RCEA
(SUSSEX)

An Association for Retired Professional Engineers

NEWSLETTER March 2019

President's Message

Welcome to the March Newsletter.

We have now reached the end of our autumn/spring session of talks.

I think that you will agree with me that we have had some excellent talks that have been well attended by members and visitors.

We always try to include text and pictures from these talks in our newsletter for the benefit of those members unable to attend the meetings, and, for the first time, in the talk on 'Getting ships there' we have included links to supporting videos stored on our website. Members reading our electronic version of the newsletter should be able to access the videos directly, although we have found that some browsers are unable to download and play them. Alternatively you can always read the newsletter on our website at www.rceasussex.org.uk and access the videos from there.

The committee has arranged outings and visits over the summer and I hope that you will be able to support them. Where on some of our engineering visits group numbers are limited, members will be given priority over non-members. In all cases where numbers are limited, spaces will be allocated in the order that bookings are received, so I recommend that you book early on all our visits and outings.

For your information the committee is looking to move the management of the Association's affairs to a purpose made Membership software package. This is to make life a bit easier for the Membership Secretary and Treasurer.
Financial transactions would be more straightforward. An update will be given at the AGM in September.

I repeat the need for Members to consider stepping forward at the AGM to join the Committee. The good health of the Association is dependent on 'new blood' from time to time. The best way to get started is to join the Committee with no specific role and contribute to the discussions. We hold three morning meetings a year so it is not too demanding on one's time.

Please give the matter some thought. If you would like to just have a 'taster' of one of our meetings, just let me know.

You are welcome to approach me or other members of the Committee if you want to know more.

Derek Webb
March 2019

PROGRAMME OF EVENTS   April 2019 – September 2019

18th Apr	**Thursday**	**Coffee - at Spotted Cow, Angmering**
25th Apr	**Thursday**	**Coffee - with Partners at Swallow's Return**
2nd May	**Thursday**	**Visit – Brookhurst Wood Waste Treatment Facility**
11th May	**Saturday**	**Visit – Culham Centre for Fusion Energy**
16th May	**Thursday**	**Coffee - at Spotted Cow, Angmering**
24thMay	**Friday**	**Outing – Leonardslee Gardens**
30th May	**Thursday**	**Coffee - with Partners at Swallow's Return**
20thJun	**Thursday**	**Coffee - at Spotted Cow, Angmering**
27thJun	**Thursday**	**Coffee - with Partners at Swallow's Return**
11th July	**Thursday**	**Outing – Weald & Downland Museum**
18thJuly	**Thursday**	**Coffee - at Spotted Cow, Angmering**
25thJuly	**Thursday**	**Coffee - with Partners at Swallow's Return**
15thAug	**Thursday**	**Coffee - at Spotted Cow, Angmering**
29thAug	**Thursday**	**Coffee - with Partners at Swallow's Return**
17thSep	**Tuesday**	**AGM & Talk – The technical challenges to taking astronomical images**
19thSep	**Thursday**	**Coffee - at Spotted Cow, Angmering**
26thSep	**Thursday**	**Coffee - with Partners at Swallow's Return**
8thOct	**Tuesday**	**Talk – Goonhilly, a tale of two half-centuries**
17thOct	**Thursday**	**Coffee - at Spotted Cow, Angmering**
31stOct	**Thursday**	**Coffee - with Partners at Swallow's Return**

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.
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.

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

C J Greatley, C Phys, M Inst P – St Leonards on Sea

D Higgins, BA, MSc, C Eng, MIET - Lindfield

A Riddet – Horsham

D K Varney. C&G Telecomms – Rustington

G M Gibbs, BSc(hons), MSc, Ceng, MICE, CSci, FCIWEM – Angmering

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.

Southern Retired Chartered Engineers (SRCE)

We have received the following programme information from the SRCE. Members wishing to attend any of these events should contact the SRCE secretary Jeff Williams on 02380 897078 or e-mail jagwilliams@waitrose.com.

Wednesday 15th May – visit to Winchester Cathedral and the Great Hall
Thursday 20th June – Salisbury Playhouse to see "Educating Rita"
Thursday 18th July - London walk – "Rail to Mail" a guided walk from Euston Station to Mount Pleasant postal museum.
Tuesday 6th August – a visit to Polesdon Lacey.
Thursday 22nd August – Sonning theatre to see "Towards Zero" by Agatha Christie.

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 April – October 2019

Visit.
Thursday 2nd May 2019 - Brookhurst Wood Waste Treatment Facility (limited to 15 people)

Members may recall that we last visited this facility in 2014 when only part operational. We have arranged this follow-up visit to hear what lessons have been learnt and improvements made over the 5 years of full operation. The visit will consist of a presentation of approximately 1 hour followed by a walk along the viewing gallery which will show the delivery of waste, shredding and sorting processes. No special footwear is required as we will not be entering the working areas of the plant. Members attending should car share as there are only 8 parking slots. Due to the location of the facility there are no public transport links. Full location details will be sent out to attendees prior to the visit as we are told that some Sat Navs will direct you to a nearby industrial estate.

Reply slip is at the end of this newsletter.
Contact Malcolm Hind: 01403251719/07899785422, email malcolmhind@msn.com

Visit.
Saturday 11th May 2019 - Culham Centre for Fusion Energy

Following the Cooch memorial lecture on 13th November last year when our speaker, Robin Stafford Allen, gave us a talk entitled "Fusion Power – within our grasp?", we have been fortunate to obtain a number of places on a tour of Culham itself. A brief programme for the event is as follows:

13:30pm - Arrival - tea and coffee will be served
Introductory talk on fusion
2 hour tour of JET and MAST fusion experiments.

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. Open-toe shoes are strictly forbidden in one of the experimental areas, so please ensure you wear covered footwear.

Reply slip is at the end of this newsletter.
Contact Ivan Farrow: 07971184207, email Ivan_farrow@yahoo.com

Outing.
Friday 24th May 2019 – Leonardslee
Meet at 11.00 am at Leonardslee Gardens, Brighton Road, Lower Beeding, Horsham RH13 6PP

We have managed to arrange a group visit to see the re-opened Leonardslee Gardens.
The gardens were sold in 2010 since when they have been closed to the public. They were purchased by the present owner in 2017 (Penny Sreet OBE), and as those of you who drive past on the A281 will have noticed, a major programme of work has been taking place both to the gardens and the house.
The gardens will re-open to the public on 6th April this year and this outing will be a good opportunity to see what has been done. The wallabies and the doll's house are still there and there are a number of eateries including the Courtyard Cafe, the Clock Tower Cafe and Farm Shop and a Restaurant.
What will be out in the gardens is always weather and season dependent but hopefully there will still be a good show of Rhododendrons etc. Access to the Upper part of the gardens, cafes and shop etc. is wheelchair friendly, however, access to some of the Lower gardens may not be.
The site is a cashless zone, so make sure you have a card if you intend to purchase anything. We have requested guides and the cost including a guide will be £15 for seniors (60+). Please advise if booking for non seniors.

Reply slip is at the end of this newsletter.
Contact Glyn Mathias: 01903 859191, email glyn.mathias@btinternet.com.

Visit
Thursday 11 July – Weald & Downland Living Museum (limited to 20 people)

The Weald & Downland Living Museum at Singleton, Chichester PO18 0EU is home to more than 50 historic buildings set in a beautiful 40 acre site in the South Downs National Park. Our visit will start with a guided introduction to the museum, including a discussion of the changing construction methods through the ages. After the introduction, members will be free to roam the museum for the remainder of the day (it closes at 6pm). There is a café which is open from 9.30am to 5.00pm. Some members may want to grab a coffee on arrival; the café also serves a range of food at lunchtime.

It is important that members arrive by 10.45am at the latest so that we have time to complete the admission process before 11.00, when our guided tour starts.

The museum advises that some of their paths are very rough and quite difficult to navigate in a wheelchair, or for those who are unsteady on their feet.

Reply slip is at the end of this newsletter.
Contact Perry Eastaugh: 01903 788858, email perry.eastaugh@icloud.com

Talk
Tuesday 17 September - The technical challenges to taking astronomical images

Our speaker, John Mallett,FRAS, Member of the BAA,and also IET and RAeS, has his own observatory in Selsey near Chichester.
John will talk about the journey he has undertaken to obtain high quality images and data from his amateur observatory. In particular he will highlight the technical challenges in dealing with mechanical, electrical, atmospheric variations, noise and errors that cause image and measurement data quality issues. As an example of these challenges, he will discuss the control loop required to track stars using a computer driven telescope mount and adjust for errors in gear systems, motor resolution, camera noise, atmospheric movement etc. In his talk he will also examine some of the other effects that cause errors in observing distant objects in terms of the uncertainty of time and our movement round the sun and solar system.

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

Goonhilly Satellite Earth Station has been instrumental in the history and development of satellite communications since the early 1960s. This talk will commence with a summary of the site's evolution over its first half-century leading up to plans for its demolition in 2009. The second part will show how the site was saved from the bull-dozer and will introduce some of the exciting plans which the new owner has for using the existing large dishes as the basis for the Goonhilly Space Science Park over the next half-century during which Goonhilly (and hence Cornwall) will be ideally placed to gain universal acclaim as a centre of excellence for space communications & navigation for missions to Mars, the Moon and beyond.

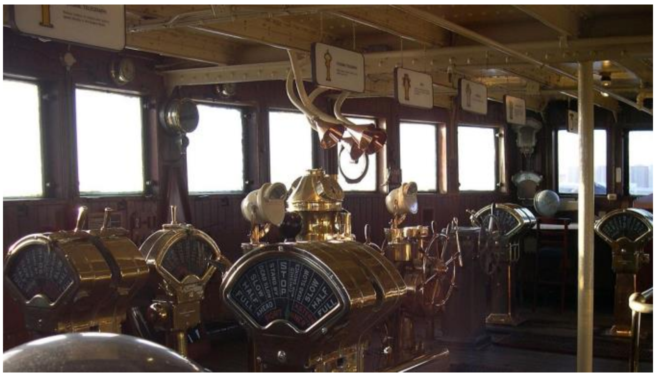
Our speaker, Des Prouse, worked in the Research & Development Department at Goonhilly Satellite Earth Station from 1971 until his retirement in 2007. He then made it his retirement passion to seek alternative uses for the site and its people, following BT's decision to cease its own satellite services and to demolish most of the site.

Reports

Talk
Tuesday, 18th December 2018 – "Getting ships there".
Antony Tomkins, Global Business Development Manager, Hamiltonjet

In Antony's last talk we saw how propulsion technology has changed the maritime environment, but technology has also changed the way vessels are navigated. The dawn of electronics has fundamentally changed how vessels are navigated, tracked and operated. Today, like most of the rest of the modern world, disruptive technologies are changing the maritime environment and propulsion and navigation systems are converging, facilitated by rapidly improving connectivity which is opening up new opportunities. Most of the major systems that enable this change have been around for some time but what makes the difference is being able to link them all together in systems that can (and will) change the world.

The beginnings of electronic navigation & Control



For all these modern advances to happen significant advancements in the world of navigation and propulsion control were needed. For ship control the traditional method of controlling engines and propulsors was using mechanical cables, levers and telegraph systems. The picture opposite shows the Queen Mary's Bridge controls in 1934. This remained largely unchanged until the 1970's when electronic control started arriving on vessels. However, the Marine industry is (or was) notoriously conservative with adoption of new technology (see most fishing boats) so it wasn't until the 1990's, with the arrival of the first digital control systems that Electronic controls became widely accepted.

Digital control systems delivered:
- Smooth, stable control of engines and propulsors
- More efficient control of engines and vessel movement
- Reduction in crew numbers
- Ability to link systems of the vessels together

The change in Navigation technology has been just as dramatic. For centuries the act of marine navigation remained unchanged, relying on compass and celestial navigation to chart progress across the world's oceans. It wasn't until the early 1900's when things began to change as ships started to be fitted with radios. Radio Frequency navigation gave the ship's Navigator the ability to check their chronometers and give a more accurate indication of their vessel's location. However, the range of these transmitters was short so, once in open waters, it was back to the traditional navigation techniques.

The next major breakthrough wasn't until 1942 when the LORAN (**LO**ng **R**ange **A**id to **N**avigation) system was introduced by the US. It was a big step forward but accuracy was significantly reduced as ships became further from shore. There followed other similar systems which all used the RF signal comparison to derive vessel location:

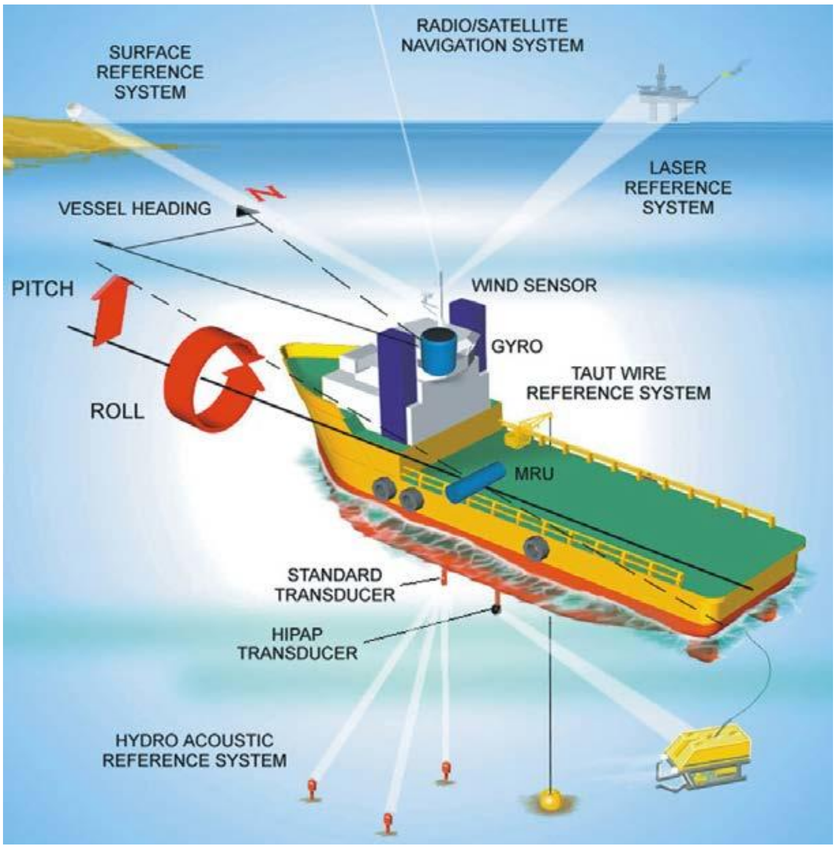
- Gee (actually invented before LORAN by the British with higher accuracy but shorter range)
- Decca – a highly successful evolution of Gee with easier to read to displays and greater range. Decca's smaller units made it very popular for all vessels and was the entry point for electronic navigation on **<u>all</u>** vessels, not just ships.
- LORAN-C, a vastly improved version of LORAN with greater accuracy and range. It was widely used by Naval and Commercial shipping alike until the 1990's. It was only turned off in the last few years and now there is even some talk of turning it back on.

The introduction of Satellite Navigation Systems made stand-alone electronic navigation possible. Work started in the 1957 with the launch of Sputnik, and the launch of the first dedicated navigation satellite system TRANSIT in 1960. However, it was not until 1985, when the first 11 Global Positioning System (GPS) satellites were in place, that standalone electronic navigation became possible – the revolution had begun! Today there are 31 GPS satellites in orbit, with a further 24 GLONASS satellites on station. Between the two systems nearly the whole planet's surface is covered.

It's not just navigation that has been affected by satellite technology: high speed data can now be received and transmitted by virtually any vessel anywhere in the world – the world of Big Data has arrived at sea!

The Vessels of Today

ECDIS – Electronic Chart Display and Information System (shown opposite), is the final step in the revolution of maritime navigation which takes us to where we are today.
ECDIS takes information in from GPS, Electronic Charts, RADAR, Navtex, AIS (Automatic Identification System for tracking ships) and depth information into one system and one display. It replaces the Navigator, and means that paper charts can remain locked away in chart tables. Initially these were mostly for military vessels, but now it's widely available for all vessels.

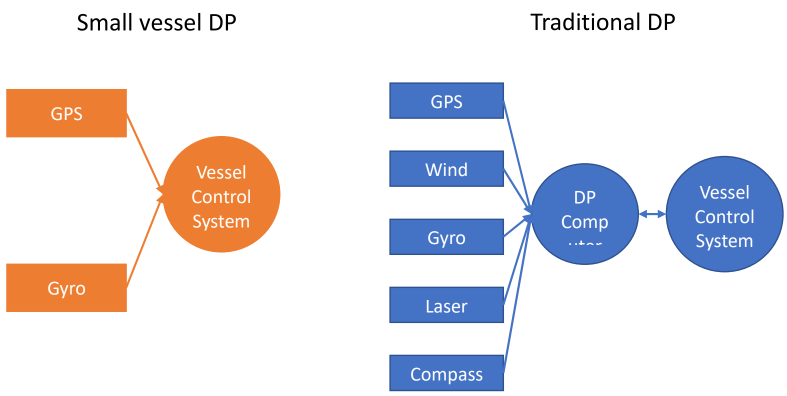


Dynamic Positioning (DP) is a great example of how all these converging technologies come together. DP is a system that takes inputs from multiple sensors and outputs control signals to the ship's propulsion system, so that a vessel can be held in fixed location and heading even in high sea states without the need for manual input from the ship's master . This allows complex offshore operations to be undertaken much more safely and efficiently.

The picture below shows a work boat unloading at a dock without being physically connected to it, relying only on DP to maintain its position close to the dock wall. Ctrl + Click on the picture below to open the link to our website where a video entitled "Platform Stability Demonstration" is held.

One good example of how DP together with another emerging technology – geo-stabilised gangways - is changing the industry is in a new vessel that is now under build with the Dutch Shipyard Damen. The combination of a modern high speed hull design capable of 40+ kts carrying up to 150 passengers, with DP and a Geo-stabilised gangway, means the vessel can safely transport and transfer industry personnel safely in even severe weather conditions. Such a Geo-stabilised gangway is shown opposite.

Ctrl + Click on the picture to open the link to our website where the video shows such a stabilised gangway in operation.



This is helping to address one of the offshore oil industry's biggest safety issues – transfers by helicopter. Until recently the biggest limitation with DP systems was that, due to the complexity of the system, it was only really suited to large vessels as the DP computers and sensors required were/are both costly and large. However, rapidly reducing size and cost of technology and manufacturing techniques is starting facilitate DP capabilities for all vessels – see opposite.

Unmanned Surface Vessels (USV)

Until this point we have been mostly talking about incremental changes in existing technology, albeit happening over a short period in time. USVs represent a quantum leap into the future and could fundamentally change the way the Maritime Environment looks, works and the way in which we interact with it. We are currently at the start of this revolution but already development is extremely rapid. The vessel has a remote command base (ashore, or on another vessel) which can be over the horizon if it is using satellite communications. To date the USV has mostly been used in Naval applications.
In the beginning Patrol operations in dangerous areas where USVs give Navies and Security Agencies the ability to increase their security presence significantly without putting humans in danger. Today the greatest growth in the use of Naval USVs is in the Mine Counter Measure Vessels (MCMV).

Traditional Minesweepers such as HMS Shoreham (see right) are some of the most expensive vessels in any modern navy (in £/ft).

USVs (see next page) are now being used to detect, identify and then destroy sea mines. The USVs work in pairs, one to search and one to destroy the target. The vessels can be controlled either from a shore-based control station or onboard a "normal" warship, either integrated into the vessels C&C center or from a 40' container placed on the helicopter deck.

The use of USVs as shown above in this role have significant benefits:

- “Taking the man out of the battlefield” – MCM is dangerous work
- Much more cost effective than a dedicated Minesweeper
- Multirole
- Can operate from any location – land or ship.
- Any/every Warship can be given OTH MCM capabilities
- Can operate fully autonomously

In short, the MCM USV is making the worlds waterways safer and more efficient for those who use them and for those who work to keep them clear.

USVs are not just being used in the Naval role though, they are increasingly being used in the civilian world too, and arguably it is here where they may have the biggest impact on the modern world. USVs are already being used for vessel detection, environmental survey and data collection. The USVs are very powerful for these operations but, to be able to exploit all the benefits that can be achieved, higher levels of automation are needed.

Autonomy is the task of automating the job of controlling and navigating the vessel with a view to reducing operator workload, or removing the human element altogether.
Currently there are two types of work going on in Autonomous development:

- Partial Autonomy – systems which help operators perform control of the vessel
- Full Autonomy – vessels that operate entirely on their own with no human input.

The major development in Autonomy is the introduction of collision avoidance. By taking inputs from various sensors, a collision avoidance system can safely navigate a vessel around other vessels and obstacles, significantly decreasing the risk of navigating at speed, and/or at night or in poor weather conditions. However, more work is needed to produce internationally accepted standards for software.

Ctrl + Click on the picture to open the link to our website where a video entitled “The Odin USV on a collision course” is held.

Full Autonomy

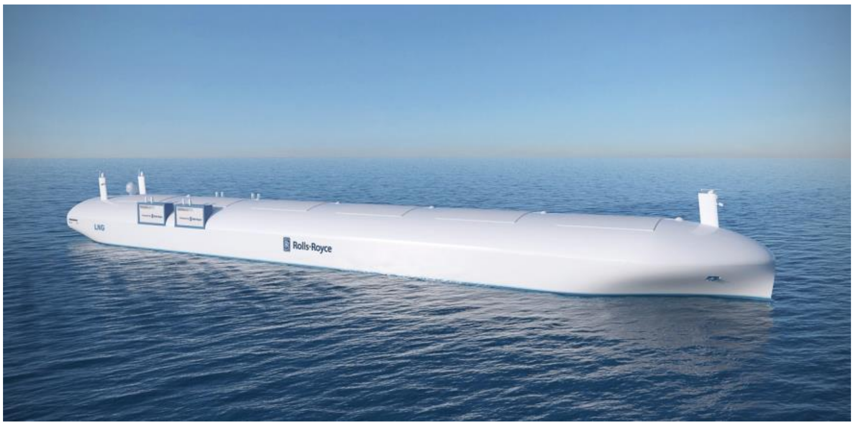
Up to this point the talk has been about systems that assist human skippers in the operation of their vessels. If we can bring these systems together, it leads to the possibility of fully autonomous vessels. ,which would have the ability to work at sea performing inspections, SAR operations and data gathering. They may eventually even deliver passengers. Once given a course the Fully Autonomous Vessel will navigate itself to its final destination. This has the potential to deliver huge efficiency, productivity and safety advantages. In the area of Maritime Surveillance full autonomy could have a major impact.

The USN is already trialling a fully autonomous submarine hunter that can remain at sea for months at a time as shown opposite.

It is not just military applications where full autonomy is starting to have a big impact.

Already in the search to understand climate change, fleets of fully autonomous survey vessels are navigating our oceans measuring and recording data on our seas.

Meanwhile the Oil and Gas industry is using fully autonomous seabed survey vessels to help the industry quickly identify where they should be looking to explore. Fisheries Protection is a hotly contested issue globally. Autonomy can have a real impact here. Over-fishing endangers worldwide fish stocks and national economic interests alike.
However, over-fishing is hard to police as current protection vessels are easily detected, giving suspect ships time to dispose of the evidence. Another area which is currently being investigated by multiple organisations is fully autonomous search and rescue (SAR) vessels. These vessels could operate pre-programmed search patterns using all their sensors to locate the casualty then hold station using their DP capabilities and work as a large data rich locator beacon.



There is currently significant R&D into developing and implementing USV and Fully Autonomous vessels into the world of general shipping – see opposite. A clear sign of how likely this is to take hold is the fact that the Class Approval Societies (who set all safety standards) are already working on developing the rules and standards to which the vessels will be built. Just what these will look like is not yet totally clear but there seems to be some convergence already on the concept of a single central control centre located in the shipping company's office.

This idea has multiple benefits:

- Crewing costs are significantly reduced
- Efficiency savings are large as one centre can control multiple vessels
- Seafarers can sleep in their own beds!
- Piracy threat is significantly reduced.

The future of unmanned shipping seems certain. Zhuhai Port in China has started work on a test site solely dedicated to docking and loading Unmanned Surface Vessels.

Passenger vessel development is likely to be slower due to underlying security and safety concerns, but despite this it is still expected that a fully autonomous Roll-on Roll-off passenger vessel will start trials in the Norwegian Fjords in 2020 – see opposite.

All of these new and emerging technologies rely heavily on data, from the navigation systems on the most basic vessels through to the full command and control systems on the most advanced platforms. Today the industry stands fairly exposed on this front. Data security on most ships is poor, and with even the oldest vessels running Ethernet based control systems, Cybersecurity is becoming an increasingly important issue for the Maritime Community. Similarly GPS "spoofing" is becoming an increasingly serious issue. This technique interferes with a vessel's location and can lead it unwittingly into a dangerous area, exposing it to threats from Pirates or Hostile States. However, the industry is already targeting these issues and is rapidly developing counter-measures from securer control systems to the next generations of navigation systems and anti-Spoofing devices.

We were most grateful to Antony for taking the time to come and talk to us again.
Perry Eastaugh

Talk
Tuesday, 8th January 2019 – "British Tanks in the First World War: an engineering and combat success but a procurement failure?"

Geoffrey Vesey Holt

Introduction:The design, initial procurement and use in combat of the first tanks was a largely British success; however a failure to maintain production meant that by the end of the war the British Army had almost run out of tanks in contrast to the French who had over 3,000 Renault FT light tanks. In the next hour I am going to attempt to explain these successes and failures.
My name is Geoffrey Vesey Holt and I am a history graduate (I have a respectable upper 2:1 – the days when that meant something - from Durham University and was offered a place to do research) and a retired regular officer of the Royal Tank Regiment – it is my forebears who manned the first British tanks. I have experience of armoured fighting vehicle procurement including the current British tank, Challenger 2, Boxer, a large wheeled eight by eight armoured personnel carrier and the current armoured reconnaissance programme. I will therefore concentrate on procurement not engineering.

The Problem:The first thing we need to do is to look at the problem that the tank, and other new weapon systems and procedures, were trying to resolve.

The start of the First World War was like previous recent major wars with rapid movement but by the autumn of 1914 on the Western Front the front had stabilised into trench warfare. There was a failure to break this deadlock in the west until 1918. Why had this revolution in warfare taken place? It was largely caused by the effects of industrialisation.

There had been a massive increase in size of armies due to increased wealth – in 1815 Napoleon aimed to raise an army of 600,000 from a population of about 30 million compared to the French Army in 1914 which was over 4 million strong and this was sustainable from a population that was only 20 % larger than in 1815. On the Western front there were only limited areas that attackers could use and the defence was also helped by railways which allowed the rapid movement of troops by the defender but the attacker was moving away as he advanced from his railhead and was largely dependent on animal power e.g. German logistic problems in 1914 and ours in 1918.

The industrial revolution also allowed a massive increase in the efficiency, range and lethality of firepower e.g. rifles and artillery. In 1815 the standard infantry weapon, the musket, was inaccurate above close range, had a low rate of fire and produced smoke due to the poor propellant. A single machine gun in 1914 could produce as much firepower as nearly 200 infantrymen in 1815 with no smoke and much extended range, accuracy and lethality. Artillery had also gone through the same improvement and barbed wire further increased the power of the defence. Communications were largely dependent on the land line telephone, pigeons and messengers.

The result of these changes since 1815 was that the defence had become all powerful as the first day of the Somme, 1 July 1916 demonstrated. The combination of the defences: extensive barbed wire (often 100 metres deep and over one metre high), well-constructed trenches and protection for machine guns and other defenders with machine gun and artillery fire covering no man land (the ground between the attackers' trenches and the enemy's front line.

THE SEARCH FOR SOLUTIONS:

Most casualties in First World War were caused by artillery fire. In theory it should have been possible to use artillery to suppress the defence but in practice this proved difficult because of, initially, inaccuracy, an inability to change targets rapidly due to poor communications and to destroy wire. It would take until 1917 to resolve some of these problems and would require, for example the remapping of northern France. In addition massed artillery fire churned the ground up and created large shell holes. There was therefore a need for something to provide immediate and flexible fire to support the infantry through the difficult ground of no man's land and the well organised and constructed German trench systems. The search for solutions started at the end of 1914. New equipment was one way forward (changes in procedures was another route).

Ordnance QF 18 pounder

- **Shell:** 18.5 lb (8.4 kg) projectile. 23 lb (10 kg) including case.
- **Calibre:** 3.3in (83.8mm)
- **Effective range**

  6,525 yd (5,966 m) Mk I & II
  7,800 yd (7,100 m) with trail dug in
  9,300 yd (8,500 m) (Mk III, IV & V)
  11,100 yd (10,100 m) (streamlined HE Shell Mk IC)

BL 6 inch 26 cwt Howitzer

- **Shell:** WWI: 100 lb (45 kg)
- **Calibre:** 6 in (152.4 mm)
- **Effective range:** WWI: 9,500 yd (8,700 m)

At the Battle of Cambrai there were 1003 artillery pieces including 498 18 Pounders and 140 6 Inch Howitzers

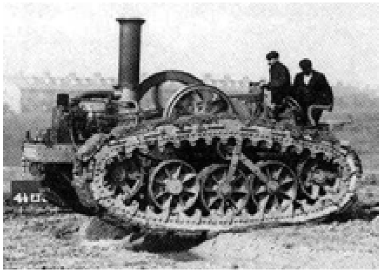
The Germans on the defensive in the west concentrated on defeating the weaker and more dispersed Russian defences on the eastern front using new tactics including a much more efficient use of artillery.

The French and the British looked for means of helping the infantry across no man's land and through the German defences, particularly the wire. These included:

- Improving artillery thanks to specialist wire cutting fuzes, accuracy (e.g. accurate mapping and calibration of guns) and the use of scientific methods – e.g. sound ranging and flash spotting - to find the enemy's guns and lethality (e.g. more medium and heavy guns and gas – a German invention)
- Increasing the infantry's firepower. This included light and more portable mortars and machine guns, grenade launchers.
- Another avenue was the use of new technologies such as aircraft and motor vehicles. One of the suggestions was powerful water jets to destroy trenches – these were tested and a report sent to the PM but it would have required 3,000 hp and hydraulics which were unreliable.

TANK PROCUREMENT –
THE CONCEPT PHASE – 1ST STAGE

- The first motor vehicle journey in UK 1895
- [Army] Motor Transport Committee (MTC) 1900
- 1902 War Office £1000 prize for a tractor that could haul 25 tons 40 miles non stop
- a Hornsby 70 bhp (oil engine) traction engine managed 58 miles, wun prize + £180,
- A chain track, nicknamed "caterpillar", was later added and first demonstrated to the Army in 1907
- Hornsby had sold most of its foreign patents to an American firm, Holts, later renamed Caterpillar. By the end of First World War the British Army had 1,651 US built Holt tractors



The British Army had looked at tracked vehicles before the war in what might be described as a preliminary concept procurement phase. The first motor vehicle journey in UK was probably in 1895. In a nice piece of symbolism the last horse drawn bus service in London was in August 1914, the month the First World War started. Even in 1918 all armies were largely dependent on animal transport as was agriculture.
As early as 1900 the army set up the Military Transport Committee (MTC) but with a tiny budget. These problems were not unique to the British: the Germans did not set up an equivalent, the Inspectorate General for Traffic and Transportation until 1911 and to quote an authoritative German source "it had nearly no men and no respect among its peers."
However In 1902 the British War Office offered a £1,000 (£115,000 in 2017) prize for any tractor that could haul 25 tons 40 miles non-stop. A year later only one candidate: a Hornsby 70 bhp oil engine traction vehicle managed 58 miles and got the prize and an extra £180 for the 18 extra miles. A chain track, nicknamed "caterpillar", was later added and this vehicle was first demonstrated to the Army in 1907. A trial in North Wales against horses resulted in an adverse report due to it being noisy and underpowered although it was able to overcome obstacles that horses could not. The Army appears to have lost interest in tracked vehicles and by the start of war Hornsby had sold most of its foreign patents to an American firm, Holts, later renamed Caterpillar. Ironically by the end of the war the British Army had 1,651 US built Holt tractors to carry stores or toe guns in difficult terrain.

TANK PROCUREMENT – THE CONCEPTPHASE – 2nd STAGE

There was renewed interest in tracked vehicles after the Western Front stabilised, trench warfare started and the power of the defence was demonstrated. The second stage of the concept phase started In France with Lieutenant Colonel Swinton DSO Royal Engineers, then the official British war correspondent on the Western Front, formerly an official historian of the Russo-Japanese War, author of a key work on low level tactics and also the proposer of the water jets project.


Swinton


Hankey


Churchill

He had previously seen a Holt tractor and suggested in November 1914 to Sir Maurice Hankey, Secretary of the Committee of Imperial Defence, the key defence committee chaired by the Prime Minister, the construction of a bullet-proof, tracked vehicle that could destroy enemy machine guns. This was in effect an outline requirement for a tank. Hankey then briefed Winston Churchill, then First Lord of the Admiralty, the minister for the Navy. It may seem odd that he would lead the design of the tank but Churchill was a man of boundless energy and ideas; the naval situation was relatively stable and there was a Royal Naval Armoured Car Division which had started on un-armoured touring cars, then improvised armoured cars. These had proved effective but due to their weight and solid tires were ineffective across difficult ground. However armoured cars were used with effect in the Middle East and in France in 1918.

Churchill initially tried to improvise the search for a solution. These included 'Revised Hetherington Proposal', a three 40ft wheel 300 ton vehicle armed with three turrets with twin 4in (100mm) guns and a Portable Bridge Machine. The latter was important because it brought into the project Forster, a small engineering firm in Lincoln.


Tritton


d'Eyncourt


Wilson


Stern

Their chief engineer, Tritton, would be one of the two designers of the first tank and the Mark I to Mark IV tanks would use an engine and gearbox already in use in one of their wheeled tractors. However by late February 1915 it was clear that these solutions would not work and with no Holt tractor available, Churchill in effect re-launched the project by setting up on 22 February 1915 a proper management committee, the Landship Committee, led by his Director of Naval Construction, d'Eyncourt. The 46 year old D'Eyncourt was in effect the senior civilian engineer of the armed forces. He had done his apprenticeship in naval architecture at the shipyard of Armstrong, Whitworth & Co and then worked as a naval engineer. He was a key driving force in the British tank project and its success.

Neither the French nor the Germans had an equivalent which may help to explain the poor design of their first tanks. Two key players also joined the committee a little later. Both were war time volunteer officers in the RNAS Armoured Car Squadron at the time:

- Walter Wilson, a brilliant engineer (First Class degree in mechanical engineering from Cambridge) had been working on motor vehicles.

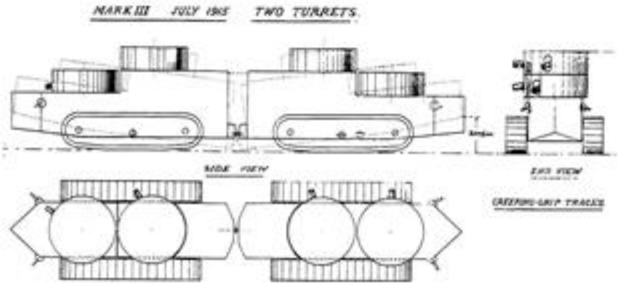
- Albert Stern was a banker with considerable and focused drive. He started as the secretary to the Committee and in February 1916 became the head of the department responsible for the procurement and supply of tanks.

The Landship Committee systematically worked through the existing options, ran demonstrations and by late June the conclusion was that the vehicle would have to be tracked and that existing available vehicles would be unlikely meet even an outline requirement. This highlighted two problems immediately facing the Committee: the lack of a requirement with some systems specifications in it. The second, and linked, problem was that the Navy, not the Army, the obvious user, was leading the project. This problem was solved when Churchill was replaced as First Sea Lord on 27 May 1915 because of the Gallipoli fiasco. His successor, Balfour, not surprisingly, wanted to transfer the project to the Army. The Army rapidly agreed to this and accepted the initial "requirement" to convey troops and provide covering fire for the infantry. This requirement was not precise enough for a design and the troop carrying requirement would have resulted in an armoured personnel carrier rather than a tank.
The development of the tank was rescued by Lieutenant Colonel Swinton who was still in France and had produced a paper "The Necessity for Machine Gun Destroyers". It covered tactical deployment, performance and armament. He proposed a tracked petrol engine vehicle with a maximum speed of 4 mph, the ability to cross a 4ft trench and climb a 5 ft parapet/step, protection against steel core armour piercing bullets and armed with two MGs and a 2 Pounder Quick Firing (QF) gun. His paper was sent to London on 22 June 1915 by General French, the Commander in Chief of the British Expeditionary Force with a "powerful endorsement."

The timing was perfect because on 30 June the Landship Committee put on a technology demonstration with a Killen Strait tractor, a turreted Rolls-Royce armoured car and two Diplock 1 ton Pedrail trailers to get buy in from key stakeholders including the Minister of Munition (and next Prime Minister) Lloyd George and the Army.
It must have been successful because Lloyd George supported the project from then on and the Army produced a more detailed requirement within two days probably based on Swinton's paper. Swinton arrived at Whitehall in July 1915 as Hankey's deputy and now took a leading role in the project

Technology Demonstration 30 June 1915

A Pedrail tracked truck, loaded with half-a-ton of bricks, of the type examined and tested by Winston Churchill on Horse Guards Parade.



Stern asked Wilson if he was put in charge of the project, who would he would choose to work with him? He replied "If Tritton and I are put on the job we would soon produce a machine that could do something." He was right and what might be called the design phase had started. The key to its success was the appointment of these two skilled and knowledgeable engineers. The existing concept options were cleared away and Tritton and Wilson were instructed by the committee to start again and produce in three weeks, working day and night, a vehicle based on the existing Bullock tracks and Daimler engine (the engine that would go into the first tank), in other words a concept demonstrator. On 4 August 1915 Tritton and Wilson left London with their orders for Lincoln's White Hart Hotel (Tritton's Forsters factory was nearby). They faced a formidable task: to design as quickly as possible a tank.
As ever time, cost and performance were key constraints

- **Time** Given the bloody stalemate on the Western Front any solution to it was very urgent and the pressure meant that designers would look for existing components even if this involved significant performance trade off. The pressure also meant that there was not time to follow a rigorous development sequence of prototypes, test, pre production, test, production, test with all the dangers in term of reliability and performance that normally follow not following this sequence. In addition the pressure to deploy rapidly this new equipment made it likely that the crews would be not properly trained, spares non existent and support not in place.

- **Cost** Curiously cost does not appear have been a major constraint. The use of existing components constrained cost and construction was fairly simple: flat riveted plates.

- **Performance** The designers faced some daunting design constraints and requirements

Movement to the battlefield would be by rail as far as possible because of a combination of need to save on wear and tear on the platforms caused by their own movement, the lack of any lorries etc capable of carrying such a heavy load and the relatively poor road network. This placed significant constraints because of the need to pass through railway tunnels on rail flats. UK designers faced an additional problems because UK rail tunnels are smaller that continental European ones. This restricted the width and height to about 2.5 metres. This width in turn restricted the length because if a tracked vehicle is too long compared its width it become difficult to steer and a wide turning circle results.
The ability to cross own trenches, no man's land and the German trenches and wire was the key requirement. To achieve this the vehicle needed to be as long as possible and have low ground pressure to get across the often soft ground churned up by artillery. This implied wide and long tracks, and because of shell holes and other obstacles, the ability to climb steps – steep short changes of gradient that are common even on normal ground.
All the early medium and heavy tanks were designed to be able to move at least at three miles an hour (a reasonable prolonged walking speed for an unladden man) and not much more which was fortunate because there were few existing engines that could produce over 100 bhp (modern tank engines are now over 1,000 bhp). This low speed also reflected the purpose of the first tanks: to assist the infantry through no man's land and the German wire and trenches to open ground but no further. Exploitation of a breakthrough was not the role of the first tanks. In the past it had been the role of cavalry and in the future it would be the role of faster lighter tanks.
These constraints were also faced by the French, and later in response to the first British tanks, the Germans. The French requirement asked for "an armoured vehicle, armed with a 75mm gun [the standard French gun] capable of crushing wire and moving through difficult terrain in support of infantry".

St Chamond

Schneider

A7V

Contracts were quickly issued, without refining the requirement, to St Chamond and Schneider, French engineering firms. Driven by the need to deliver quickly both firms took Holt tractors; put an armoured box on them and a 75mm gun at the front. These tanks were produced rapidly (although less rapidly than the British Mark I) and used with some success in 1918 by the French but, like the German A7V tank which was also based on Holt track, had a number of very significant flaws:

- Because the Holt Tractor was not designed to carry the weight of the armoured box its relatively short and narrow track did not spread the weight when used for these vehicles resulting in poor ground pressure and an inability to get across the difficult ground of no man's land in particular.
- The relatively short track length also restricted the trench crossing capability and much more importantly these track systems were not designed to climb steps with a sharp change in gradient i.e banks or embankment and shell holes or to push wire down.

The problem can be illustrated by looking at a modern bulldozer's track system. It has lots of small road wheels in the centre to transmit the weight of the vehicle to the ground via the track. The sprocket at the back drives the track and the idler at the front turns it through 180 degrees. They are both as close as possible to the ground – this reduces track length and cost etc. However as a result there is almost no step at the front in particular and as a result an inability to cope with large sudden changes in gradient.

In addition the St Chamond and Schneider tanks had pointed fronts to push down the wire down but these got embedded in banks and other obstacles.

- All three tanks did not have turrets but forward facing main armament, 75mm and 57mm guns for the French and the Germans respectively. This meant that in modern terms they were assault gun rather than tanks which have a turret to give them the ability to engage targets to their flanks as they move forward. The problem of a fixed front facing gun was demonstrated in the first tank to tank engagement in history on 24 April 1918. A German A7V was engaging with its hull mounted front facing main 57mm armament two machine gun only armed Mark IV tanks when it was engaged to its right by one of the 57mm guns of another Mark IV tank. Before it could respond by turning the whole vehicle the Mark IV had scored three hits and the A7V crew appears to have decided that discretion was better part of valour and evacuated the tank.

It is therefore clear that the use of an existing platform such the Holt tractor was a dead end as demonstrated by failure of the French and Germans to renew contracts for the St Chamond and Schneider and A7V respectively in contrast to the British Mark tank series whose final in service version, the Mark V tank was used not only by the British but also by the French as their replacement heavy tank directly after the end of the First World War. The alternative to adapting an existing platform is to design a new platform but the danger is that this will result in delay.

In Britain construction of, what was in effect a concept assessor, the No 1 Lincoln Machine, with existing track and Daimler engine began on 11 August 1915. This vehicle, better known as Little Willie (a British nick name of the Kaiser's son), is at the Tank Museum. Even before it was tested on 19 September (note the short time for construction) it was clear that it would not meet the requirement because of limited step climbing (just over two foot) and trench crossing capabilities. In addition the existing track was not fit for purpose. However, concurrently, Tritton and Wilson had been working on other solutions.

Wilson suggested running the track round the hull with a steeply angled front end. This shape, the one used in the Mark1 tank series, would meet the War Office's final requirement to cross a 5 ft trench, climb 4ft 6 ins parapet (previously 5ft) and a steep slope. However there was a major problem: because of the rail gauge it was not possible to make the vehicle any wider or to fit a turret because the step requirement pushed the height of the hull up to the UK rail gauge limit. A front facing gun was a solution but, as we have seen, it had major limitations.

PHOTOGRAPH OF THE ORIGINAL TANK—*Centipede*, "Mother," "Big Willie," afterwards known as the Mark I Tank.

The compromise was to fit removable sponsons (armoured barbettes) on either side with guns that could be traversed and a front facing machine gun. The design was probably copied from the Navy. Sponsons with quick firing 57mm six pounder guns had been fitted to important ships to counter fast torpedo boats. Although the shape and track were new, the engine and gearboxes were proven. D'Eyncourt was briefed and instructed them to build the design, nicknamed "Mother", in all speed.

A demonstration on 19 September confirmed that Little Willie could not meet the requirement. Meanwhile from 23 August for four weeks Tritton and Wilson worked to solve the other major problem: the track. They considered all options: multiple roller chains, rubber and fabric. By 21 Sep Tritton had developed a steel track with spring flanges on rollers to keep plate shoes on. A full size wooden mock up of Mother was sent to Wembley and viewed on 29 Sep by Lloyd George, d'Eyncourt's committee and representatives from the BEF Experimental Committee. Swinton briefed and all were "well pleased". The next problem was to produce a prototype and the first combat tanks. The name tank was adopted probably as part of the secrecy measure. Despite it taking until 28 October to get together the materials required to build Mother; Mother was test driven on 13 January 1916 and test fired on 20 January. Kitchener, the Secretary of State for War and the de facto commander in chief, was briefed and minuted the report on the tank saying that it should be tested under field conditions "without such a test we may be wasting material and men uselessly." A test course was built near Hatfield House with British and German wire and trench systems between no man's land which included a replica shell hole and a swamp. Mother crossed the test course without problems. It had taken the Navy 11 months and just under £35,000 (that would have bought you seven Mark I tanks) to go from concept to requirement compliant prototype.

Stern, who was by now in charge of tank production, and Wilson visited the Metropolitain Bus Company (Tritton's firm, Fosters, did not have the capacity for all the production) and the price fixed at £5,000 a tank.

A few days after the test, on 12 February, an order went in for 150 Mark I tanks and on 14 February manpower agreed. A training area was built at Elverden and the first production tank, the same tank as Mother with very minor modification, arrived from 18 June with the fiftieth a month later. The sponsons did not start arriving 17 July. Because of the terrible casualties being suffered at the Battle of the Somme, the first major British offensive, partially trained crews were deployed in August 1916 and the first fifty tanks were in action on 15 September 1916.

Around Christmas 1917 William Orpen, "one of the leading fashionable portraitists of his day", visited HQ Tank Corps at Bermicourt, 25 miles NW of Arras, to paint the then Brigadier General Elles, its commander, and Major Hotblack DSO and bar, MC etc, its extremely brave intelligence and reconnaissance officer. Orpen had chosen to paint them not only because they were handsome, brave and dashing soldiers in the tradition of Lawrence's portraits of Wellington, but also because of the success, a few days earlier, of the Battle of Cambrai.

From the First Tank Action to Success

- September 1916 to November 1917

•Expansion: 3 Brigades and 9 Battalions
•Creation of an Esprit de Corps for a Corps d'Élite
•Training and Doctrine
•Logistics:

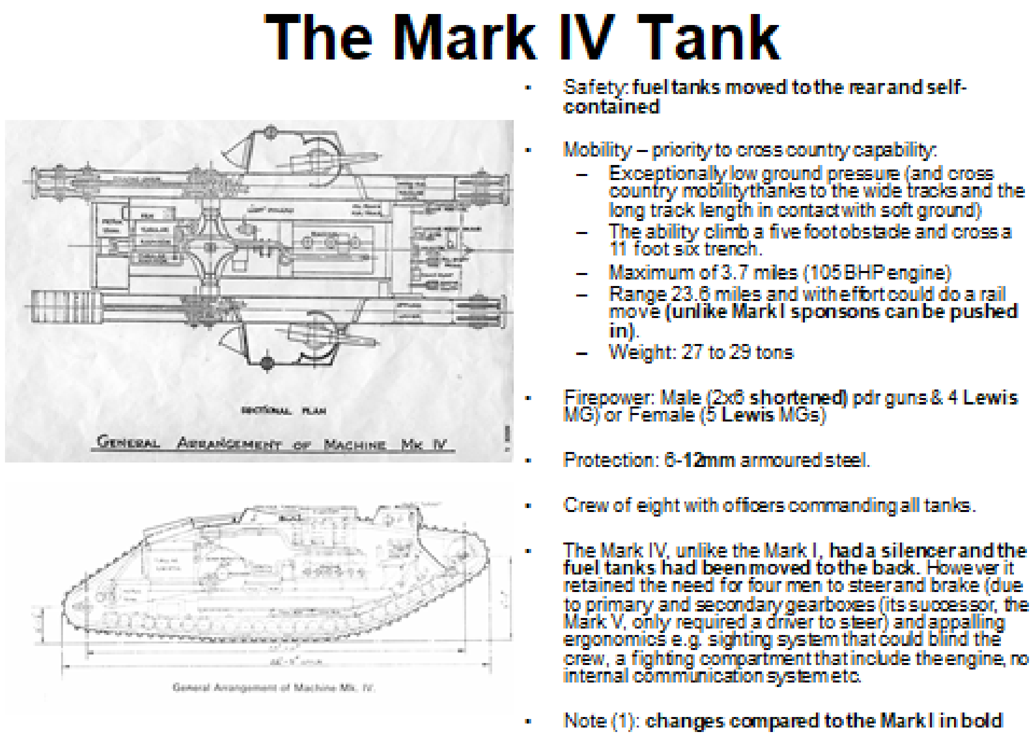
Baths, cinemas, rest centres
Supply tanks
Maintenance and salvage [including recovery & repairs]

•Learning through Battle:

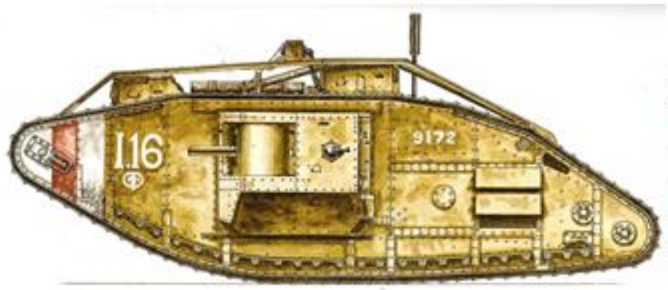
Arras (April 1917) 60 Mark I, II & III in one brigade
Bullecourt (April & May 1917)
Messines (June 1917) 72 Mark IV in one brigade
Third Battle of Ypres (Passchendaele) over 200 Mark IV in three brigades

For the Tank Corps this success was the conclusion of a remarkable journey from the slightly amateurish first steps at the Battle of Flers in September 1916 through the creation of an effective training and support system and the difficult learning through combat at the Battles of Arras, Bullecourt, Messines and Third Ypres from April to October 1917

In addition enough Mark IV tanks had been produced to enable the Tank Corps to field an effective force of nine Mark IV tank battalions with just under 400 fighting tanks at the Battle of Cambrai. Stern’s abrasive but effective drive had contributed to this but rapid production was also possible because the changes from the Mark I which was really a prototype were what might described as “quick wins”: the fuel tanks were moved to the rear and made self contained.

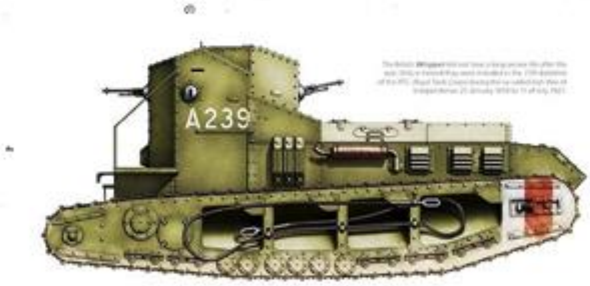


The sponsons were put on hinges so that they could be pushed in for a rail move rather than laboriously unbolted and re-bolted and a silencer was fitted (A Mark IV tank could be driven in the lowest gear to within a thousand yards of the front line without being heard by the Germans). However the underpowered but proven engine and the cumbersome but proven three gearbox arrangement were retained in order to maintain production rates. As the Battle of Cambrai had proved, good procedures, training and logistics had more than compensated for these performance trade offs.
Even well before Cambrai a further expansion of the Tank Corps to 18 battalions (there were nine battalions at Cambrai) had been authorised and in January 1918, as Orpen painted Elles and Hotblack, a further expansion of nine battalions was planned. The War office had already asked in August 1917 for 2,800 fighting tanks to meet most of these requirements including enough replacement tanks to meet a 96% replacement rate per year. In fact only 1,177 Mark V and Medium A Whippet were produced in 1918. This deficiency is one of the key problems of the Tank Corps in 1918.
However in January 1918 the Tank Corps had reasons for optimism. In 1917 an effective support system had been set up including a training organisation which was producing well trained crewman as would be demonstrated in 1918.



Mark V Tank:

Weight: 29 tons
Max speed: 4.6 mph
Range: 45 miles
Armament: 2 x 6 pounder guns and two MGs or four MGs



Medium A Whippet:
Weight: 14 tons
Max speed: 8.3 mph
Range: 45 miles
Armament: four MGs

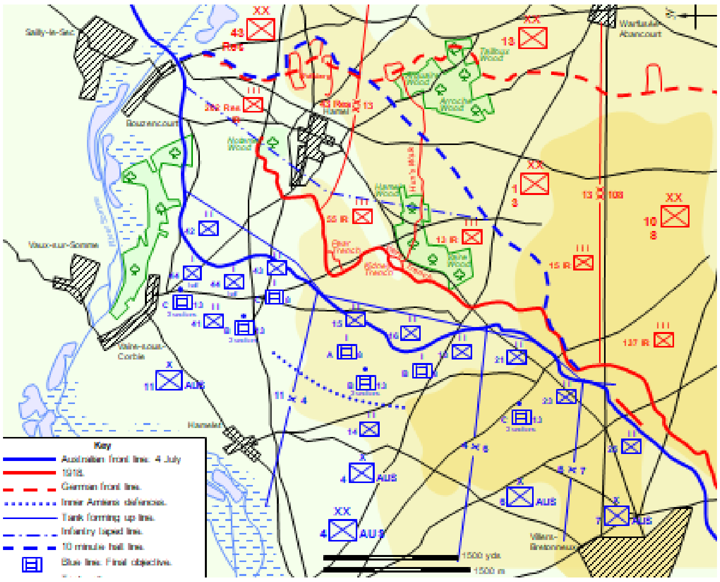
New tanks were about to arrive. The new Mark V tank had retained the excellent cross country mobility and firepower of the Mark 1V series with two significant improvements: a more powerful Ricardo designed engine and a single Wilson designed epicyclic gearbox that allowed the driver on his own to manoeuvre the tanks to, for example, avoid shelling or crush German machine gunners. The Medium A Whippet could do a maximum of 8.3 miles an hour, over three miles faster than the Mark V and as fast as cavalry at the trot, and had an 80 mile range. The Mark V also had considerable firepower.

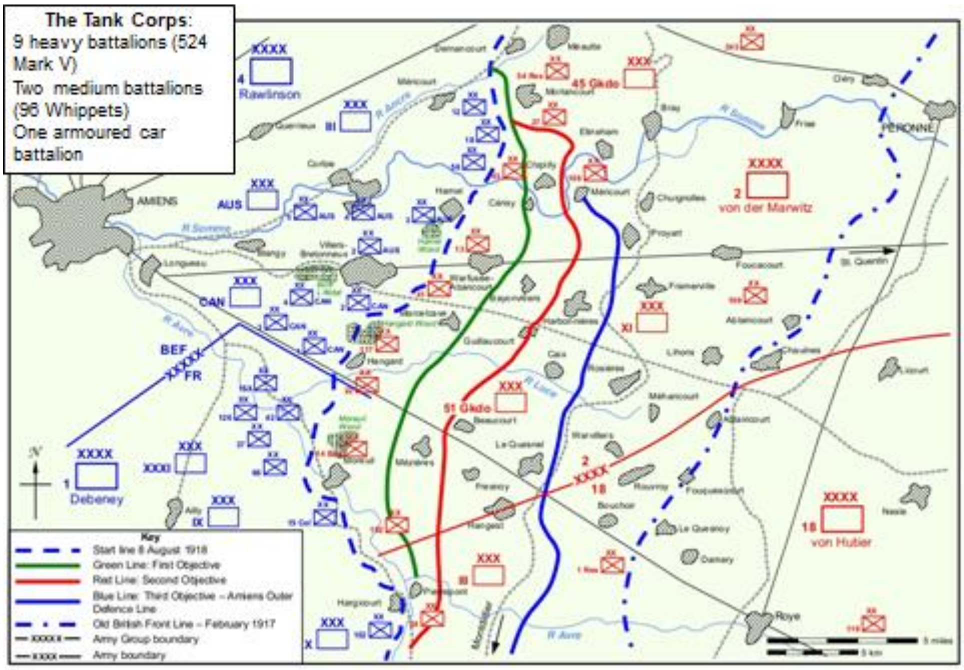
A 12 tank company in support of a three battalion infantry brigade, a fairly standard allocation in 1918, had 12 * 6 pounder guns and a minimum of 36 machine guns with over 3,000 rounds per machine gun. This firepower compared to the maximum of 36 Lewis guns in an infantry battalion, and this and the success at the Battle of Cambrai help explains the emphasis on tanks by even senior commanders such as Foch, Pétain and Rawlinson amongst other. The usefulness of the tanks' combination of firepower and protection can be seen anecdotally in Lord Gort's and Captain Pollington's VCs on 27 September and 5 October 1918 respectively in which tanks pay key roles. The other important roles of the tanks were to crush the wire and support the infantry particularly when out of field artillery range.

<u>Summary of ops to illustrate allocation, numbers</u>

So tanks were clearly useful but the degree of usefulness was dependant on the numbers of tanks available, constrained by sustainability. There was another underlying constraint: the lack of significant numbers of German tanks (only 20 A7Vs were produced). This meant that there was less pressure for more tanks unlike for example aircraft. Nevertheless the importance of tanks can be seen by the careful allocation of them to priority armies and offensives.

The Battles of Hamel and Moreuil in July 1918 started the new phase of the Tank Corps with the first uses of the Mark V. Hamel was particularly important because it refined the concept of operations used at Cambrai: a surprise attack based on the tanks crushing the wire and leading with a lifting, not rolling, barrage in front them. However as a result of the failure of the tanks at Bullecourt in May 1917 the Australians insisted on a rolling barrage and as a result at the Battle of Amiens and subsequently the tanks followed very closely the rolling barrage dealing with any remaining threat and the infantry following a little further back in file. The protection of the tanks was sufficient to withstand all but a direct hit from field artillery. The success at Hamel was such that Australian soldiers were even seen to salute Tank Corps officers after the battle, a privilege rarely accorded to British officers.





Map 23.1 - The Battle of Amiens, 8-11 August 1918

The Battle of Amiens could be described as the Battle of Cambrai on steroid: the Germans lost over 12,000 prisoners compared to 4,000 at Cambrai and the advance was over twice the distance. To achieve this there was over twice the artillery and many more aircraft in support. The second echelon of the attack was much reinforced from one division at Cambrai to the equivalent of five divisions at Amiens. The second echelon of tanks was also reinforced and had to lead the second echelon alone because the advance went beyond rolling barrage range.

However there were actually only 324 heavy fighting tanks at Amiens in nine battalions and only two Whippet battalions. Since there should have been 12 heavy and six medium tank battalions there was already clearly a problem with the number of tanks available.

Mark V Tank Saga: The problem was that by the start of the Battle of Amiens only 472 Mark V and Mark V star (lengthened Mark Vs) had been delivered and to make things worse only 146 Medium A Whippets had been produced by 1 July. I will look at the reasons why there were only ever two Medium tank battalion later. Since 546 Mark V would have been required two battalions, 7th and 12th, received obsolescent and tired Mark IV tanks "many of which [as the contemporary Battalion history tells us] had been in use, and in some cases, in action, a year before."

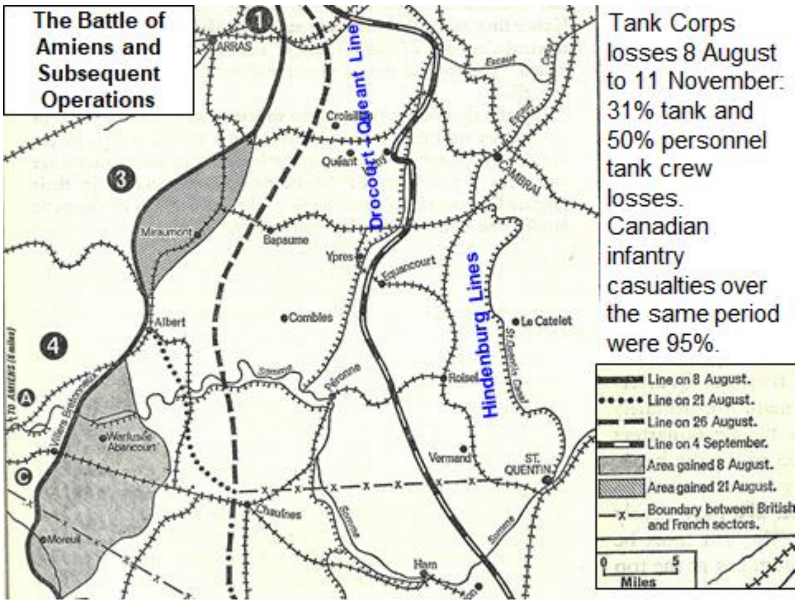
Tank Numbers Insuffiicent The key point to note is that even at the Battle of Amiens there were not quite enough Mark V tanks to meet even the requirements of the existing tank battalions, let alone replacements, and that the number of tanks available at Amiens was only just sufficient to support one Army with no tank reserve. The commander in chief of the Allied Armies in the West, Foch, insisted on maintaining the pressure on the Germans and this would put the Tank Corps under further pressure.

Between the Battle of Amiens and the end of the war the Tank Corps would supports a series of operations including:

- The Battle of Bapaume 21 – 24 August.
- The Second Battle of Arras 1918 25 August to 2 September.
- The Second Breaching of the Hindenburg Line 27 September to 8 October

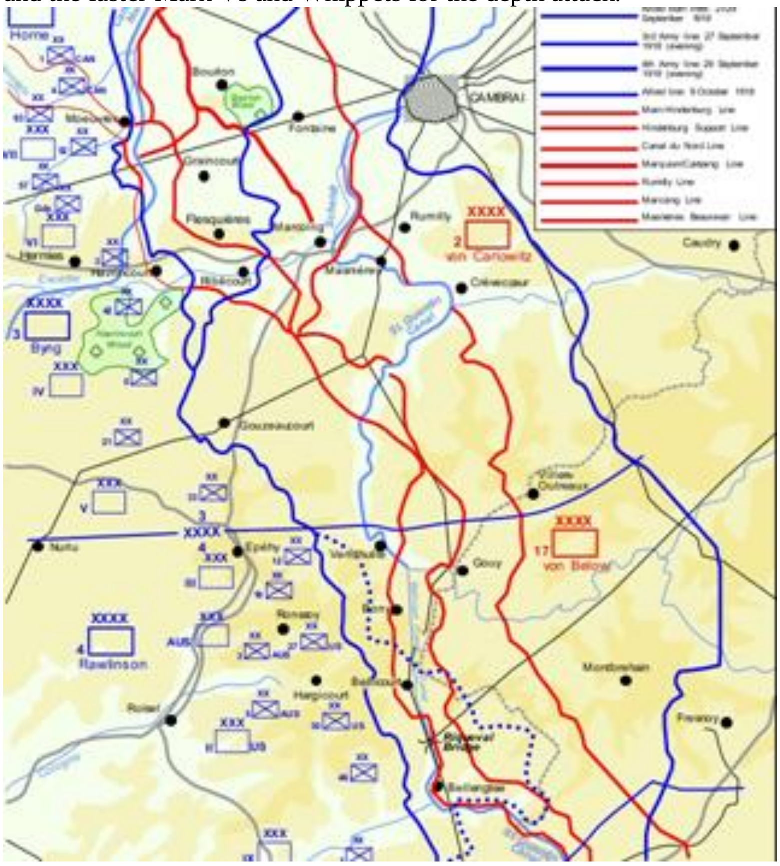
These battles illustrate problems faced by the Tank Corps which reduced its usefulness:

- After the Battle of Amiens the Tank Corps would never muster over 200 fighting tanks when, had it been up to establishment it should have been able to field 600 plus. 200 tanks is the equivalent of a single tank brigade in the BEF in 1944 and 45. A tank brigade was a fairly normal allocation for a single infantry division in 1944-45. The Tank Corps in 1918 was being asked to support up to two armies plus.



- It suffered 31% tank and 50% personnel tank crew losses between 8 August and 11 November. The tank casualties would have been manageable if the replacement tanks required by the Army had been produced. However as we have seen insufficient tanks were produced in 1918. The crew casualties were high but sufficient replacements existed and significantly less than those of the infantry the Tank Corps was supporting. For example the Canadian infantry casualties over the same period were 95%.
- The large decline in numbers on the second day of major operations. For example at the Battle of Amiens there were only 143 fighting tanks available on the second day although 312 had survived the 8 August without being knocked out. This was caused by a combination of crew exhaustion, tank failures and a lack of reserve tanks.

These problems were compounded by the increasing distance from the railheads during the latter part of the Hundred Days which resulted in long moves and wear and tear. Nevertheless thanks to careful management the limited number of tanks was used to effect. For example at the Battle of Bapaume the slower Mark IV tanks were used for the initial assault and the faster Mark Vs and Whippets for the depth attack.



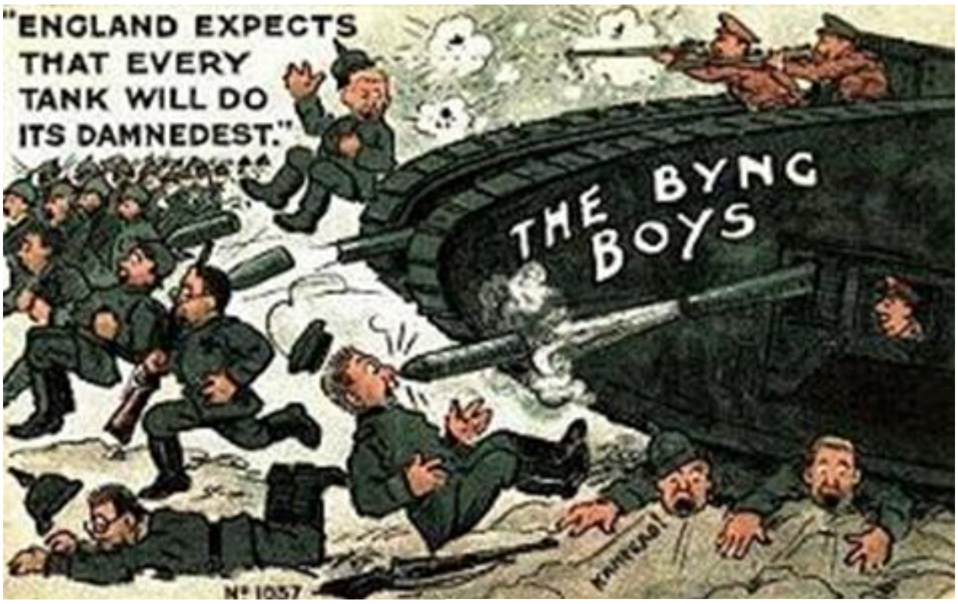
At the second breaching of the Hindenburg Line in late September the majority of the limited number of tanks were allocated to the second echelon of Fourth Army attack. The shortage of tanks in support of First and Third Army is one of the reasons for a reversion to a long preparatory bombardment to cut the wire but at the price of surprise.

As we have seen there should have been six Medium A Whippet tank Battalions but there were in fact only two Medium tank battalions in 1918 and there were not enough replacement tanks to keep even these two battalions up to strength. Even if more Medium A Whippets had been delivered would they have been of use? We can get an insight into their possible usefulness if we look at 17th Armoured Car Battalion. It was formed in haste (such was the haste that the commander officer had to refuse to deploy to France until his drivers had had a few days to learn to drive the armoured cars) with cast offs as a result of the Russian revolution. However despite their very limited cross country capability but helped by very careful planning they wreaked havoc in part of the German administrative area at the Battle of Amiens including capturing the detailed plans of the Hindenburg Line.

Although the Whippets were slower (maximum of 8.5 miles per hour) than the armoured cars, they had already demonstrated during the March retreat and near Villers-Bretonneux the ability to catch out infantry and a Whippet called "Musical Box" knocked out a German artillery battery because its relative speed allowed it to avoid German artillery fire unlike the slower Mark V tanks with it. A concentrated attack by several hundred Whippets might have a significant effect. As it was the limited numbers of Whippets were usually used as heavy tank substitute.
The reason for the failure to produce more Whippet tanks is a classic example of how not to it. The Medium A Whippet tank was designed in late 1916 by Tritton, one of the two designers of the Mark I. It was clearly a rushed job: it had two linked engines and associated gearboxes which the driver had to operate together. The crew compartment could get so hot that ammunition jammed in the weapons. Its suspension was undamped etc etc. As a result:

- In Oct 1917 the Army halved the Medium A contract from 400 to 200 and 650 Medium Bs were ordered. The first Medium B was rolled out in Sep 1918.
- Jan 1918 Elles called for the cancellation of the Medium B and replacement by the Medium C.
- On 24 Feb (six weeks later) Elles decides that the Medium C is too slow, heavy and poorly armed and redesign takes place. 200 of the new design are ordered in March and another 400 on 31 May.

As a result only 200 Whippets were produced late. 29 Mediums B and C were produced by the end of the war however none reached France and the only Medium B or C to see action were two Medium Bs in north Russia in 1919 one of whom eventually ended up in the Red Army. Ironically the last British tank action in the First World War was by Whippets and the two battalions still had 35 Whippets at the end of October. The well trained crews had worked through its defects.



In conclusion the first tank, Mother, was a remarkable and rapid engineering achievement. Her children and grandchildren, the Mark IV and V respectively, enabled the return of surprise and success to the British Army at the Battles of Cambrai (November 1917) and Amiens (August 1918). The later battle inflicted a decisive defeat of the German. The successful development of the first tank is due to a combination of leadership and engineering skills.

Winston Churchill played a key role as did three engineers: d'Eyncourt, the Director of Naval Construction, Tritton and Wilson. However although the Army had called for eighteen tank battalions in early 1917 insufficient tank production and an unwillingness by the Army to accept obsolescent or partially inadequate equipment meant that the well trained crews of the Tank Corps never had enough equipment and tank strength would steadily decline after the Battle of Amiens and by the end of the war the British Army had almost run out of tanks due to a failure to maintain production.

Photo 10: 'With Mr Punch's jubilant compliments to Sir Douglas HAIG and his Tanks'

Tanks, which used to be objects of ridicule, have become a major weapon. They come rolling forward in a long line, heavily armoured, and they embody the horror of war for us f more than anything else. We cannot see the gun batteries that are bombarding us, and the oncoming waves of enemy attackers are human beings just like we are - but tanks are machines, and their caterpillar tracks run on as endlessly as the war itself. They spell out annihilation when they roll without feeling into the shell holes and then climb out again, inexorably; a fleet of roaring, fire-spitting ironclads, invulnerable steel beasts that crush the dead and the wounded. Before these we shrivel down into our thin skins, in the face of their colossal force our arms are like straws and our hand-grenades are like matches.
Shells, gas clouds and flotillas of tanks - crushing, devouring, death.
Dysentery, influenza, typhus - choking, scalding, death. trench, hospital, mass grave - there' are no other possibilities.
Remarque's *All is Quiet on the Western Front, p. 199*

Talk

Tuesday, 12th February 2019 – "The History of Westland Aircraft Ltd".

Bill McNaught

Our speaker gave a fascinating insight into the history of Westland from initially manufacturing cast iron fire grates, through Petter stationary engines, aeroplanes and helicopters over more than a century. Bill himself started as an apprentice and progressed to General Manager during his 25 year employment with the company.

James Bazeley Petter, an agricultural engineer and iron founder, had premises in Yeovil It was there that Ernest and Percival, his twin sons, designed and built a self-propelled oil engine in 1892 amongst many other items including fire grates Three years later they designed the first internal combustion engined motorcar to be made in the United Kingdom.
The car, using a converted four-wheel horse-drawn phaeton and a 3 hp (2 kW) twin-cylinder horizontal oil engine, had a top speed of 12 miles per hour (19 km/h) The vehicle weighed 9 cwt (457 kg) including the 120 lb (55 kg) of the Petter engine with its flywheel and sidebars.
This first diesel car predated the first serious adoption of the diesel engine by around 30 years but was not successful and only 12 were built.

1915

Short 184/225 wings and centre-sections from the factory to Yeovil's GWR Junction

Westland seaplane testing at Hamble

In order to help the war effort, Petters volunteered their factory and to their surprise were asked to build seaplanes along with shell cases, despite having no relevant experience of aircraft.
They accepted the seaplane contract and threw themselves at the problem completing the first one in six months! They then had to transport it by horse and cart to the Hamble for sea trials!
At this point they renamed the aircraft division of the company Westland after the piece of land they had planned to use for a new iron foundry.
12 Short seaplanes were made and flew successfully.
The Petter engine business was eventually separated from the aircraft division.

Further orders found them supplying parts to Airco (who later became British Airways) and Vickers.
Many planes were designed and built but despite being competent aeroplanes were not commercially successful. All Westland plane names began with W such as the Wapiti (right), which was successful, selling almost 600 units.

One of the most influential characters in the Company was the chief test pilot, Harald Penrose, who survived many a precarious flight during his career. The controversial selection of the son of Sir Ernest Petter as Technical Director was unpopular, but he proved himself as a designer of many excellent aircraft. Aircraft production was stepped up with many successful aircraft, including the Lysander (right) and the Spitfire, of which they built more than any other factory.

1946/48

Start of a long-term relationship with Sikorsky

After the war Westland decided to move into helicopters and abandoned fixed wing aircraft much to annoyance of W E W Petter who left to join English Electric. They negotiated a licence to build Sikorsky helicopters (Dragonfly) and began supplying the Royal Navy. Alan Bristow was employed as Chief test pilot.

Westland Dragonfly derivative of Sikorsky S-51

133 built

Whirlwind (left) and Wessex (right) models followed in the 50's.

From 1959 to 1961 the British government forced the consolidation of 20 or so British aviation firms into three larger groups with the threat of withheld contracts and the lure of project funding. While the majority of fixed-wing aircraft design and construction lie in the British Aircraft Corporation and the Hawker Siddeley Group, the helicopter divisions of Bristol, Fairey and Saunders-Roe (with their hovercraft) were merged with Westland to form Westland Helicopters in 1961.

In 1961 Bill joined the Company as an apprentice and related some of his early experiences which revived memories of many in the audience.

1967 saw the introduction of the Iconic Sea King (left) to be followed by the world-speed-record breaking Lynx (right).

Bill showed some impressive video proving that the Lynx could roll, loop-the-loop backwards and fly inverted. Up to this time these feats were thought to be impossible. Another video demonstrated how difficult it is to land a helicopter on a ship in rough weather.

By the early seventies Bill had progressed to the role of Chief Industrial Engineer and was involved with development of the WG30 (left) and Augusta (right).

In the mid-eighties he became General Manager. This was also the time of the Westland affair involving Michael Heseltine, and Westland were forced to amalgamate with Sikorsky.

Production of military helicopters such as the Black Hawk (left), Wild Cat (over page left) and assembly of the Apache (over page right became higher priority.

This was to be the start of series of corporate changes: in 1986 GKN took over the Sikorsky shares and GKN Westland was created in 1994. This became Augusta Westland in a joint venture between GKN and Finnmecannica in 2000, and in 2004 GKN sold their shares to Finmeccanica but kept GKN Westland Aerospace. The name has since been changed to Leonardo Helicopters.

Our thanks to Bill for a very detailed and fascinating history of Westland.

Talk
Tuesday, 12th March 2019 – "Malaysia Airlines MH370 – How could it have happened?"

Ian Gilbert C.Eng, MRAES – Avionics Consultant

Ian began his talk by emphasising that as an engineer he would be primarily discussing the subject from a factual viewpoint (hence the title) rather than covering all the theories and conjecture of what might have happened, much of which has little or no basis in proven fact. He was aware (as were most of the audience) of the recent TV programme on Channel 5 regarding the loss of MH370, and some of the more bizarre theories that had been suggested – see later.

Ian started his career at British European Airways, then British Airways, Honeywell and finally as a consultant on Avionics which he is still involved in today. He began his talk by presenting the undisputed facts of the last flight of MH370.

Malaysia Airlines Flight 370 was a scheduled international passenger flight operated by Malaysia Airlines that disappeared on 8 March 2014 while flying from Kuala Lumpur International Airport to Beijing Capital International Airport. Flight 370 was operating with a Boeing 777-200ER, 9M-MRO, which was new in May 2002. The aircraft was powered by two Rolls-Royce Trent 892 engines, was fitted with an integrated avionics system, and had accumulated 53,471.6 hours in service without any previous history of having been involved in any major incidents. At the time of its loss it was carrying 12 crew and 227 passengers.

Flight MH370 took off from Kuala Lumpur at 00:42MYT, and some 38 minutes after take-off , when the flight was over the South China Sea and close to a way point called IGARI, all VHF radio transmissions ceased.

The aircraft was lost from Air Traffic Control (ATC) radar screens minutes later, but was tracked by military radar for another hour, deviating westwards from its planned flight path, crossing the Malay Peninsula and Andaman Sea. It left radar range 200 nautical miles (370 km) northwest of Penang Island in northwestern Malaysia

The search for the missing aircraft focused initially on the South China and Andaman seas.
However subsequent painstaking and novel analysis of the time taken for radio signals to travel between satellite and aircraft revealed that the aircraft was in the air for a further 6 hours after it's 'disappearance' from ATC radar, and that in this 6 hours it must have taken one of two routes – either northwest over former USSR territory, or southwest over the Indian Ocean. The northern route was quickly discounted as Kazakhstan has a number of high power military radars which had not detected MH370. Several pieces of marine debris confirmed to be from the aircraft have washed ashore in the western Indian Ocean during 2015 and 2016 – thus confirming the theory that MH370 had indeed taken the southwest of the two possible tracks that the analysis had identified.
Unfortunately this analysis took many days to carry out, by which time search vessels had a relatively limited window in which to detect the underwater detection beacon before it stopped 'pinging'. Furthermore, the analysis of the satellite data would probably not have been precise enough to pinpoint a viable search area. As almost all of the known facts concerning this flight are related to the communication that took place between the aircraft, ground stations and satellites, Ian gave us a very in-depth appreciation of each of them.

VHF

The Boeing 777 is a very comprehensively equipped aircraft with an excellent safety record.
The primary communication system used to provide voice communication between the aircraft and ATC is the VHF radio operating on 118Mhz – 139Mhz. This provides a two-way radio link and has 3 independent systems on the aircraft.

The last voice signal to air traffic control occurred at 01:19:30, when Captain Zaharie acknowledged a transmission from ATC in Kuala Lumpur.

“Lumpur Radar. Malaysian three seven zero, contact Ho Chi Minh one two zero decimal nine. Good night."

The response from MH370 was "Good night. Malaysian three seven zero."

The crew was expected to signal ATC in Ho Chi Minh City as the aircraft passed into Vietnamese airspace, just north of the point where contact was lost. No such contact was made.

The captain of another aircraft attempted to signal the crew of Flight 370 shortly after 01:30, using the International Air Distress (IAD) frequency, to relay Vietnamese air traffic control's request for the crew to contact them: the captain said he was able to establish communication, but only heard "mumbling" and static.

Radar

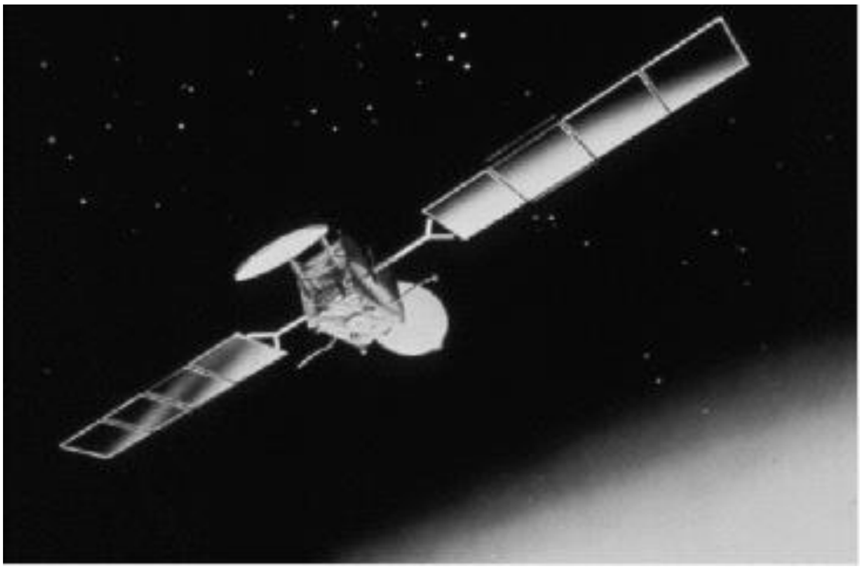
The aircraft was also fitted with secondary surveillance radar, which when interrogated by a radar transmission from the ground (Primary radar), returns an acknowledgement via one of two transponders which are switch selectable in the aircraft. Pilots are able to deactivate both transponders which appears to have happened onboard MH370 as it disappeared from air traffic controllers' radar screens at 01:22 MYT.

The great advantage of the secondary surveillance radar is that it provides identification information in the response, but the aircraft was still tracked on primary military radar as it deviated westwards from its planned flight path and crossed the Malay Peninsula, until it left the range of the military radar at 02:22 while over the Andaman Sea, 200 nautical miles (370 km) northwest of the island of Penang in northwestern Malaysia.

ACARS

One of the most important communication systems on the aircraft is the Aircraft Communications Addressing and Reporting System (ACARS) which is a two-way link between the aircraft and ground stations using either VHF radio or a satellite link.

Although it is theoretically possible to deactivate ACARS, it requires a very high level of technical knowledge. Ian went on to explain that few pilots (or, indeed, avionics experts) would know how to disable ACARS (whilst keeping other linked electronic systems operational), exacerbated by the fact that the associated circuit breakers are located outside the flight deck in the floor of the galley.



The ACARS on MH370 stopped working at the time it was using the SatCom link which is operated through Inmarsat satellites (see opposite) which provide almost total global coverage (except the poles). Should the ground station not hear from the aircraft for 1 hour, it can ‘ping’ ACARS via the satellite link to seek an acknowledgement. The ACARS procedure was invoked each hour without a response. The Inmarsat satellite could however still ‘track’ the aircraft, albeit in a rather imprecise way as described previously..

The southern route is over the Indian ocean, which is the third largest ocean in the world with an average depth of 3,890m dropping down to 7,450m at its deepest point. There is very little radar coverage – an ideal location to get lost in.

Flight Recorders (‘Black Boxes’ (actually painted bright orange))

Since the final location of MH370 is still unknown, the contents of the flight recorders are similarly missing. The aircraft carried two flight recorders, a cockpit voice recorder covering the last two hours of conversation on the flight deck, and the data recorder logging up to 1300 parameters of the last 25 hours of flight.
Both recorders are fitted with locator beacons activated in sea water which should transmit for 30days in depths down to 6096m.

Suspicious events

In the absence of the aircraft itself (some small parts of it have been washing up in the Indian ocean since 2015), investigators have had to focus on those unusual events concerning this flight, amongst which are;-

- The aircraft disappeared from radar at the junction of two ATC areas
- The left turn at the way point IGARI was relatively steep (25 degrees) and not possible unless the auto-pilot had been switched off
- Some critical systems remained operational until the end of flight when, presumably, it ran out of fuel. Indeed the final SatCom restart would correspond very neatly to the APU (Auxiliary Power Unit) starting up and coming on line immediately following a main engine spooling down due to running out of fuel

Changes proposed in the wake of this disaster

Even though the cause of this disaster still remains a mystery, a number of changes to general flight procedure have been proposed, amongst which are:-

- Flight tracking should be initiated every 15 minutes
- New aircraft should have systems installed that detect abnormal flight and transmit data every minute. Such systems must be tamper proof. There is still ongoing discussion as to what constitutes abnormal flight.
- Automatically deployable flight recorders
- Cockpit voice recorder should record for 25 hours rather than 2hrs
- Underwater locator beacons ‘lifetime’ extended to 90 days, and work to greater depths (30,000 feet) using 8.8kHz radio.

Popular theories

For completeness, and audience interest, Ian listed some of the theories he has seen in the press as to what may have gone wrong. He offered no endorsement of any!

- Hijacking
- Alien abduction
- The Russians
- A passenger took over the avionics via a USB port on the entertainment system
- Fire in the freight hold
- Deliberate ditching in order to transfer a valuable cargo to a waiting craft

- Flight deck oxygen bottle exploding
- Technical failure.
- Malign action by one or more crew members

Of the likely crew members, the captain seems to come under most suspicion as:-

- He seemed to have and demonstrate the requisite depth of knowledge about the system
- He had quite a sophisticated flight simulator at his home, which, upon analysis, revealed that he had recently programmed a similar flight over the Indian Ocean, complete with many of the same waypoints
- He is reported to have had problems in his home life.

Ian did also point out that he would like to learn if and when the cabin was de-pressurised. It's possible that the captain, having donned his own oxygen mask, then depressurised the aircraft in order to render all the passengers and crew unconscious.

At this point Ian opened the meeting to questions:-

Question: If the pilot wanted to commit suicide, could he get the First Officer to leave the flight deck? The question was prompted by the crash of the Germanwings Airbus 320 flight in March 2015, when the co-pilot bolted the door as soon as the Captain had briefly left the flight deck, and then deliberately crashed the aircraft with the captain still hammering on the door.
Answer: Yes. But for the MH370 First Officer to leave the flight deck at, or before the point at which the aircraft turned onto its new course, would presumably have required a deliberate request from the captain, such as 'Get me a coffee', or 'Visually check the port engine'. It seems that captains of Malaysian airliners are held in such high esteem that crew members are unlikely to query such a command.

Question: When the aircraft banked steeply near the IGARI way point to change direction, or during subsequent 'unusual' events, why didn't passengers get on their mobile phones to query this?
Answer: Mobile phones unlikely to operate at 35,000 feet, although the First Officer's mobile was subsequently found to have briefly registered with Panang station some 33 minutes after the final 'Good Night' signal on VHF.

Question: Can the autopilot be re-engaged to enable the aircraft to navigate to different way points?
Answer: Any pilot can change the way points, and often does (e.g. change of route due to bad weather ahead.)

Question: Now that wreckage of MH370 has been found, why can't the aircraft be located?
Answer: Although the debris since recovered gives a good indication that it is in the Indian ocean, the effects of ocean currents, wind and time have spread the debris over a wide area in the ocean. It is very akin to looking for a needle in a haystack, but without knowing which haystack.

Question: Reports that have been published suggest that there had to be human intervention – comments please?
Answer: I cannot believe that this disaster could be caused by a technical malfunction. There must have been a very knowledgeable person at the controls who knew what he (or she) was doing.

Question: Today we are learning of problems with the Boeing 737-MAX8 (witness latest Ethiopian Airlines crash). If the problem is caused by one faulty sensor, is there not redundancy built in to prevent this?
Answer: I am not an expert on the 737 but once the flight recorders have been analysed, there will be more definitive information available.

It was clear that there were still many unanswered questions in the audience about what happened to flight MH370, but as the talk had already overrun, the meeting was brought to a close.

Our thanks go to Ian for taking us through a very puzzling topic that attracted a high turnout of members and guests, despite the very inclement weather on the day.

Malcolm Hind and Mike Wooldridge

REPLY SLIP – BROOKHURST WOOD WASTE PROCESSING DEPOT

To: Malcolm Hind, 7, The Castle, Horsham, RH12 5PX
or email malcolmhind@msn.com with full details as below.

I would like to attend the **visit to Brookhurst Wood Waste Processing Depot, Horsham, RH12 4QD on Thursday, 2nd May, 2019 at 10:00am.**

The operator, Biffa, has requested that attendees car-share due to the limited on-site parking, and the following additional information from all attendees as follows:-

Full Name……………………………………………………… Telephone………………………..

Address……………………………………………………

……………………………………………………………

…………………………………………………………...

…………………………..……………………………….

Email address………………………………………..

Emergency Contact telephone number in event of accident……………………………………..

Car Registration No………………………………………………………….

Applications by 17th April 2019 please.

REPLY SLIP – VISIT TO CULHAM CENTRE FOR FUSION ENERGY

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 11th May 2019 commencing at 13:30pm. Please reserve me ………..places. Priority will be given to RCEA members, as places are strictly limited. We will be operating a reserve list in the event of over subscription which may result in places being offered at short notice nearer the visit date.

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

LEFT INTENTIONALLY BLANK

REPLY SLIP – LEONARDSLEE GARDENS

To: Glyn Mathias, 16, Tamarisk Way, East Preston, BN16 2TF

Telephone 01903 859191 or email glyn.mathias@btinternet.com

Please reserve me ………. places to attend the **o**uting on May 24 commencing at 11:00am to Leonardslee Gardens.

Full name:………………………………………………………(Block capitals)

Address…………………………………………………………

…………………………………………………………

…………………………………………………………

………………………………………………………..

Phone No……………………………. e-mail address   ……………………..

Cheque enclosed for £…………. at £15 per person, made out to the RCEA.

Applications by 10th May 2019

REPLY SLIP – WEALD & DOWNLAND LIVING MUSEUM

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

I would like to visit the Weald & Downland Living Museum on Thursday 11 July at 10.45am. Please reserve me the following places:

Category	Number of people	Cost
Visitors aged 65+ @ £14.00 per person		
Visitors aged 18-64 @ £15.50 per person		
Children aged 4-17 @ £7.75 per person		
	Total cost:	

Full name……………………………………………………………………

Address…………………………………………………………………….

…………………………………………………………………...

Telephone (mobile preferred):……………………………………………

Email address:…………………………………………………………………….

I enclose a cheque (non-refundable) made payable to RCEA for ……………..
(Separate cheque for this event please)

Applications by Thursday 27 June 2019.

End of Newsletter