What have we done? And why does it matter?

A technology manifesto from Locata's founders

Revolutions don't start in a vacuum. They start because there's *a problem*.

For Locata's founders, the problem arose when we relied totally on GPS for an application – *and it failed us badly.* We therefore understood many years ago just how much future mobile devices and applications will rely on accurate positioning... and the incredible frustration caused by that positioning technology when it lets you down.

When a serious problem meets people that are stubborn enough to *demand* a fix… determined enough to slog for years in a seemingly epic quest to deliver an elegant solution... that's the day when "a problem" becomes "an innovation".

Alan Kay, the visionary founder of the legendary Xerox PARC Labs in Palo Alto, described the process beautifully in 1982 when he said something so profound that it's now become part of technology folklore. It's also a declaration that has been the driving force for Locata's founders for 20 years: ***The best way to predict the future is to invent it.***

Inventing the future is exactly what we've had to do. By setting out to overcome the many shortcomings which GPS displays for modern applications, we have had to invent a slew of completely new technologies… from scratch.

New thinking was needed. That's what Locata has delivered. And plenty of it.

Reinventing a system that has cost the US taxpayer more than $40 billion is *not* an exercise for the fainthearted. In fact, the entire industry was extremely sceptical about the chances of "two guys in a garage" ever actually achieving it! Yet despite the many cynics and detractors, Locata has now undeniably demonstrated – and begun to commercialize through impeccable global partners – an entire platform of *critically important and radically new advances in the art of positioning*. Locata's inventions will create a revolutionary new level of performance for future positioning systems, as we literally drag GPS-style positioning into the 21st Century. Locata answers the question: "What comes *after* GPS?". That's one of the reasons why we call Locata "**GPS 2.0**". It's the next-generation revolutionary advance in the art and science of location. And it will change the world forever.

The overview below provides an introduction to our achievements. It's written as a relatively non-technical outline of the core technologies Locata has created to *really* fix GPS problems. We trust it will provide the reader with a window into the revolution that is coming – and an introduction to the exciting future we have spent many years inventing.

Nunzio Gambale and **David Small**
(Locata founders)

LOCATA TECHNOLOGY DEVELOPMENTS

1. Locata's founders understood in the mid-1990's that satellite-based positioning systems were *never* going to be robust enough to supply Position, Navigation, and Time (**PNT**) information for future mobile applications – especially for the large number of positioning environments not anticipated when the Global Positioning System (GPS) was designed more than 40 years ago. They saw five fundamental problems with GPS:

a. It has extremely weak satellite signals that are easy to block, jam, spoof, or accidentally interfere with;
b. Civilian GPS signals are unsecured, lacking encryption or authentication, and cannot be readily upgraded to secure them in the future;
c. There is never any guarantee that signals will be available from the satellites – *"with GPS you just get what you get"*;
d. It takes 20 or more years to modernize the space and related terrestrial infrastructure components of a Global Navigation Satellite System (GNSS), a period of time which is now untenable when attempting to keep up with the pace of evolution of modern electronics (*especially from the threats!*);
e. All GNSS systems are incredibly expensive to build and maintain, restricting control of these systems to super-power nations (*and hence reduce all other countries to an unacceptable state of dependence, and lack of sovereignty*).

2. Locata's founders knew these problems "had to be fixed". The Locata team has therefore spent many years inventing and developing new technologies which elegantly deliver <u>all</u> of the core advances we believe future positioning applications <u>must</u> have in order to function in the way the world wants them to.

3. Locata had to invent a trio of completely new *foundational* technologies to deliver the advances which will solve GNSS inadequacies. This allows the delivery of all the essential **<u>P</u> <u>N</u> <u>T</u>** functionalities required in the future for areas where GNSS fails today, namely:

a. **<u>P</u>OSITION** – supplied by the Locata ground-based **<u>network</u>**.

These Locata networks today are robust, well-proven, already taken up by some of the most demanding users on earth, and on sale to early-stage markets which are analogous to the early-stage GPS markets.

This core *Locata network enabling technology* now allows any entity to deploy a **<u>local</u>** radiopositioning system which:

- can be designed to ensure accurate PNT is available in areas where satellite signals cannot reach;
- is extremely accurate – as good as "survey-grade" GPS;
- can be designed for a repeatability which is simply impossible with space-based systems;
- can easily scale from the size of a room to thousands of square miles;
- can be under full local control, thereby returning sovereignty to nations;
- can be transmitted at power levels and deployed in a configuration which will guarantee performance for an application;
- can readily be adapted to a different frequency or signal coding scheme;
- can be encrypted and secured as required;

- can be deployed as independent, redundant, robust networks which look remarkably like "an Internet model" that has no single point of failure;
- can evolve at the same speed as modern electronics;
- *and importantly* – can easily be integrated into core GNSS receiver designs as "just another constellation" (albeit a local, ground-based one instead of a traditional space-based one).

Locata's network system is well-reported on the web and in many academic papers, and can be readily investigated by an interested reader that wants to learn more. Locata networks are being sold *now*, through superb partners. Bottom line: *It works.*

In the future, as Locata electronics become tightly integrated into an ASIC chipset (a development which is already underway), our transmitter and receiver units will become much less expensive, and therefore eventually able to address larger, more price-sensitive markets such as mobile phones and personal devices.

However, Locata's founders understood that, as difficult as it was to locally replicate an extremely complex and expensive space-based system like GPS, it was still only the first step….

b. **NAVIGATION** – supplied by the new Locata **VRay technology**.

Despite Locata successfully developing a local wireless positioning network which could effectively "replace GPS satellites", it was clear that most future mobile systems had to navigate in applications and environments which the original designers of GPS never imagined would need high-accuracy positioning… like mobile phone systems working deep in urban areas, and especially indoors. To ensure the new networks would function well in these challenging environments Locata's founders had to tackle yet another exceptionally difficult problem – **multipath**. This is the name describing radio signals which bounce off many surfaces in cluttered environments such as cities and indoors – and therefore take a *non-direct travel path* to a receiver. It causes large positioning errors and serious reliability problems in these environments. Multipath has always been the bane of reliable radiopositioning in these areas. It's a problem which has never been effectively solved.

That's why, after inventing the core network technology, Locata spent *seven more years* inventing the completely unique **VRay** antenna technology which is today demonstrating *unprecedented* high-accuracy positioning in extreme multipath, especially indoors. The Locata website is now featuring the first commercial version of the VRay – a basketball sized antenna designed specifically for large machine control in warehouses, ports, steel mills and many other industrial-scale applications.

It's hard for a layman to appreciate the enormity of the advance which VRay represents for positioning. In fact, Locata believes *it is virtually impossible* for wide-area radio-positioning systems to deliver the future expectations of personal navigation in cities and indoors without this type of technology advance becoming available. The VRay is too complex to cover in detail here, but the most important take-away points are:

- VRay is a **technology platform**, not a single device. It has been designed as an extremely flexible and adaptable foundation upon which many variations can be built for different uses. It is therefore **a new suite of technology solutions** which will allow the entire industry to address the many environments and applications where modern mobile positioning is needed in the future, especially indoors and in urban areas.
- A reader should not fixate on the relatively large size and seeming complexity of the very first VRay antenna (see Locata website). The sheer scale of the multipath problem is such that Locata engineers had to concentrate on solving the many technical challenges without having to worry about producing a smaller or less expensive initial solution. Locata's multi-year VRay development effort has led to an immense body of new knowledge which can soon be leveraged into designs for smaller, less complex and less expensive versions. This will lead to revolutionary new capabilities for GPS-like positioning in difficult urban, indoor and consumer environments. *Two important examples follow…*
- Locata's Advanced R&D team has been working for some time on a version of the VRay which does not require the current complex-looking antenna to deliver Locata's indoor multipath mitigation benefits. This "version 2 VRay" has been absolute cutting edge research, and came with a high probability of failure if myriad technology hurdles could not be overcome. It is therefore immensely satisfying to know that these many years of development have paid off, with the first successful demonstration of a v2-VRay advanced technology in November 2013. Locata now *knows* this v2-VRay advance can deliver multipath mitigation technology with a very simple antenna, and hence "**it can now be taken all the way to an iPhone**". *This invention gives the first glimpse of a Locata-enabled future where standard consumer-style mobile devices will have high-accuracy positioning capabilities in places where GPS fails today*. Importantly – this is only the first version of the v2-VRay. Other Locata-based versions are also in development to further entrench this Locata technology into the future of mobile systems.
- ***In May 2013 the US Air Force Institute of Technology (AFIT) signed a co-operative research contract to gain access to VRay technology for application to GPS receivers***. This is such an important point it needs to be emphasised again. The USAF understands that VRay can improve performance of GPS receivers in difficult modern environments, *showing that VRay is not only for Locata-enabled devices*. This was stated clearly in the USAF press release when the contract signing was announced. In the second half of 2013 Locata engineers have been transferring VRay knowledge and building techniques to AFIT engineers. The USAF is currently making good progress with the integration of VRay technology into their GPS receiver. It is expected that by mid-2014 the USAF GPS receiver will be demonstrating superior real-world performance in many "difficult GPS environments" such as deep within urban areas. *It should be clear from this USAF development that Locata's ground-based inventions are now evolving at a rate whereby Locata is actually beginning to drive improvements to space-based GPS systems!*

So, where does all this VRay development lead?

- VRay takes the positioning network Locata has already invented and *extends* its reach with new technology tools which will allow mobile devices to navigate in areas where it was previously impossible with GPS. Locata's VRay promises to revolutionize mobile device positioning indoors, in urban canyons, and other environments where GPS does not work because of multipath and signal obstruction problems.
- The USAF already understands VRay can materially improve "standard" GPS when it is integrated into a regular GPS receiver. This is such an important advance *that we believe VRay capability will become an indispensable technology component which receivers must have to remain competitive in a future marketplace.* Locata's VRay technology therefore has the potential to be an essential ingredient in almost every new GPS receiver made in the future, via an IP license or royalty structure.
- A VRay-enabled receiver is, because of the very nature of Locata's developments, no more expensive or complex to make than any other modern GPS chipset. This will ensure of Locata advances are easily taken up by all GPS device manufacturers in the future.

By this point it should be clear that Locata has, over many years of effort, diligently and single-handedly built and delivered the technology foundations which will finally enable the "GPS everywhere" future the world clearly wants.

However, there is *yet one more piece* of the PNT puzzle which Locata has also had to deliver via new inventions:

c. **TIME** – supplied by the synchronization technology which is at the very heart of Locata networks, and which is trademarked under the name **TimeLoc**.

Any study of modern GPS systems will quickly show that high-accuracy time synchronization for digital technologies is one of the most important uses for GPS satellite constellations today. Locata calls GPS "the heartbeat for the digital world". The depth of the world's dependence on GPS time synchronization truly surprises most laymen because GPS timing, distributed from the satellites, is essential around the world for the proper functioning of:

- mobile phone cell systems
- the international banking and finance systems, including ATM's
- the Internet
- stock exchanges
- transportation systems
- and, in many countries, even the electricity supply grid networks.

The dependence on GPS timing is so deep and, unfortunately, *so vulnerable* that in February 2013 the US President issued Presidential Directive #21 which in part directed the US Department of Homeland Security (DHS) to *"harden 16 critical national infrastructure sectors against GPS disruptions"*. The dependence which the world has placed on the availability of GPS time is now recognized as a critical problem which must be addressed urgently by every nation. The core issue, of course, is that *there is currently no real or viable backup to GPS time* which can cover and/or replace all the benefits derived from GPS systems today:

- nanosecond accurate time synchronization
- the ease and flexibility of completely wireless distribution of synchronized time
- the effortless addition of unlimited numbers of receivers
- low cost and ease of integration into GPS chipsets
- true synchronization backup capability that is *completely independent* and does *not* rely in any way on GPS time, or on any complex system of atomic clocks that is commonly expected as a basic prerequisite for accurate synchronization.

With TimeLoc, Locata can supply all of these benefits over large local regions such as a city, or over strategic areas like an airport or a military base covering thousands of square miles. Again, TimeLoc is too complex a subject to be covered here, but it can be researched easily by an interested reader either on the Locata website, in many university research papers, or by studying the first USPTO TimeLoc patent #7,616,682. Suffice to say here that via TimeLoc Locata can deliver *completely unprecedented* wide-area levels of wireless synchronization and frequency stability. In November 2013 Locata had the opportunity to demonstrate this time-specific PNT functionality. It was the last of the current trio of technology platforms Locata has invented – and for which our claims had not yet been publicly, independently verified.

Locata's time synchronization capability is best illustrated by an example of what a large industry like the mobile phone system requires for the next-generation 4G cell networks. In November 2013 researchers from the University of New South Wales (UNSW) set up a demonstration which compared a Locata network's real-world time synchronization performance against the requirements for cell network timing specified to us by a global telecom firm. The demonstration of Locata capability was independently tested and analysed by UNSW. The world-first results were presented to the Precise Time and Time Interval Conference [http://www.ion.org/ptti/] in Seattle on December 4th 2013 by UNSW researchers. [http://www.ion.org/ptti/abstracts.cfm?paperID=1002].

Important points to note about this vital time-specific market segment:

- Next-generation 4G mobile phone networks (known as LTE-A in the industry) require a time and frequency stability across an area (e.g. Boston USA) as set out by the Institute of Electrical and Electronics Engineers in a global standard specification called IEEE 1588. The desired minimum performance is:
    - **Synchronization:** ±1.5 to ±5 millionths of a second (μs)
    - **Frequency stability:** 16 - 50 parts per billion (ppb)
- The preferred method for achieving this IEEE level of performance is via GPS or other satellite-based positioning systems. However, as stated very clearly in many industry papers: *"…the vulnerability of GPS signals is of growing concern"*. [https://www.aventasinc.com/whitepapers/WP-Timing-Sync-LTE-SEC.pdf]
- The fall-back position for the mobile industry when GPS has problems is an IEEE 1588 fiberoptic cable distribution system which incorporates large numbers of atomic clocks embedded in almost every major hardware component of a mobile phone network in a given area. This IEEE physical infrastructure solution soon becomes extremely complex to deploy, and very quickly loses the elegance and easy scalability represented by a *wireless* distribution of time.

- The biggest problem, however, is that despite the complexity and cost of this IEEE 1588 non-GPS based back-up system, it still struggles to meet the 1.5 millionths of a second timing and ~50ppb minimum frequency stability requirements which are essential for the next-gen cell network. The industry regards the IEEE level of performance as technically hard to achieve, and considers it to be at the very cutting edge of current technology capabilities.
- Locata's world-first TimeLoc demonstration in November 2013 (as reported by UNSW at the above ION conference) provides a valuable point of comparison to the global IEEE requirements. Over a transmission coverage area of 73km (46 miles), a standard Locata network was independently tested to deliver the following real-world performance, relative to GPS:
    - **Synchronization:** 5 nanoseconds (billionths of a second)
    - **Frequency stability:** <1 part per billion (ppb)
- Not only is this demonstrated Locata performance *orders of magnitude better* than what is demanded by the most stringent requirements of the mobile phone industry and the IEEE specification… Locata clearly delivers an unprecedented level of performance for a terrestrial wireless network. Locata is not aware of any other wireless technology (other than GPS systems) that can approach this level of performance.
- *Moreover*: Locata knows the above performance figures are simply an initial demonstration of TimeLoc's synchronization capabilities. TimeLoc will certainly be further improved in the future. Additionally, as Locata devices become incorporated into chipsets, this synchronization performance will become much less expensive, and so be more readily available and useful to mobile applications.
- Finally, TimeLoc delivers a true, incredibly accurate "back-up to GPS time" capability which other technologies clearly struggle to approach. This Locata timing attribute has immediate use for systems which can be developed to meet wide-area national infrastructure security requirements, as stipulated by the US President, and by many other nations. The dollar and strategic value of this capability alone will become manifest to many companies in the future.

4. SUMMARY

a. The information above is relatively lengthy because it has to cover a multitude of completely new inventions, and the reader needs to appreciate both *why* Locata inventions were necessary, and *what* new features our inventions deliver to this technology sector. It's critical to understand that modern mobile technologies in cities and indoors have stretched GPS positioning far beyond its original 1970's design parameters. GPS simply *cannot* deliver on the ever more demanding expectations the world now has for location-based systems. A major advance is needed to take us to next-gen mobile systems. That's what Locata has created.

b. **Locata has invented a complete suite of unprecedented and new technologies** – they cover all of the GPS system's **PNT** shortcomings, and in the process fill the PNT holes that GPS cannot reach. These inventions represent revolutionary advances in positioning for future mobile devices.

c. Today the trio of core Locata inventions described above:

- are proven to a point where they are *already* being sold by some of the most important GPS integration partners in the world; *or*
- are proven to a point where Locata business partners can now begin developing revolutionary (and profitable) new devices and applications for many multi-billion dollar markets;
- are in the process of being miniaturized so that Locata IP may be integrated and sold into progressively larger and more price-sensitive markets;
- are beginning to influence even the development of satellite-based GPS receivers, delivering important new capabilities which may lead to Locata technology being licensed into most GPS chipsets which will be sold in the future; and
- are starting to deliver unmatched new time synchronization capabilities to the industry, and so begun to enable development of locally controlled "back-up to GPS time" systems which are *essential* for every nation's infrastructure security.

d. Locata believes the inventions it has now created promise to become the functional cores of many future mobile devices that need reliable positioning. When GPS *and* Locata are combined in one device, with VRay *and* TimeLoc added to the mix, it will revolutionize what can be done with personal-level positioning in urban, indoor and mobile environments.

e. This extremely powerful **GPS+Locata** combination is the very definition of what future professional and consumer positioning devices *must* be. In a very clear pointer to this vision of the future, Leica Geosystems – the world's largest professional GPS company – *has already produced and is now selling* GPS+Locata receivers for their fleet automation systems. Leica's new GPS+Locata receiver is today delivering "previously impossible performance", with critical public acclaim from industry, the press and customers alike. More of these GPS+Locata systems will become available from other partners in the near future.

f. Finally: despite the huge advances revealed so far, Locata still has multiple other technology advances in development. In December 2013 Locata had 122 granted patents and over 100 more in process. The industry can therefore expect to see more revolutionary advances delivered by Locata in the future.

Locata is a driven and passionate company. We are clearly on a mission to revolutionize what can be done with positioning, and our accomplishments in this quest now speak for themselves.

Through the process of invention and commercialization, we are today building the foundations for a valuable, global company that will have an enormous influence on mobile applications in the 21st Century. We welcome enquiries from parties interested in learning more about how they can exploit our work for themselves, and wish to partner up for their own success. Information and business development discussions can be initiated by e-mail to enquiries@locatacorp.com, for the attention of Nunzio Gambale (CEO). Thank you.

Nunzio Gambale and **David Small**