Queen Elizabeth Prize for Engineering  
awarded to the creators of the GPS

It was announced from London on 12 February 2019 that this year’s Queen Elizabeth Prize for Engineering (QEPrize) has been awarded to four engineers responsible for creating the first truly global, satellite-based positioning system – GPS.

The QEPrize is the world’s most prestigious engineering accolade, a £1 million prize that celebrates the global impact of engineering innovation on humanity. The 2019 winners are Dr Bradford Parkinson, Professor James Spilker, Jr, Hugo Fruehauf, and Richard Schwartz – announced on 12 February by Lord Browne of Madingley, Chairman of the Queen Elizabeth Prize for Engineering Foundation, in the presence of HRH The Princess Royal in London.

As we know the global positioning system represents a pioneering innovation which, for the first time, enabled free, immediate access to accurate position and timing information around the world. Today, an estimated four billion people around the world use GPS, and its applications range from navigation and disaster relief through to climate monitoring systems, banking systems, and the foundation of tomorrow’s transport, agriculture, and industry.

**Reintroducing GPS as a concept**

To remind our readers GPS uses a constellation of at least 24 orbiting satellites, ground stations, and receiving devices. Each satellite broadcasts a radio signal containing its location and the time from an extremely accurate onboard atomic clock. GPS receivers need signals from at least four satellites to determine their position; they measure the time delay in each signal to calculate the distance to each satellite, then use that information to pinpoint the receiver’s location on earth.

The basic tracking required for GPS dates back to the start of the space race, when radio operators tracked Sputnik I on its groundbreaking flight in 1957. Sputnik’s radio signals appeared to drop in frequency as it passed overhead, a phenomenon known as the Doppler shift that allowed the satellite’s position to be determined.

GPS has had a revolutionary impact upon modern society. At just $2 per receiver, GPS provides an accessible service and a powerful tool that people can integrate with their own applications. Simple smartphone apps can track disease outbreaks, self-driving tractors can optimise crop harvests, and sports teams can improve team performance. New applications for GPS continually appear, and
its annual economic value has been estimated to be $80 billion for the USA alone.

The chief architect, Bradford Parkinson, is often called the ‘father of GPS’ after successfully building upon several separate systems to create the current GPS design. Parkinson directed the programme and led the development, design, and testing of its key components. He insisted that GPS needed to be intuitive and inexpensive, which later made navigation accessible to billions.

To realise the project, Parkinson recruited James Spilker to design the signal that the satellites broadcast. This type of ranging signal is critical to the success of GPS for civilian use; it is resistant to jamming, precise, and allows multiple satellites to broadcast on the same frequency without interfering with each other. Spilker’s team also developed and built the first receiver to process the GPS satellite signals; his delay-locked loop process, used for tracking code division multiple access (CDMA) signals, is essential to GPS accuracy.

GPS receivers rely on accurate timing information, broadcasted from satellites, to determine their position on earth. Each satellite uses multiple atomic clocks – accurate to within billions of a second – to ensure consistent timing. Hugo Freuhauf, then Chief Engineer at Rockwell Industries, led the development of a miniaturised, radiation-hardened atomic clock – the heart of the GPS satellite. Its accuracy is the backbone of communications systems, power grids, financial networks, and other critical infrastructure.

For the GPS programme to be affordable, each satellite had to be long-lived. Richard Schwartz, the Programme Manager at Rockwell during the development of these satellites, was tasked with ensuring a three-year life span. His design was resistant to the intense radiation from the upper Van Allen belt, and it also lasted over nine years.

How GPS changed the world
When asked whether the winners knew that GPS could change the world, Dr Bradford Parkinson said: ‘One of the most important things we had when the project started was a vision of world impact. Without that inspiration, it would have been difficult for us to weather the storms of doing something for the first time. Back in 1978, I made a few drawings that depicted GPS applications that I could personally foresee; they included an automobile navigation system, semi-automatic air traffic control, and wide-area vehicle monitoring, and seem to be rather accurate 41 years later. That said, none of us could fathom the sheer breadth of GPS applications – the many ways that it would become a System for Humanity.’
When asked which GPS applications surprised him the most, Hugo Freuhauf said: ‘What surprised me the most was the general response from industry – it blew me away. The world’s tech industry reduced a 40lb (18kg), $100K backpack-sized GPS receiver into a fingernail-sized chip receiver that now costs less than $2. Because of that, GPS is everywhere; it is part of the global economic engine and key to global safe-keeping. It’s had an almost unimaginable impact on the globe.’

When asked about his future predictions for GPS, Richard Schwartz said: ‘It’s hard to imagine what young and creative engineers will come up with next – it’s such a rapidly developing world. That said, in the not too distant future I think I will be able to step into a driverless car, tell the car where I’d like to go, and then sit back and enjoy the ride.

‘The second prediction relates to farming, as we are already starting to see rapid innovation in agriculture. If farmers can precisely tend to their fields around the clock – at low cost – then food supply around the world will significantly increase, providing the next step towards ending world hunger.’

Lord Browne of Madingley
Lord Browne of Madingley, Chairman of the Queen Elizabeth Prize for Engineering Foundation, said: ‘The 2019 Queen Elizabeth Prize for Engineering recognises the four engineers responsible for providing accurate position and timing information for billions of people around the world. Their revolutionary work epitomises the excellence in engineering that the QEPrize both recognises and celebrates, and we hope that it continues to inspire the next generation of engineers to take up the challenges of the future.’

Picture caption
The Queen Elizabeth Prize for Engineering

The creators of GPS awarded The Queen Elizabeth Prize for Engineering, from left to right: Richard Schwartz, Bradford Parkinson, James Spilker and Hugo Fruehauf.