The Navigation of Navigation

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These meetings every three years of the institutes of navigation from around the world are important occasions, times when we can look around and take stock of our world of navigation. They are sufficiently infrequent that the changes over each gap of three years are quite startling. I attended my first World Congress in San Diego in the year 2000. At that meeting and at my second one I was a researcher, presenting technical papers. At my third meeting, I was president of one of the member institutes. This is my fourth. How remarkably our navigation technology has developed over that short period; how far Navigation has travelled! And how much the roles of the institutes of navigation have changed!

The members of our institutes involved in this world of navigation are the stewards of an exceptionally successful technology. Satellite navigation is one of the outstanding scientific developments of the late twentieth and early twenty-first centuries. Among science-based industries, it has been a star. Every time we have met we have seen huge growth, and products that are more powerful, more user-friendly, more cost-effective. And unlike most new high-tech industries, everybody loves satellite navigation. No-one has a bad word to say about us: we don't pollute the Earth's atmosphere, and we don't frighten the horses!

When GPS started, those of us then in navigation saw it as a navigation system - different, but that not that different. Our vision was that it would serve ships and aircraft; that it would replace what had gone before with something a good deal better, leaving the world of navigation and the institutes of navigation essentially unchanged. How small our vision was! How little sense we had of the revolution GPS was to bring about!

Looking back, that revolution had started even before civil GPS appeared on the scene. The first phase of the revolution had brought lower cost, smaller, digital navigation equipment. Amateur sailors and aviators got technology more powerful than professional equipment, and very much cheaper: Decca Navigator and Loran-C sets for yachts, for example. That equipment disrupted a world in which navigators were professionals and the practice of navigation was the specialised art of a small number of highly-skilled people who mostly wore uniforms and always had beards!

Yet, though a wider group of professionals and a large number of amateurs now acquired electronic navigation equipment, still they were all involved in transport. They conducted voyages and flights, though now more accurately and more reliably.

When GPS first emerged into the civil world very little changed. The early adopters were all good solid navigators. But very soon satellite navigation left home. It began

to consort with surveyors, geodesists, desert travellers, people with at least loose connections to traditional navigation. Then came all sorts of strange and unexpected folks: miners, farmers, truckers - people not so much voyaging to the far horizons of the great oceans, as delivering burgers to McDonalds! In a remarkably short time, these people outnumbered what the world thought of as navigators: chaps like us! Global satellite navigation ceased to be primarily about navigation; GPS became a public utility.

Significantly, GPS encompassed more than latitude, longitude and height. GPS also delivered time so precise, and in a form so convenient, that it was soon recognised as the best means of synchronising our telecommunications systems and the Internet.

And then the revolution entered a further phase in which satellite navigation became universal - and largely invisible: its users no longer realised that satellites and navigation were involved in what they were doing. The trigger for this phase was the US government's requirement that mobile phone networks should automatically locate users who called the 911 emergency number. So now your phone tells you where you are, downloads a map for you and guides you to your destination. It locates the nearest police station or hospital, the nearest pub for young men, the nearest toilet for elderly gentlemen. It gives you tourist information, tells you of traffic problems ahead, tracks your family and friends and brings you to them - or helps you avoid them!

The cost of the devices that receive and decode GPS signals has fallen so low that for a couple of Euros they can be embedded not simply in car navigators and mobile phones, but in every kind of portable electronic device. Many of the tens – soon to be hundreds - of millions of users of GNSS worldwide don't realise that they are carrying a satellite navigation receiver. Our sophisticated navigation technology has escaped from us and become simply a location sub-system in a world of low-cost consumer products.

Have we as institutes of navigation come to terms yet with this new reality? We will see!

At the time of my first IAIN Congress, satellite navigation in practice meant GPS, as for most people in the world it still does. There was also GLONASS of course, an excellent system technically. But by then GLONASS had gradually lost satellites, so its constellation then was no longer adequate. Europe had just realised that satellite navigation was not a toy, but was going be vitally important to transportation, industry and commerce. The system on which all this depended was controlled, not just from another continent, but by the military there. So, Europe clearly needed its own civil source of satellite navigation. This was to be Galileo, an exciting new system scheduled for completion in 2008 – or even 2006 if an accelerated schedule was adopted! Technically, Galileo was to be quite different from GPS, and better. And Galileo was not only to bring Europe this independence of the US in satellite navigation, but also a large and vigorous new industry.

None of that turned out quite as predicted. Independence of the US proved to be a myth since the mass market demanded technical compatibility between Galileo and GPS receivers. US national security blocked Europe's freedom to operate Galileo

without US co-operation. So free-to-air Galileo became essentially another version of GPS.

That fits neatly into today's world in which the US is developing an improved GPS, yet one still compatible with the GPS we know and love. Russia's GLONASS is being rapidly upgraded and it too will radiate signals compatible with GPS. China's Compass has appeared, apparently a world system also compatible with GPS. So GPS has become not simply a positioning, navigation and timing system of universal application, but actually the world standard for all Global Navigation Satellite Systems!

The four speakers who follow me will fill in the details of all this far better than I could. Let us stand back and look at what is coming. According to the Russian Institute of Space Device Engineering, there will soon be some 30 satellites each from GLONASS, GPS and Galileo, and probably 27 from Compass: a total of 117 GNSS satellites. Now add in the augmentations from the US, the EU, Russia, China, Japan, Taiwan and India: a further 29, many of them with ranging signals. The grand total: 146 satellites. The sky, ladies and gentlemen, will become dark with satellites – the sunlight will dim and there will be no more Global Warming!

So, the future world of navigation, even more than the present, will narrow into a single dominant technology. This will bring huge benefits: compatibility across the world and across all modes of transport; common positioning for industry and commerce; common highly-precise timing for communications systems. For the civil user, who neither knows nor cares who supplies his receiver with signals, provided they are in Brad Parkinson's term "interchangeable", this is all wonderful.

Yet the implications of this convergence are profound. Satellite navigation systems that share a technology and share a small number of frequency bands also share vulnerability. Let me give you just one example. GPS jamming devices are now being used by criminals to overcome GPS tracking systems so letting them steal vehicles and their valuable contents. They are low-power transmitters that drown out GPS reception. They are readily available from multiple Internet sources for about $150. Their transmissions cover all of the civil and the military GPS frequencies plus the Galileo and GLONASS signals. Recently, powerful jammers with ranges of kilometres have also appeared on the street. And there are now jammers in use that cover the whole of the L1, L2 and L5 frequency bands in which the world's present and planned GNSS systems operate.

Present jammers are relatively simple and crude devices. But they are highly effective with civil receivers. They are readily available, they are being sold and they are increasingly being used by criminals and others. They render our GNSS systems vulnerable to attack. They will be followed shortly by spoofers that will allow assets to be stolen and some road user pricing systems to be defeated. That is one unhappy consequence of the convergence of technology and of our focus on a single solution.

A further consequence is that for many, GNSS has become the only game in town. They have turned their backs on all other navigation matters. Some institutes of navigation now have no time for any other technology. A generation of engineers and practitioners knows little else. The European Commission has no resources for any

navigation topic other than Galileo and has apparently shelved the rest of the European Radio Navigation Plan.

Here is an example of how this single technology can drive out all others: this year's European Navigation Conference in Naples scheduled 160 presentations – some very good ones, too. But, of that 160, 145 were about GNSS. By the most generous interpretation, only 15 – that is 9% - were about anything else.

Now I think this really matters: in the maritime world currently, the number one navigation topic is eNavigation, the International Maritime Organisation's major initiative to enhance safety at sea, saving lives and preventing collisions and groundings and pollution. Our IAIN Congress this week has two whole sessions on eNavigation. At Naples – as far as I can see - there was not a single paper!

How has this come about, this dramatic narrowing of the vision of navigation? I suggest it is this way: the growth of GNSS has presented us as institutes of navigation with a formidable set of problems. I know that the Royal Institute of Navigation, of which I was President, is struggling with falling numbers of members and is losing money. I suspect that most of the institutes gathered here are facing the same crisis. Your heart goes out to them!

But it is not surprising, is it? After all, institutes of navigation were set up to deal with those specialist navigators in a world of maritime and aviation transportation. They find themselves instead having to cope with a technology of universal application in which only a few percent of users are at sea or in the air. Even defence – where GPS was born – is a now just tiny part of the spectrum of GPS applications.

In response to this challenge, institutes of navigation and their members have reacted in a variety of ways. Some, as we have seen, have chosen to narrow their vision to GNSS alone. Others have simply given up the fight: some in the Royal Institute of Navigation have told me that "now any fool can buy a satnav from Radio Shack and measure his position, anywhere on earth, accurate to metres, it's all over".

Navigation is dead!

I believe this apocalyptic conclusion to be quite untrue. It is a reflection of the fact that for a good part of our Institute's history the challenge was indeed to measure positions accurately. Yet thirty years ago we already had systems of metre-level accuracy and we were using them to land aircraft automatically in fog. So, was navigation dead by then? Of course not! Now navigation systems have to meet demanding specifications, not just of Accuracy, but also of Integrity, Availability and Continuity. These are the four horsemen of our apocalypse – the bane of many of our lives! Of course we still need accuracy; but integrity is harder to achieve and matters much more. Lack of accuracy may give you a horrid fright; lack of integrity will kill you!

And there remains the challenge of expanding our navigation capabilities from the present easy places in the open air to the really difficult ones. We still cannot measure positions precisely and reliably in the urban canyons of our cities, in deep rainforests, or in underground car-parks. We still face the challenge of spreading precise and

robust navigation and timing everywhere from below ground level to out beyond the MEO orbit. Oh, believe me, navigation is alive and well!

Others in our institutes have taken refuge in the past. They look back to that Golden Age in which men with beards and uniforms were kings. Well, certainly the History of Navigation is a proper study for our institutes. But let us not become backwards-looking in response to a changing world. If the charm of obsolete technology is what you seek, try steam trains not a cutting-edge high-tech business like navigation!

I believe that successful institutes of navigation will follow a quite different path. First, they will accept completely the world of navigation as it is – not as it used to be or as they might wish it to be, but as it is - and they will travel with it to where it is going. They will accept that though GNSS is dominant it is no longer mainly about navigation. They will recognise that GNSS is simply one powerful central enabling technology, not the whole world of navigation. Then, they will identify and focus on the issues that matter in this new world. They will seek their members – corporate and individual – among the practitioners there. I suspect that currently very few institutes are doing that.

Here is an example. In my country as others, there are hundred of companies engaged in developing, manufacturing and supporting GPS products. In addition to the very few chip and receiver manufacturers, these people run tracking systems for vehicles and individuals, used in industry, commerce and sports. I operate in that world. Not a single one of the companies I work with is a corporate member of an institute of navigation. Their employees are not individual members, either. Indeed, very few of them have ever heard of their national institute of navigation.

Now many in our institutes take the view that these commercial and consumer-dominated industries are beneath our attention. I believe that is nonsense! Do accuracy, integrity, availability and continuity somehow no longer matter when an ambulance is sent to a critically ill patient? Are the gifted professionals who design and create this new navigation equipment, and those who use their products - professionals or amateurs - somehow less worthy to be part of our institutes of navigation than their bearded forebears were? Is the peacetime world of ploughshares less important than the swords of the defence world? Are not all these practitioners and their organisations among today's navigators, and do they not all belong in our institutes?

Yet how little attention we give to the concerns of those active in today's navigation world. Here is an example. This year both houses of the US Congress have spent considerable time debating a navigation topic. It is the question of a backup for GPS to cope with its vulnerability. Last year the Department of Homeland Security announced that the US was to adopt Enhanced Loran as its national backup; some of us cheered, others invested their money! This year the Obama administration zeroed Loran out of the recession budget. Now, this battle has played - and is still playing today - in the Congress, in the technical press and even to a remarkable degree in the US public media. The single group of players who have been absent from that debate, with a very few exceptions, have been the institutes of navigation!

Here are just some of the other key topics that really matter to many people engaged in navigation. In the maritime world they talk about: eNavigation; about the low navigation safety standards at sea and the high rates of accidents; about hijackings and the role of AIS in them. For aviators: there is controversy over the future mix of systems and which of them will fall by the wayside; about the training of pilots in the safe use of GNSS; about compulsory carriage of Mode-S by everyone from hang-gliders to jumbos and the inability of some national administrations who have mandated that to cope with the consequences! On the roads, experts and citizens alike are concerned about the training of drivers in the safe and sensible use of satellite navigation. And there is controversy in many European countries over road user pricing, and whether GNSS-only solutions will be defensible in court, given the vulnerability of GNSS. There are a lot more such topics across Navigation.

Some institutes of navigation are facing up to these and to the many other questions that really matter to people in the navigation world, or who use its products. Meetings about these hot topics are very well attended. Industry comes and government comes. The institutes begin to matter to companies and individuals who had not previously realised that there actually were organisations with the depth of knowledge and experience to hold debates on, and tackle, today's important questions in navigation.

I question how many of the institutes present here in Stockholm will be at the next IAIN Congress in three years time. Which institutes will they be? I firmly believe they will be those that have successfully managed the present difficult and traumatic transition to this new world of navigation, those that have identified themselves with the issues that matter to practitioners in this world. That way lies success!

As we tried to work our way through these difficult questions in our institute – a process that is still continuing – I described the RIN as "a failing business in a booming industry". As you can imagine, that was not a popular view! But I believe it was true when I said it and I suspect it may be a fair description of many institutes of navigation.

Ladies and gentlemen, it does not have to be that way! This booming industry is a place of success and very bright people. What was once a specialised set of professional techniques has expanded into an industry with hundreds of millions of users. Navigation is a unique place where bright engineers - hardware and software - work alongside systems analysts, geographers, surveyors, geodesists, map-makers, and those who design, manufacture, market and support navigation equipment, and those who use their products as practitioners. All these people are today's navigators!

Navigation needs the wisdom and experience of the institutes of navigation. Here is what it takes: we must stop looking back to a Golden Age of Navigation and realise that never have so many participated in, and enjoyed the benefits of, the amazing technologies we have wrought. Let us celebrate that success. Let us welcome this new world and play a full part in it. Let our institutes of navigation realise that, not in the past, but now, today, is the real Golden Age of Navigation!

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