Resilient Positioning, Navigation and Timing - for Europe?

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This is the third in a series of meetings on the topic of Resilient Positioning Navigation and Timing, a theme that has come to dominate many navigation conferences in the last few years. The first of these meetings was in Rotterdam last year and the second in California in January, alongside the ION winter conference. Those previous meetings were very well attended – 150 in California - certainly by engineers and navigation specialists but markedly less by policymakers. The divisions between those tribes reflect wider divisions that have appeared in the world of navigation. Let me suggest what those divisions are, because they profoundly affect the degree of recognition of the need for Resilient PNT and thus our ability to respond to that need and deliver effective solutions.

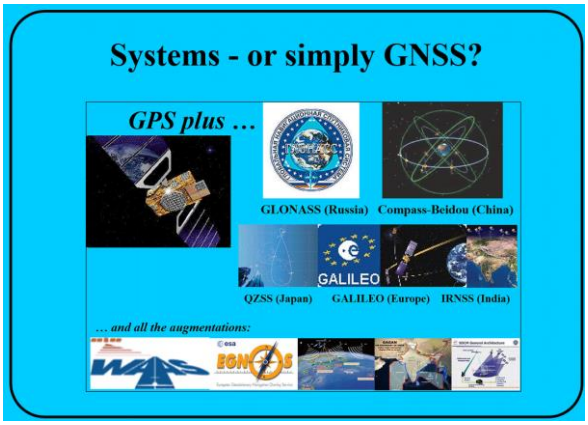

Figure 1: Systems - or simply GNSS?

For a decade or more, these navigation conferences have opened with a plenary session in which a speaker from the US reports on the status of GPS. Then there will be a Galileo briefing. There may well be presentations on GLONASS and Beidou, on Japan's QZSS or India's IRNSS (see Figure 1). Alongside are the augmentations: WAAS and EGNOS and a bunch of others. The view is of competing systems, each vertically-integrated - with satellites, receivers, applications and users – and to a degree overseen by a national or regional administration. Galileo markets and GPS markets are assessed. The relationships between the systems are always an area of friction: this week's hot issues include the degree to which Galileo might be mandated in Europe and the recent US "bombshell": that the reception there of "foreign" GNSS might be illegal, inappropriate for public use, even un-American! The view is that of governments and of diplomats: separate control, spheres of influence, geo-political competition for dominance.

But many of the users of navigation and timing, and manufacturers and those who develop services, now have a completely contrary view. They foresee a world in which Galileo or GPS or Beidou will each be 30 satellites among maybe 150. They view all these systems as just versions of two technologies, either GPS-like or WAAS-like, with a hint of garlic here, a whiff of curry there, differences of compelling interest to Geeks, but not to them. They see receiver chips already accommodating these multiple systems; indeed, receiver designers are well ahead of satellite launchers. Increasingly our receivers use these multiple signals to deliver the best possible PNT. Many users neither know nor care about GPS or Galileo anymore; they don't even realise their iPhones are receiving GLONASS. Which of these two world-views will prevail matters greatly for the provision of Resilient PNT.

Another division has opened up: between Vulnerability and Autonomy (Figure 2). Two tribes – which are you? The "Vulnerablists" declare that GNSS is fallible, depends on very weak signals that are easily disrupted by noise or interference, some

natural, some accidental and some - jamming and spoofing - malicious. Their view is that you should not rely on GNSS alone, any system or all systems, but back it up with a different but complementary technology.

Figure 2: Vulnerability or Autonomy?

The "Autonomists" take the contrary view. All is well! GNSS combined with mode-specific sensors and very advanced computer systems is reaching the point at which it will support autonomous cars, autonomous ships, even pilotless passenger aircraft. The conflict between these two views is so wide that at the recent Manchester conference, the Royal Institute of Navigation scheduled them into parallel sessions, so physically separating the protagonists!

If we are to make progress with developing and delivering Resilient PNT, we are going to have to find ways to bridge some of these gaps. And there are others (Figure 3).

Those who argue that GNSS, while undeniably the centre of our future navigation repertoire, is vulnerable to disruption by interference from natural and man-made sources receive a warm welcome from the engineering community, deep concern from practicing navigators and a response from policy makers that varies across a very wide spectrum.

Some governments accept vulnerability. South Korea does: following attacks on its GPS-based national infrastructure from North Korea, it is actively implementing an alternative navigation solution – eLoran - to mitigate the threat to GNSS. At the other extreme, are governments - especially in Europe - who wholly reject that view. They respond that the problem is overstated and anyway can be solved simply by relying on Galileo in addition to GPS; essentially, that GNSS alone can guarantee Resilient PNT. For them, geopolitical arguments trump engineering concerns. This division will have a major influence on the future resilience of Europe's PNT.

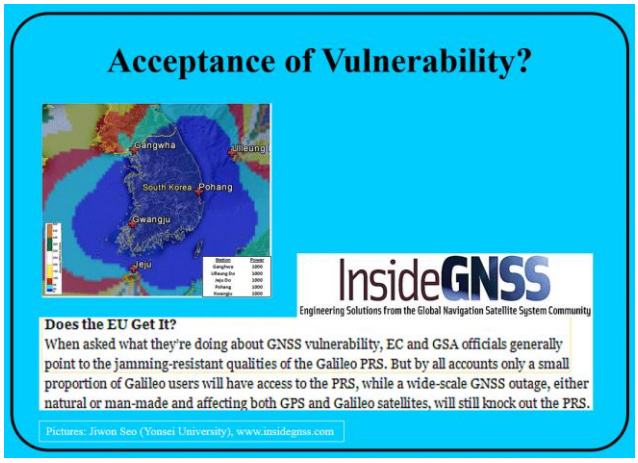

Figure 3: Acceptance of Vulnerability?

There are also profound differences in the degree of resilience we already have built into our everyday use of satellite navigation systems. Compare maritime and aviation …

Figure 4: Maritime

Many recent publications have shown the extreme degree to which the maritime world now depends on GPS in bad weather (Figure 4): multiple navigation and communications functions are partially or wholly dependent on GPS. The loss of GPS on many commercial vessels would even affect the non-satellite fall-backs, radar and gyrocompass; even the ships clocks would be affected!

In contrast, aviation has taken a very conservative approach to GNSS. It has maintained multiple independent and dissimilar technologies (Figure 5). So, London Heathrow runway 27 Left has a GNSS Instrument Approach. But it is supported by an ILS, an MLS, plus DME, VOR, ADF, inertial navigation, radar and baro altimeters and magnetic

compasses. RAIM and EGNOS are mandatory, plus reversion to a legacy system as soon as GNSS is less than perfect. That set of independent and dissimilar technologies is specific to aviation

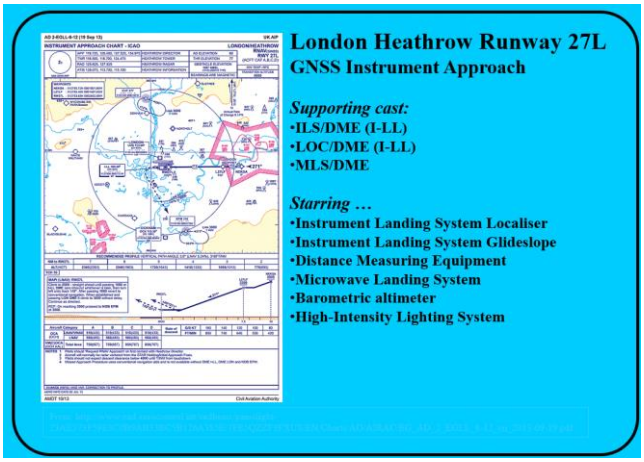

Figure 5: Aviation

But every activity that employs GNSS already has, or is developing, some mode-specific alternatives. For maritime use, Europe is experimenting with a ranging system, R-mode, and working on deriving position data from advanced ships' radars (Figure 6). Telecommunications operators need precise time which currently they receive locally from GPS; they are exploring time distribution via PTP technology. All these players recognise the need for dissimilar, independent and sky-free complements to the central technology of GNSS.

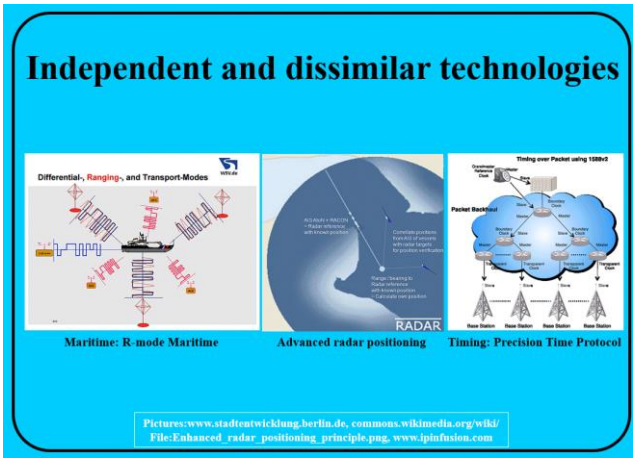

Figure 6: Independent and dissimilar technologies

Meanwhile, in Washington, US policy regarding complementary technologies is developing rapidly (Figure 7). The Advisory Board to the cross-government PNT Executive Committee has recommended a strong policy on resilient PNT, essentially as articulated by its Chairman Professor Brad Parkinson at the first of these meetings last year in Rotterdam; he called on us to "Protect, Toughen and Augment" GNSS. He has described GNSS vulnerability as "a single point of failure for the United States". The augmentation recommended by the Advisory Board as the primary alternate PNT is the US-developed Enhanced Loran, eLoran. The Congress recently passed legislation that preserves the infrastructure of Loran-C, the now-obsolete precursor to eLoran, and authorises its modernisation into eLoran and (this is significant to us) its operation by a non-governmental commercial entity. Then just last week a bipartisan Bill was submitted to the House requiring the Secretary of Defense to establish a reliable land-based PNT system as a complement and backup to GPS.

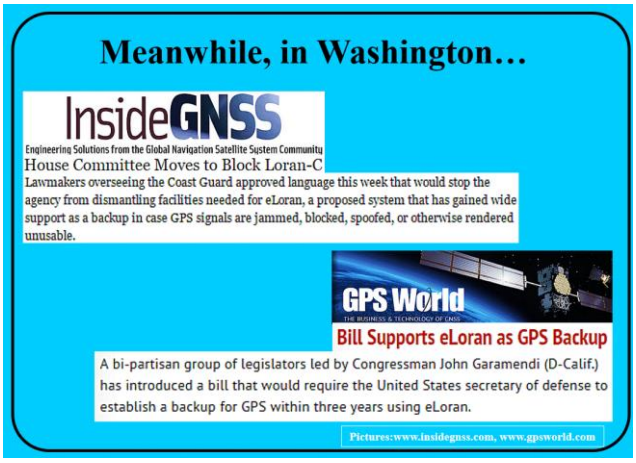

Figure 7: Meanwhile, in Washington …

That proposal had been strongly influenced by the prototype system developed in Europe, which has now reached maritime Initial Operational Capability at 7 ports, plus a high-precision pilotage version at Rotterdam Europort (Figure 8).

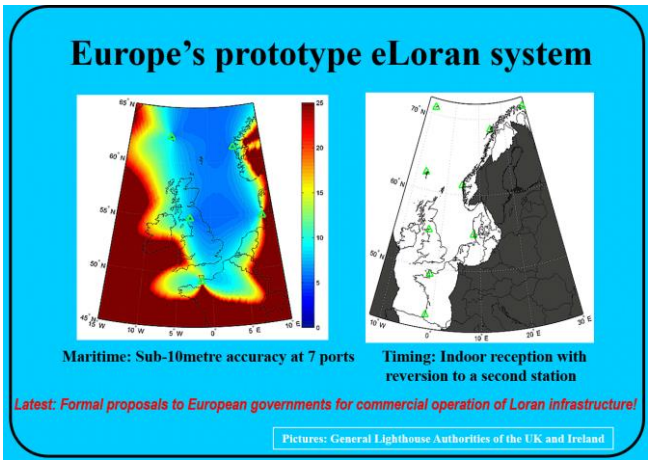

Figure 8: Europe's prototype eLoran system

Coordinated by the UK and Ireland, it uses transmission from stations in Norway, the Faroes, Germany and France. It is delivering an automatic fall-back in the event of GNSS failure for shipping, plus a robust data channel for UK national security use. But the greatest driver to its development is

turning out to be is its ability to deliver nanosecond time for the next generation of mobile telecomms base-stations, including the numerous cells indoors at the edges of the networks. Resilient time from GNSS plus a complementary alternative is also becoming vital to broadcasters and for aviation ground facilities. As a result, certain European governments have now received formal proposals for their Loran facilities to be released for commercial development and operation.

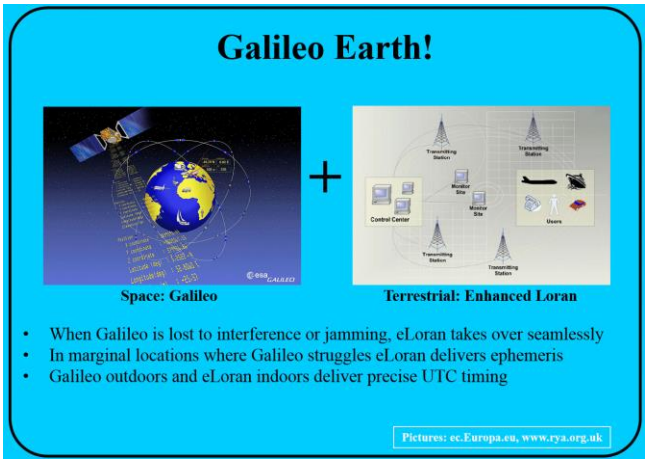

Figure 9: A new vision

Over the year since we met in Rotterdam, a new vision has emerged of a possible relationship between Galileo and a terrestrial complement such as eLoran - one that could be mutually beneficial in driving the adoption of both technologies (Figure 9). We are familiar with the idea that when the space component suffers interference, the terrestrial component would take over. But the terrestrial component can also assist in marginal locations where the space component struggles; there the Loran Data Channel can deliver Galileo ephemeris to receivers, letting them work in the assisted mode. But most importantly, since the timing of the two systems is aligned, eLoran would deliver precise Galileo time for telecomm and other users indoors. The combination would provide a resilient, seamless, position and timing solution.

Some are calling this concept "Galileo Earth!" It might just give Europe an advantage – a competitive edge - in a world turning to resilient PNT solutions.

I would also like to show you a concept presented at a NATO meeting recently. In Western Europe we have 9 stations ready for conversion into a terrestrial complement to GNSS (Figure 10). Our neighbours to the east have many more. Figure 11 shows our present coverage.

Figure 10: Europe's terrestrial complements to GNSS

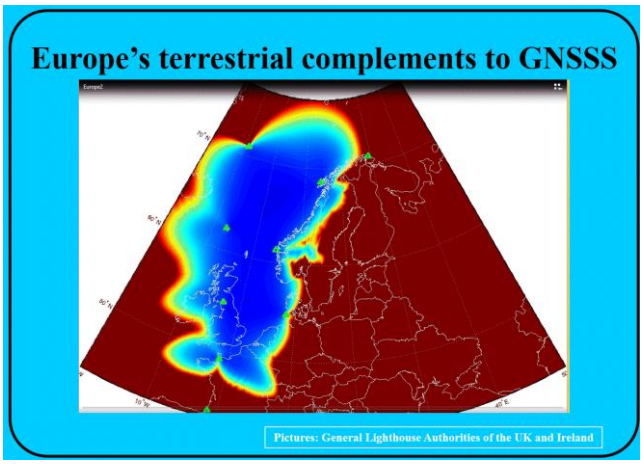

Figure 11: Current Western European coverage

Figure 12 shows this plus their version: eChayka, or Skorpion. We could expand ours to cover the gap; technically straightforward, given the political will.

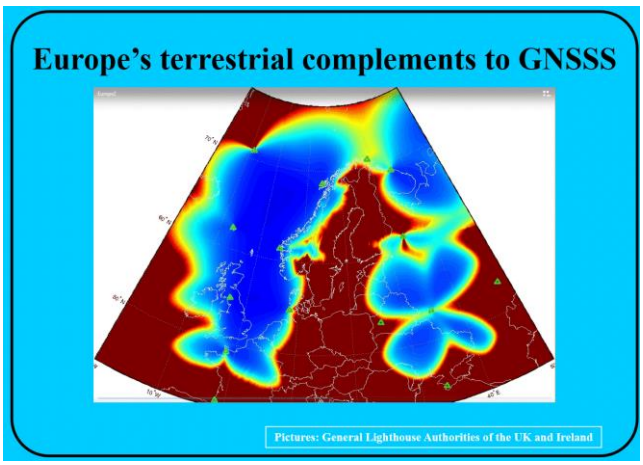

Figure 12: Western and Eastern Europe

But, as things stand today, this will simply not happen: in just under 8 months' time the transmissions from 6 of the 9 Western stations collaborating in the prototype system will be switched off and the facilities permanently demolished.

Figure 13 shows what the situation will be next New Year's Day.

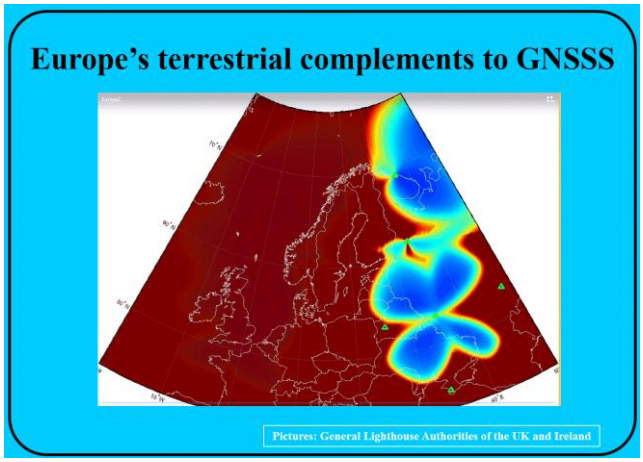

Figure 13: Potential coverage on New Year's Day 2016

In Western Europe we urgently face the key decisions shown in Figure 14. Firstly, do we actually value and see the need for Resilient PNT – or is all well? If we do have a need should we not decide, as the US has done, to stop plans to decommission infrastructure for alternative PNT while we work together to develop resilient solutions? I do not know which technologies we will adopt: perhaps R-mode, perhaps advanced radar, perhaps inertial, perhaps timing over PTP, maybe Galileo Earth. But I do know that unless Europe takes this matter of resilient PNT seriously and ceases to believe that the loss of GNSS either does not matter (as some tell us) or can simply be avoided by the provision of Galileo (as others argue), we will finish up with an ever-increasing dependence on GNSS – Europe's "single point of failure" - and an ever-increasing vulnerability. We urgently need a Resilient PNT initiative.

Figure 14: Key decisions for Europe

Who might lead this initiative? Well, our ENC conference is organised by EUGIN, the European Group of Institutes of Navigation. They are sponsors of this meeting, too, together with two world bodies: the International Association of Institutes of Navigation and the maritime organisation, IALA. In my view, it is Europe that now needs to find a way ahead. So, if in our discussion we agree on the need for a policy that leads to Resilient PNT for Europe, then EUGIN might well be the best focus for that initiative.

And, if this initiative receives support in Europe, then a similar model could be considered for other parts of the World, perhaps at the fourth of these RPNT Forums, next October at the IAIN Congress in Prague. Maybe IAIN should then take a role.

Ladies and gentlemen, it is time for Europe and its governments to decide either that no action be taken, or that we are faced with the need to act together to deliver an effective – and potentially world-leading – system of resilient positioning, navigation and timing.

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