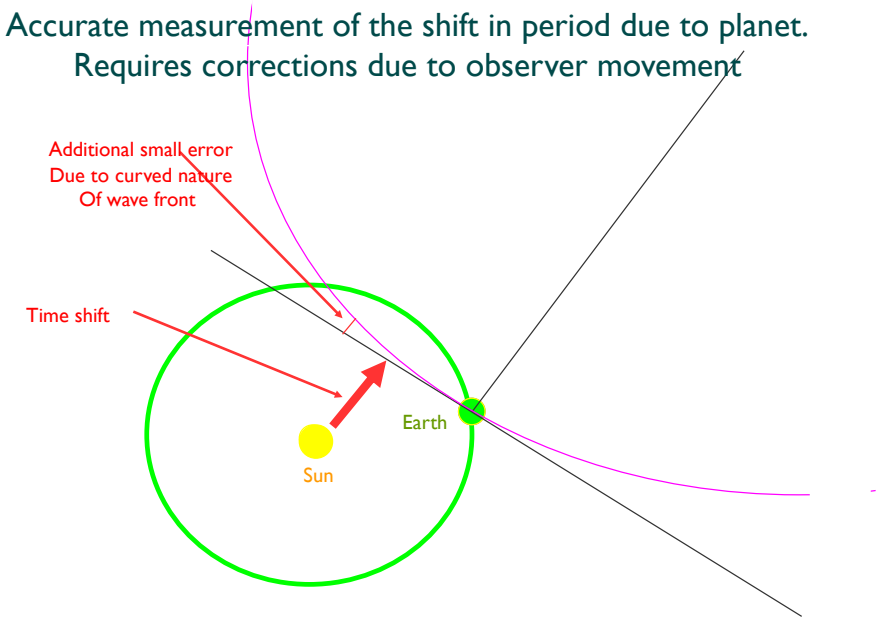
The quality of the image is also affected by the change in focus of the mirror with temperature. An electronic servo focuser measures the temperature of the mirror and adjusts the focus. It needs to be trained by measuring best focus at a number of temperatures in the observatory (or it can initially be set to a linear rate). Focus also changes depending which filter is being used: there is a link to the computer for this correction.

So, once all this hardware and software has been added to the telescope and camera, the system is ready to collect some images. The data on the star location is available, and it's high in the sky. The night is clear and everything is working as it should. Now all that is needed is to take about 100 images so that the period of the binary stars can be measured. Each image involves an exposure of about 40 seconds, and images are taken continuously. There is one further potential problem – DUST!!

It is possible to compensate for the effect of dust on the mirror by taking a photograph of the dust and then subtracting it from the images. An alcohol wipe is the conventional way of cleaning the mirror, but in a good example of cross-pollination, John has been helped by his window cleaner, who supplies him with specially treated water which is very effective at cleaning telescope mirrors as well as windows! Another problem can be the marks left by spiders, but this problem can be minimised by ensuring that the telescope is not left pointing upwards when not in use. Then, even if a spider does get in, it doesn't drop onto the mirror. And a third nuisance factor is salt from the sea air (John lives in Selsey). The need for all this cleaning takes its toll on the mirror surface, and John generally had to buy a new mirror every 5 years.

Having done all this, the next step is to calculate the period and variation of a binary pair of stars. This brings yet another problem: if you want to find a planet going around the pair of stars, the change in orbital period may be small, so you need to be able to be accurate to better than 25 milliseconds. Computer clocks are not this accurate, so they need to be synchronised to an atomic standard: John uses a link to a Stratum 1 clock (aka a Time Server which gets its timing source from a Stratum 0 hardware clock) at a university, which gives an accuracy of +/- 25ms. The time stamp needs to be in the centre of the frame exposure (which is about 40s).

But there is a further complication: accurate measurement of the shift in period due to a planet requires corrections due to observer movement as shown opposite – see also 'barycentric time' on Wikipedia. Finally, everything is in place to plot the deviations from a nominal constant period, in order to identify one or more planets.



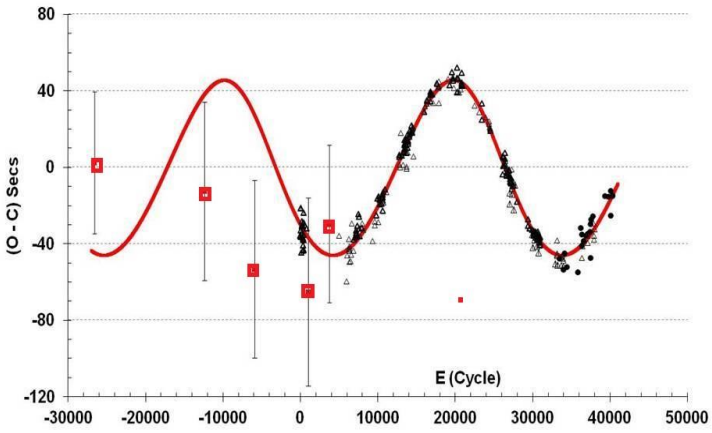


Fig. 4: (O - C) residuals for NSVS 14256825 based on our revised ephemeris, Eq. 3, and single circumbinary object hypothesis. Open triangles indicate historical data; solid black circles are our new data; red squares are ASVS and NSVS Beuermann's phase folded data. The red curve is the predicted third body.

The diagram opposite is taken from a paper that John and colleagues will be publishing shortly, using data collected over the past 8 years. If the red line were straight, this would indicate that there were no planets present – ie no deviation in the (Observed – Calculated) axis. In practice, a deviation of up to +/- 5 seconds is within normal error. Their deviation of +/- > 40 seconds clearly shows the presence of a planet(s); you need a good mathematician in the team to be able to make these deductions! It is perhaps also interesting to note the square points on the graph, going back to over 10 years ago.

John told us that one team had published some observations that seemed to indicate a desire to show what they wanted to see without the rigorous attention to detailed error corrections that John and his team have applied.

We hope that this report begins to do justice to the amazing (World Class?) work that John has carried out to achieve the required level of accuracy – and, although we haven't been able to give details, he did make it clear that he created some of the hardware and software, for minimising tracking errors etc, himself.

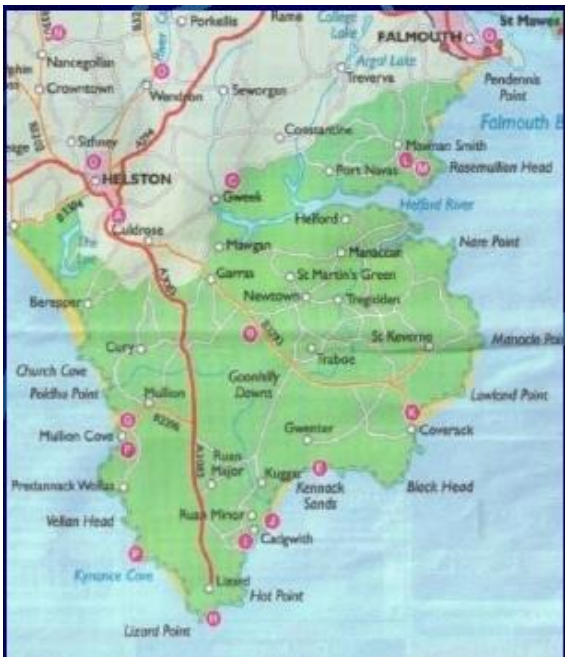
Perry Eastaugh and Mike Wooldridge

Talk
Tuesday 8 October – Goonhilly, A Tale of Two Half-centuries

Des Prouse

Our speaker, Des Prouse, worked in the Research & Development Department at Goonhilly Satellite Earth Station from 1971 until his retirement in 2007.

Goonhilly Satellite Earth Station is a large radio communication site located on Goonhilly Downs near Helston on the Lizard peninsula in Cornwall as shown opposite.



The site and facilities were owned and operated by the GPO (later named BT). It was the first operational earth station in the UK for transatlantic satellite communications, and at one time the largest satellite earth station in the world, with more than 25 communications dishes in use and over 60 in total as shown below. The site also links into undersea cables.

Goonhilly's first dish, Antenna One (named "Arthur" and shown opposite), was built in 1962 to link with the satellite Telstar shown below. Arthur is 25.9 metres (85 feet) in diameter and weighs 1,118 tonnes. Arthur received its first transmission from Telstar on 11 July 1962. It is now a Grade II listed structure.

Telstar was owned by NASA and built by Bell Labs in the USA and used NASA's earth station at Andover in Maine. It was the first satellite to make communications possible, initially monochrome television pictures, telephone calls, faxes and data transmissions.
Because Telstar was placed in a 45-degree elliptical orbit, Goonhilly, being the most suitable southerly location in the UK, was chosen for the reception and transmission point for the UK's contribution to this European / US experimental system. Situated in a remote part of Cornwall it also had the advantage of being electromagnetically quieter than most other locations.
Due to Telstar's Low Earth Orbit (LEO) it raced across the sky making access possible for only around 20 mins per orbit of 2.5 hours. Signals to the satellite communications payload were in C band with an uplink at 6GHz and downlink at 4 GHz. The downlink signal was further down converted for retransmission by a series of microwave links back to London for processing. These links used line of sight communications and the nearest example of a tower in this chain sits atop Butser Hill just south of Petersfield. Constrained by weight and power limitations, Telstar's single repeater had only 8 * 50MHz channels.
The biggest contribution on the ground was the tracking antenna which was required to follow the satellite across the sky with a pointing accuracy of less than 0.06 degrees whilst following the satellite moving 1.5 degrees per second. No mean feat for a parabolic structure of some 26M in diameter weighing 1100 tonnes in windswept Cornwall!
The best way to capture the public's imagination was to use it for television transmissions. However this presented problems in that just about every European terrestrial service for television used different standards than those in use in the USA where 525 lines was the standard as opposed to the 425 used here and 819 in France. It was down to the BBC to build a converter which was installed in the Television Centre at Wood Lane in London at the far end of the microwave link from Goonhilly. With technology available at the time this required a whole room with an exceptional air conditioning system to cope with the power consumed. Although this also initiated the era of telephone connections by satellite, this was mired by the delay caused by distances to and from the satellite of somewhere in the region of 0.5 secs which can be disconcerting for those accustomed to making land-based calls. Consequently, services gradually returned to subsea cables.

The site has also played a key role in communications events such as the Muhammad Ali fights, the Olympic Games, the Apollo 11 Moon landing, and 1985's Live Aid concert.

The site's largest dish, dubbed "Merlin", has a diameter of 32 metres (105 feet). Other dishes include Guinevere, Tristan, and Isolde after characters in Arthurian legend, much of which takes place in Cornwall.

Des described in detail many of the achievements of Goonhilly in its 'hey day', some of which are shown below: -

Goonhilly 'firsts' in the 1960s

1962 (July): 1st British satellite earth station

1962 (11th July): 1st live transatlantic TV pictures (Goonhilly to Andover)

1962 (12th July): 1st two-way transatlantic telephony via satellite

1962 (16-17th July): 1st transatlantic colour-TV signals (Goonhilly to Andover)

1962 (23rd July): 1st "made for satellite transmission TV programme" (GHY-AND

1962: 1st site to pioneer the parabolic dish design (became global standard)

1965 (June): Goonhilly begins commercial operation to USA via Early Bird

1966 (November): 1st European station to receive live TV from Australia

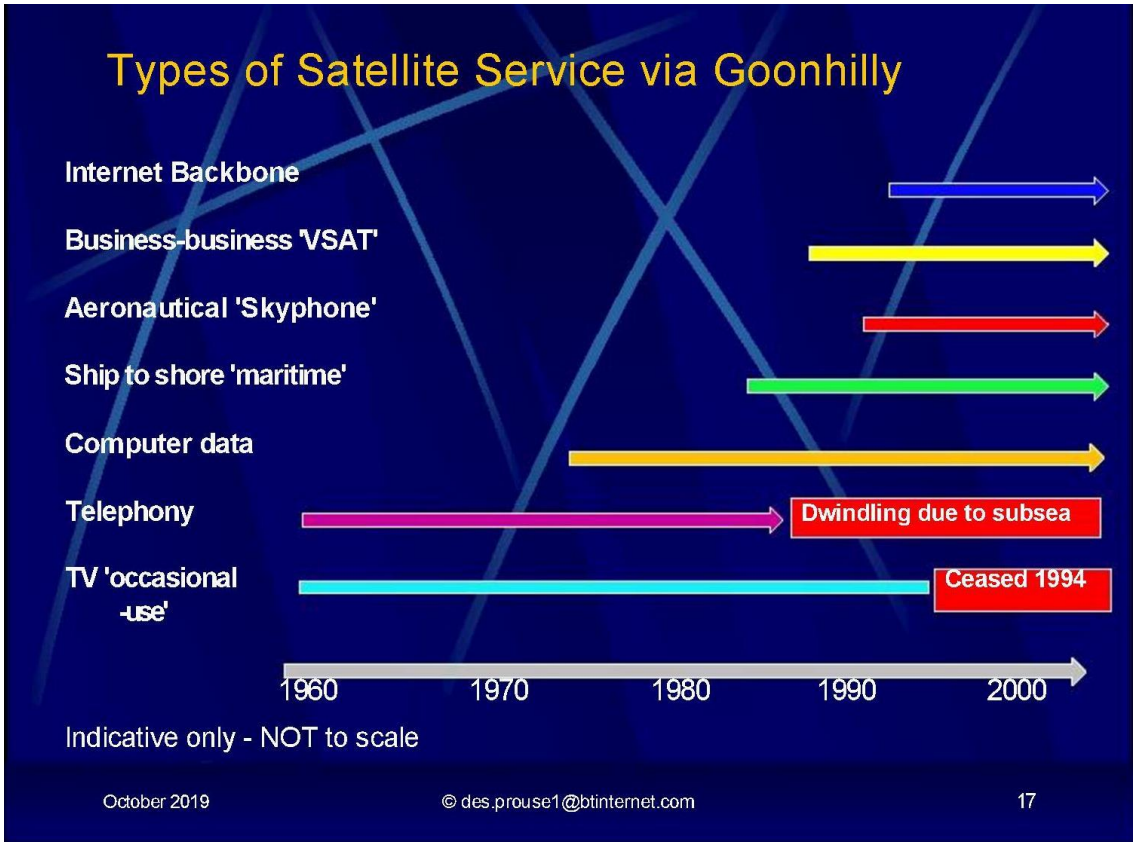
1967 (September): 1st earth station to receive colour-TV from Canada

1968 (October): 1st to bring colour-TV from Olympic Games to Europe

1969 (July): 1st earth station in the world to have 2 working antennas

1969 (July): GHY-01 and 02 part of the 1st 3-ocean region global coverage

1969 (20/21 July): Goonhilly brings 1st TV pictures to Europe of Man's 1st steps on the Moon



From Goonhilly's opening in the 60s to its closure in 2008 (see later), the facilities on the site were involved in a wide and diverse range of activities, many of which are shown opposite.

In the early days radio and television transmission relied heavily upon microwave links to the UK nerve centre in London. Initially analogue TV required a bandwidth of around 35MHz as opposed to the digital systems used today whereby 6 studio quality channels can be accommodated in the same bandwidth without the line restraint (digital TV uses pixels). In order to achieve the gain required with an acceptable noise level from received signal technology available at the time not only required a large antenna but also low noise amplifiers (LNA's) that operated in the region of -40 ºC and needed to be situated very close to the horn output in the antenna (i.e. kept in a freezer).

As satellite technology improved, greater download power and EIRP (Equivalent Isotropically Radiated Power) from geostationary satellites in equatorial orbit greatly changed the situation and reduced the necessity for complex receiving antennae. This encouraged more operators to enter the field at an affordable price and eventually procure their own satellites and ground infrastructure, the most notable being ASTRA in Luxembourg and Eutelsat in France.

The most notable advance in the creation of home satellite TV was an LNA/down converter which could operate at ambient temperatures. This device is attached to the back of domestic satellite dishes and not only receives a signal at 12GHz but down converts it to a much lower frequency that can be handled by a cable to a set top box without losing too much power. Hence it dispensed with the need for operators to deal with distribution allowing them only to deal with the uplink transmissions from smaller less complicated antenna.
As time rolled on satellites became much more powerful and were hence more capable of providing many more services, largely for data transmissions with the capability of putting their antennae virtually anywhere. BT have a second ground station at Madley in Herefordshire. Initially most of the communications satellites in orbit were owned by a consortium of national telecommunications agencies which later became privatised with each having their own or selected ground station sites. Being far north of the equator did not favour the use of sites in the UK other than for national data transmissions.
Control stations for a satellite could now be virtually anywhere and are normally installed in the owners premises, the data produced to control the satellite readily relayed to antennae much further south. A very popular European station is Fucino in Italy owned and operated by Telespazio.

In 1983 a new organisation, Inmarsat, was created by BT to provide **In**ternational **Mar**itime **Sat**ellite services. Goonhilly was considered Inmarsat's exemplar Coast Earth station and demand for the services grew rapidly in the early 90s.

BT sold Inmarsat in 1999 to Stratos.

Currently Inmarsat use 3 locations for its global networks, Fucino in Italy, a site in Hawaii and another in western Australia all connected digitally to their nerve centre in London.

Fucino, the closest to the UK is much further south which allows greater "vision" of satellites in geosynchronous orbit, sits in a plain on top of a mountainous area and is unusually quiet electronically.

As can be seen from the illustration opposite, Fucino is a very large site.

On 12 September 2006, BT announced it would shut down satellite operations at Goonhilly in 2008, and move them to Madley Communications Centre in Herefordshire, making that centre BT's only earth station.

In its heyday Goonhilly had a visitor centre (now closed) attracting around 80,000 visitors. There were also tours around the main site and into the heart of Arthur (the first dish on the site)..

Following closure, a new company was formed to manage the operations, Goonhilly Earth Station Ltd (GES). The company leased most of the antennas for at least three years with the option to buy the entire complex in the future. Goonhilly Earth Station Limited took ownership of the site in January 2014.

Des gave a detailed explanation of the development of GES from its beginnings, including plans for site upgrades and the development of new markets for the company, some of which is shown on the slides on the following page. It is hoped to re-open the visitor centre at some point in the future.


UK Space-Innovation & Growth Strategy
A 20-year strategy published 2010
Turn a £6bn industry into £40bn by 2030
From present 6% of global market to 10%
17 recommendations - all adopted by incoming coalition Government; including:
Industry & Universities working together
Visible demonstration of UK Space Capability
Education & Outreach - STEM agenda
Training 100,000 scientists & engineers
October 2019
© des.prouse1@btinternet.com
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Goonhilly Space Science Park
(as envisaged in 2011)
Space Communications Gateway
Radio Astronomy & Deep Space Comms & Navigation
Space Centre for Visitors
Space-themed to inspire future generations
Public outreach & education
Skills Training & CPD
Practical & innovative Continuing Professional Development
Open Innovation Centre
Knowledge transfer between Industry & Universities in a practical environment
October 2019
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In April 2018, Goonhilly became part of a collaboration partnership for Commercial Lunar Mission Support Services, with the European Space Agency and Surrey Satellite Technology Ltd (SSTL).

Following Des's talk many questions were posed, including one relating to the security of the electricity supply to the site. Although normal demand is met by the National Grid, as many of the site's activities are mission critical, all essential equipment can run off batteries for up to 20 minutes, during which time four one-megawatt diesel generators will take over.

A second question concerned the potential conflict between the site's communication capabilities and the nearby wind generator farm which is not part of the complex. Des explained how the wind farm had been carefully sited during the planning phase to avoid any such problems.

Overall a very well attended talk by an entertaining and knowledgeable speaker.

David Thomas & Malcolm Hind

Visit
Tuesday 5th November – Visit to Network Rail Ludgate Cellars DC Substation

In December 2016 we were given a talk by Martin Sigrist about the Electrification Traction Power arrangements for the Thameslink Project and particularly the management of the interface between the 25kV AC and 750V DC systems between Blackfriars and Farringdon stations.

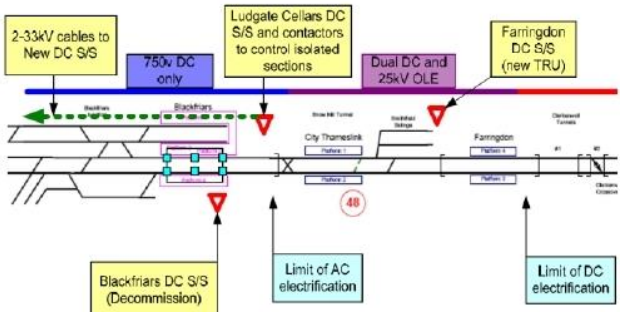
Today's visit enabled RCEA Members and 2 guests (13 in total) to see said substation and ask questions (of Martin and his colleague Alan Hodge).

The picture on the left above shows the group outside before we entered. Note the expanded stainless-steel sheet cladding. The picture on the right above shows the group clustered around the mimic diagram on the control panel, waiting to see the depicted contactors change from close to open and vice versa.

The substation is a short walk from City Thameslink station and contains 33kV and 750v DC switchgear, Rectifier Transformers and, uniquely as Network Rail substations go, DC contactors operated automatically by the train movements being detected and relayed by the signalling system. (A note here for non - electrical readers - a contactor is a switch designed for normal loads, but a circuit breaker will safely break fault current which can be many times higher than normal.)

To provide 100% redundancy the substation was constructed as two (nearly) identical halves A and B.

As a reminder, here is a system diagram and a photo of the substation: -



The August 2017 Newsletter gives a good description of what is going on, and readers should read this first (see the RCEA website). Below, are some further notes taken by MCW/DW on the day, which pick up on some of the anecdotes relayed by our guides, together with our impressions as visitors.

The building itself is clad in a form of expanded stainless steel - a bit like one sees on Grand Designs, but not actually rusty. We climbed two flights of stairs, behind the cladding, and spent most of our time in the standby plant room – with a shorter time spent in the operational one, which was subject to the heavy clunk of dc contactors operating as a train passed by every 2 or 3 minutes.

The A and B halves are switched over every week by the Electrical Control at Lewisham, so during our visit, the standby room was effectively off load and suitably quiet. Each room feeds 4 x 2.5 MW of DC, with power entering at 33kV via independent feeders from the network south of the Thames. Switching is by vacuum circuit breakers which are contained in an SF6 gas atmosphere to minimize space. The rectifier feeder cables then go down to an oil-filled transformer (4 per room) which has star and delta secondary windings feeding a 12-pulse diode bridge delivering the required 750v DC.

This is then fed via DC high speed circuit breakers and load breaking contactors (see diagram) to the track. The circuit breakers can handle a fault current of up to 100,000 amps, though the prospective fault current here is nearer to 60,000 amps. Given their high speed of operation (14-20ms) the current will not have built beyond 20,000 amps before being broken. We were fore-warned that the breakers, when opening, sound like an artillery gun firing. Thereafter we were on edge, waiting for a trip. But it never came: apparently most faults originate in depots (apprentice drops spanner across rails?) but a few per year also arise in the open (e.g. supermarket trolley dropped on rails). And occasionally if several trains are all taking peak load (up to 4000 amps for a 12 car train) together, this can cause an overload trip. The breaker(s) are generally immediately reclosed, and reclosed yet again after a short wait. If the tripping persists, the cause will be investigated. In the case of multiple tripping the situation will be raised with the signaller straight away.

We had quite a discussion about earthing. On the 25kV side, one or two of the running the rails are earthed at many points via the overhead line structures. On the DC side great pains are taken to keep the negative running rails free from earth, cabled to the respective sub-station negative busbar. This avoids, or at least minimises, stray earth DC ground currents which can be very electro-corrosive (1 amp for a year will dissolve 10kg of steel in the ground) as well as upsetting sensitive electrical equipment. It is this difference in earthing regimes between the two systems that has given rise to the need for the isolated section of rail between north and south, and the special arrangement of interlinked dc contactors.

We also had interesting discussions about the implications of train movements. It is anticipated that 24 trains per hour will be the timetabled maximum (the theoretical maximum being 32/hour). This will use ATO (automatic train operation) of the trains (with drivers present), anything above about 22/hour demands such precise control and close gaps between trains, that it would otherwise oblige drivers to approach very close to the train in front which they may not be comfortable with. Over 24 could be used to recover from disruption by moving empty trains through.

Maintaining safe passenger distances from 25kv live equipment when on the platform, can also be a challenge. Clearance has been achieved by removing the ‘stagger’ in the o/h line and placing to the non-platform side. ‘Stagger’ is the name given whereby the contact wire is stretched into a zig-zag when viewed in plan; this produces more uniform wear on the pantograph head carbons strips.

Probably the biggest 'surprise' that the engineers discovered as soon as the new track isolating system was commissioned *was the excessive level of rail head arcing when the train wheels bridge the Insulated Rail Joints that provides the electrical separation (a few mm) in the running rails.* It was realised that this was due to the small but significant inductance in the length of cable between the train and the rectifier supply. Various solutions were tried with varying degrees of success, finally ending up with slave contactors being installed close to the affected rail section. This has meant installing slave contactors including two in sound proof boxes on the north going platform at Blackfriars. (Two of us noted these on our way home; passengers seemed to be unaware of the contactor clunking going on inside.)

Two points of local interest for RCEA members. We noted the name of Allen West (an old Brighton switchgear firm) on some of the 415v control panels. And the additional dc contactor system installed to overcome the rail arcing problem, came from LCS Portslade. Presumably the 'LC' stands for 'Le Carbone' – a French company that has been there for decades.

Finally, it's worth commenting on transformer noise. All the (oil filled) rectifier transformer units were quiet, or maybe had a slight hum. But if there was a hum this was completely drowned out by the 'scream' coming from the signal supply transformers just outside the compound – of much lower voltage and KVA capacity, but we were informed, comprising resin encased windings which don't seem to have the capacity to absorb sound!

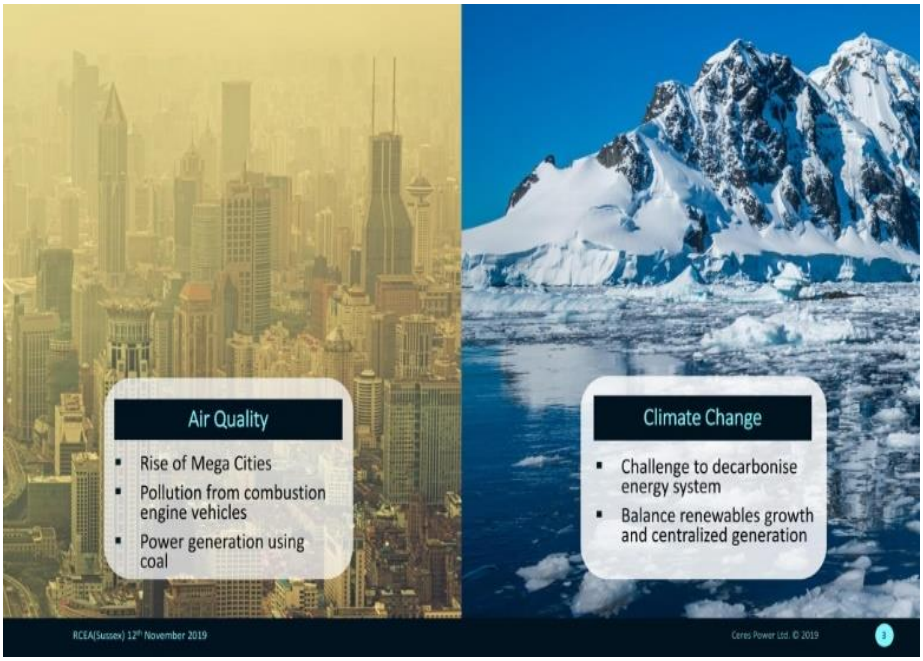
The overall cost of the project was just under £30m; £18m for the original equipment, £2.5m for the slave contactor system, and £7m for moving cables etc.

Although a layman might wonder how a bunch of chaps could be entertained for a couple of hours just looking at grey cabinets with a few buttons and lights, we have to say that the visit was really interesting and pretty unique. We are lucky to have Derek, retired, but still with sufficient contacts and goodwill, to be able to arrange such a well-informed tour with commentary straight from the horse's mouth.

Mike Wooldridge & Derek Webb

Talk
Tuesday, 12th November 2019 – "The Electrified World – a Perfect Place for Fuel Cells".
Paul Barnard, Director of Special Projects, Ceres Power Ltd., Horsham

Paul began his talk by 'setting the scene' for us. He highlighted the current problems of air quality caused by the burning of fossil fuels and its link to climate change. He explained that as the world becomes more electrified and moves away from traditional sources of energy for electrical generation and transport, there are many challenges both in the transition and within the final energy mix.
Some of these challenges include the fact that renewable sources of electrical energy have intermittency limitations, traditional generating assets emit harmful emissions, the national grid has capacity limits and electric vehicles have battery and charging challenges.



Energy Storage Technologies

	Short Term (Hours)	Medium Term (Days)	Long Term (Up to Years)
Low Capacity (<10MWh)	Flywheel Batteries		
Medium Capacity (1 MWh - 10 GWh)		Compressed Air Storage Water Pumped Storage	
High Capacity (>1 GWh)			Power-To-Gas : Hydrogen Power-To-Gas : Synthetic Natural Gas

One of the challenges of renewables sources of electricity generation is their intermittency which to a degree can be mitigated by storing the electricity at times of surplus and recovering the energy at times of shortage as shown opposite. Apart from the additional investment cost there are obviously also losses involved within the storage and recovery cycle.

If we consider energy usage today in the UK, as shown opposite, we have an awful lot of work to do to significantly change the situation in our quest for a cleaner, more sustainable future.
Fuel cells offer an answer to some of these challenges. They are the most efficient means of converting chemical energy to electrical energy. Historically, they have been a mixture of science fiction and space race fact; now they are proving to be real world products. Today's fuel cells offer electrical power outputs ranging from Watts to greater than Mega Watts.

Great Britain's Daily Energy Consumption

Energy	Daily Consumption
Natural Gas	400-2600 GWh
Logistics Fuels (Planes/Cars/Etc)	1400-1700 GWh
Electricity	700-1000 GWh

Both the natural gas and electricity demand show seasonal variation

Up to 80% of Great Britain's energy need is supplied by hydrocarbon fuels (2014-2017 data)

A Brief History of Fuel Cells (1)

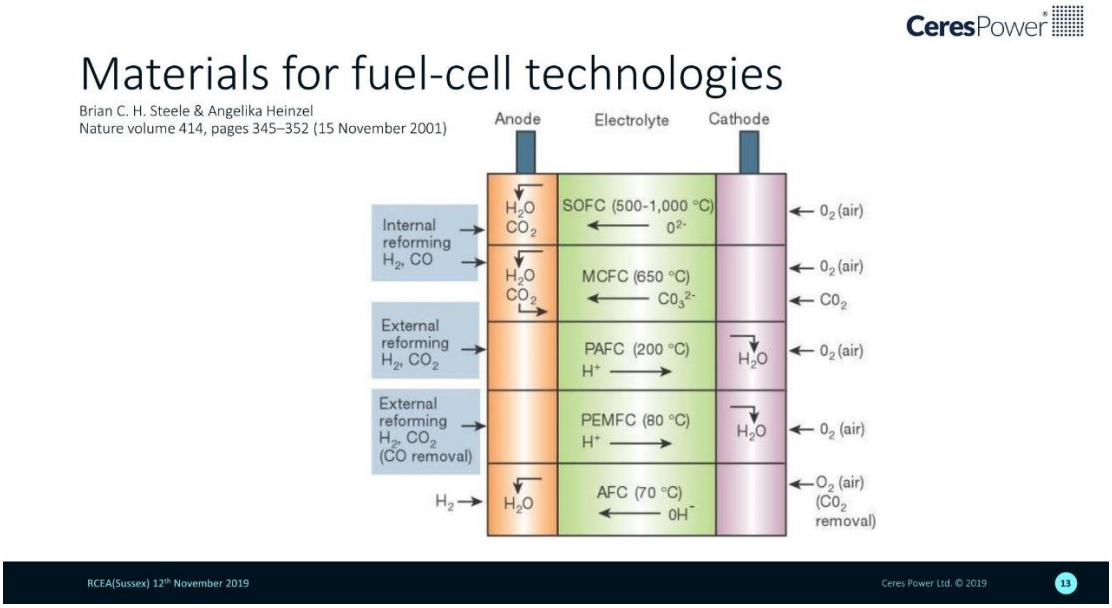
1801	Humphry Davy demonstrations the electro chemical principle behind fuel cells
1839	William Grove invents the "gas battery", the world's first fuel cell
1889	Charles Langer and Ludwig Mond develop Grove's invention and use the name "fuel cell"
1950s	Proton exchange membrane fuel cell is invented by General Electric
1959	A 5kW alkaline fuel cell is demonstrated by Francis Bacon
1960s	Fuel cells enter the space race and are used on space craft
1970s	Oil Crisis promotes investment in alternative technologies and fuel cells
1990s	Large station fuel cell systems start being installed for commercial operations
2008	Honda commence manufacture of the FCX Clarity fuel cell vehicle
2009	Japan starts installing domestic micro-CHP fuel cell systems under a government program

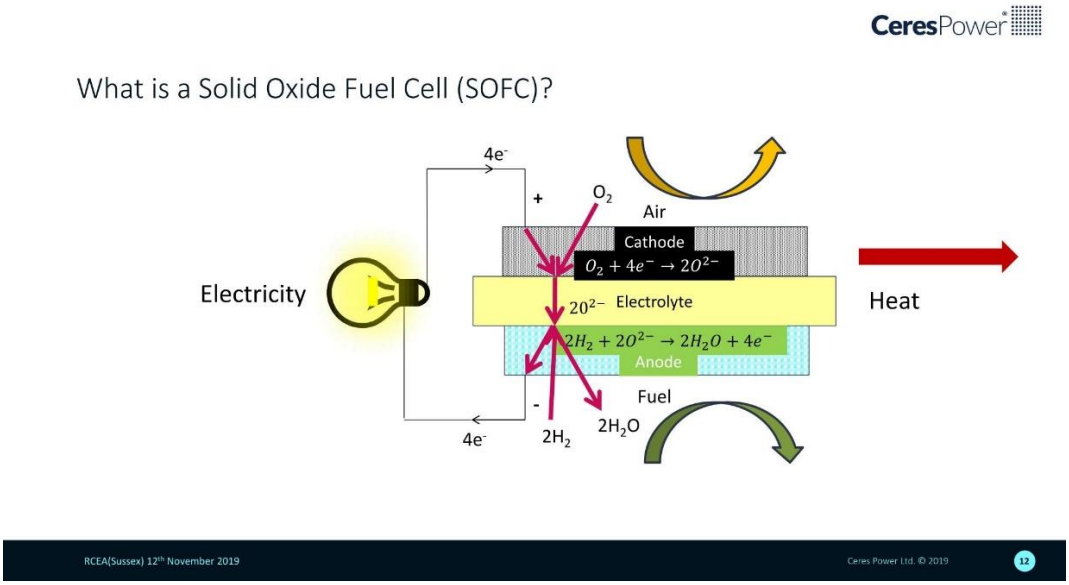
If we look back into the history of fuel cells we find that the basic concept has been known for a very long time.

Although fuel cells are now the preferred source of power on spacecraft, their widescale use elsewhere is largely restricted by commercial considerations – but things are changing.

Paul then discussed the different types of fuel cell available today.

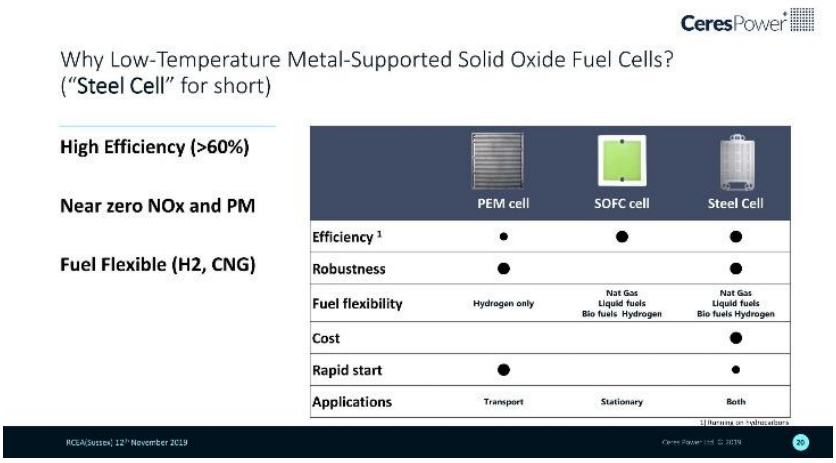
As can be seen from the diagram opposite, one of the key differences between fuel cell technologies concerns the temperature at which they operate.

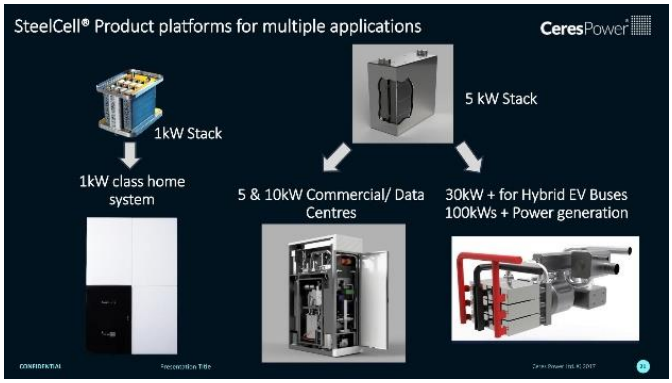


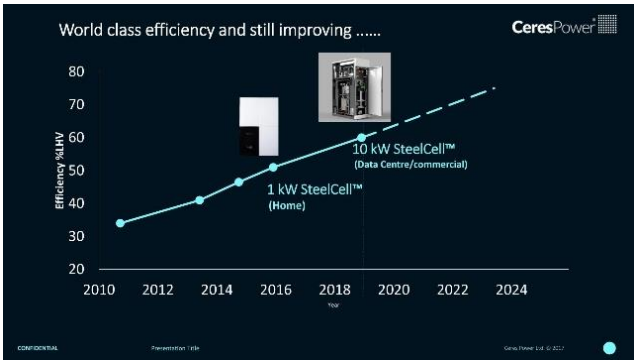


Ceres Power are currently concentrating their development efforts on intermediate temperature solid oxide fuel cells as illustrated opposite.

Paul discussed the reasons why Ceres Power have chosen the low temperature metal supported solid oxide fuel cell (steel cell for short) and compared its performance with, in particular, the PEM cell as shown opposite,



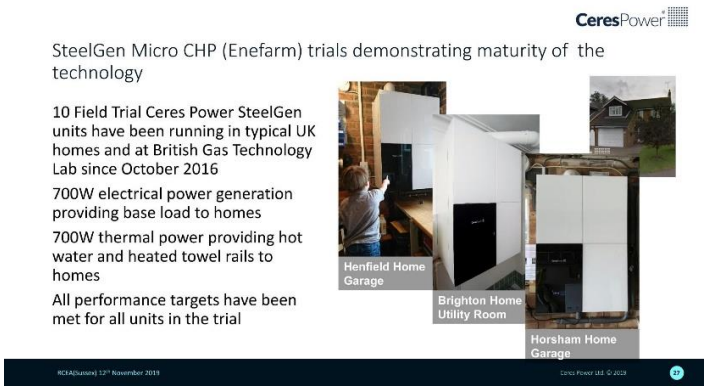


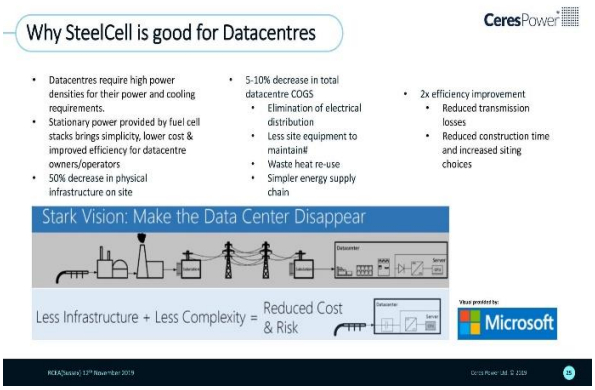


Currently Ceres can offer prototype cells in 1 and 5 KW stacks (above left) and have been able to continuously increase the efficiency of their cells over time (above right).

Although Ceres Power headquarters and R&D centre is currently located in Horsham, a manufacturing unit is under construction near Redhill.

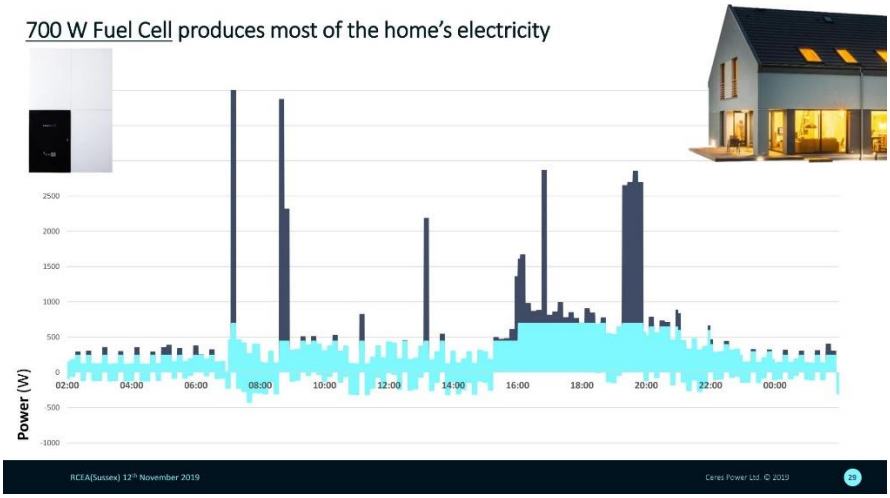
Two current applications for Cere's fuel cells are for domestic use (below left) and for data centres (below right) which require a very secure power supply.





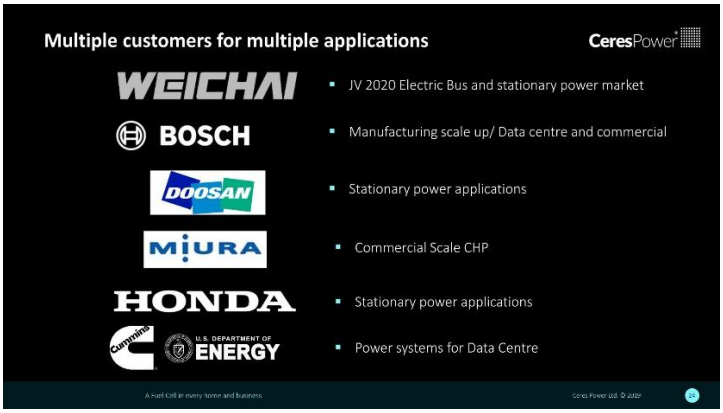
The 700w domestic unit can meet most of a typical home's electical needs but must rely upon the grid for those peak demands as shown opposite.

If an electric vehicle were to be trickle charged at night this could be accommodated, but if a 'fast' 3kw charger were needed this would dramatically affect the demand picture.



Following the talk, a number of questions were posed :-
Are fuel cells susceptible to poisoning? Yes – particularly those using natural gas as natural gas contains sulphur which has to be filtered out. All fuel cells will degrade in use at about 0.2%/1000 hrs. The domestic units currently on trial do contain a de-sulphur unit which requires service every 2 years. The target life for a domestic unit is 88,000 hrs.
Can the output be modulated? Yes, but there are limitations on the speed of control of output. In this regard PEM cells are better if you need to modulate the output rapidly.
What happens when we have no natural gas supplies? Use hydrogen which can be produced in a number of ways.
Can you recycle fuel cells? The cell itself can not be recycled other than recovering the materials for reuse. The external components such as pumps etc can be refurbished.

Are you still working with British Gas? Not currently as we have focussed our anticipated long term customers in other application areas as shown opposite.



Our thanks to Paul Barnard for a thoroughly entertaining and interesting talk on a very topical subject.
Malcolm Hind

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REPLY SLIP – Talk & Visit South Downs Heritage Centre, Hassocks, BN6 9LY

The talk on the **development of the lawnmower** from the first steam driven devices to the present day will be given by Clive Gravett, an acknowledged expert. He has published a book "Two men went to Mow" on the subject and the profits go towards his charity. A guided tour of the museum and the talk will cost £5 payable to the RCEA by cheque with the application. Attendees may also wish to have a meal (optional at own cost) in the Garden Centre cafe on the day. It can be preselected from their standard menu which I will send later to attendees.

To Ivan Farrow, 14 Ring Road Lancing W Sussex BN14 0QF
ivan_farrow@yahoo.com

I would like to attend the above talk & visit at 11:00 am on Monday 20th April 2020. Please reserve me ……...places for the lecture and museum@£5 each for which I enclose payment.

Please reserve me……. places for the meal (optional)

Full name…….

Address…….

……..

Phone…… E mail address……

REPLY SLIP – Ford Materials Recycling Facility

We are planning a visit to the Materials Recycling Facility at Ford, which we hope will take place at 10.00am on 14th May. The visit will include a short presentation in the Education Centre, followed by an opportunity to the the MRF's state of the art technology from their viewing platform. Finally, there will be a Q&A session. The visit is expected to last for about 2 hours. Please note that visitors need to climb stairs to reach the viewing platform, so the visit is not suitable for those with limited mobility. Also, anyone with a pacemaker will not be able to go on the visit because large magnets are used in the separation process. The visit is limited to a maximum of 14 people, so priority will be given to RCEA members. Please note the early cut-off date. This is because Ford require full details of all visitors at least a month in advance of the visit, and this may take a little time to assemble. Please make sure you give your FULL NAME when completing the reply slip below.

To: Perry Eastaugh, 33 Ruston Park, Rustington, Littlehampton, BN16 2AD
(01903 788858) email: perry.eastaugh@icloud.com

I would like to visit the Ford MRF on Thursday 14 May. Please reserve me the following places (priority will be given to members):

Members …….Guests …….

Full name (s)
……

Address…….

……...

Telephone (mobile preferred):……..Email address:……..……

Applications before Tuesday 10th March.

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REPLY SLIP – Visit to Culham Centre for Fusion Energy

Following the very successful visit to Culham this year I am proposing to organise another visit in May this year. However, Culham have not decided on the exact date but expect it to be either the 9th or the 16th of May 2020.
I do need some indication of numbers before they decide on a date so this reply slip is just to indicate your interest and will be followed up when the exact date is known.
Mike Woodridge has once again offered a limited number of seats in his Ford Tourneo, so first come first served

To Ivan Farrow 14, Ring Road, Lancing, W Sussex. BN15 0QF

Ivan_farrow@yahoo.com

I would like to attend the visit to Culham on Saturday afternoon mid May 2020 Please reserve me ……..places.

Full name……
Address……
……..
……
Phone……
Email address……..

We would like to make you aware that there will be a significant amount of brisk walking during the tour (3-4 km of walking and standing) so it is advisable to wear comfortable shoes. Please also note that open-toe shoes are strictly forbidden in one of the experimental areas, so please ensure ALL visitors wear covered footwear.

A brief programme for the event is as follows:
Arrival - tea and coffee will be served
Introductory talk on fusion
2 hour tour of JET and MAST fusion experiments.

End of Newsletter