A1

TYPE-1

GNSS

AUGMENTATION

SERVICE

GNSS

AUGMENTATION

SERVICES

[Background]

The Positioneering mission is to provide precise positioning solutions, primarily to the high-end marine sector, with the aim of delivering radical positive change through innovation, optimum implementation of technologies and techniques for each and every aspect.

We recognise that our customer's applications are operationally very demanding and highly dependent upon precise positioning, requiring tight tolerances and total availability. The consequences of poor positioning are significant both commercially as well as from a safety perspective. The primary demands of this market therefore include; accuracy and precision, robustness, resilience and redundancy as well as comprehensive service support available globally twenty four hours a day, year round.

Although perceived as a mature technology now, Positioneering has, through its substantial experience in this field since creating and building one of the first providers into a current market leading position, coupled with an extended period of intensive research, discovered many areas in current offerings that fall short of the mark. The result of its extended period of development is a suite of products and services that deliver optimum performance and functionality throughout from the service solutions through user hardware and software.

So, How Have We Achieved This?

Throughout all of its development activities, Positioneering adopts a clear Product Management Process that begins with users and their functional and performance requirements, leading to a concept and then rigorous design, development and testing. Through a philosophy of partnering with the best in their relative fields, subsequent outsourcing and optimum combination of the final elements, Positioneering has created the most complete and functionally optimum GNSS Augmentation service and solution to date.

All About Availability

There is a plethora of rhetoric about accuracy, convergence, number of delivery beams, QC software etc. in precise positioning. To deliver the optimum solution it is first necessary to understand what is most important to users and this is without contradiction “Availability”. But what is availability? This can be defined as the time during which the produced position meets all operating and performance requirements including accuracy. But this is only part of the story; Positioneering's view is that this should include all elements that contribute to the status of the position solution including availability of active Quality-Control to validate the position, sufficient resilience, including redundancy, timeliness (Latency) and any other parameter required to ensure that the position is meeting the user's ultimate requirements. Should any of these elements be missing then the position must be considered as possessing reduced availability. There are many limitations in current systems that prevent this full assessment to be conducted and this is a major area of focus for Positioneering.

Setting the Scene

If it isn’t broken then don't fix it! It is quite easy to believe that nothing is indeed broken with available positioning solutions but this is mainly due to a level of expectation that has been set and largely unchanged for decades. With a blank canvas Positioneering set off on its quest to raise this level of expectation and to then meet or exceed it with a holistic approach towards the products created. The starting point for this was the redefinition of the position solutions themselves including how to make best use of the value of even unsupported free-to-air services. Once the final destination was understood, the route was then developed, making use of every potential approach and solution available but always with focus on achieving the optimum.

Solving The Problem

The target for the ultimate solution is 100% Availability. Availability can be split into two areas :

i) Performance - Accuracy / Latency - The system is online and the solution is operating within specification

ii) Physical - When the system is physically available

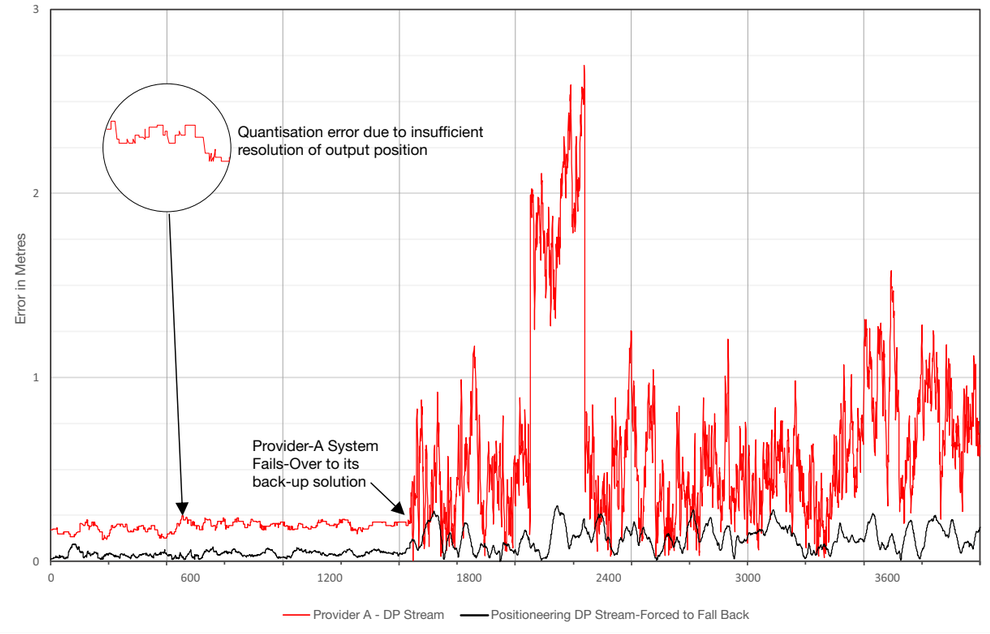
To ensure position performance in all conditions a philosophy has been developed that provides a dual position solution; one that is focussed on providing the highest possible accuracy (Primary / P) and a second (Secondary / S) that focusses on the highest availability, using only the strongest signals available. The focus is to ensure that whatever operating conditions may be a position is provided that always provides the required accuracy.

The following table shows the main elements impacting availability in both performance and physical terms.

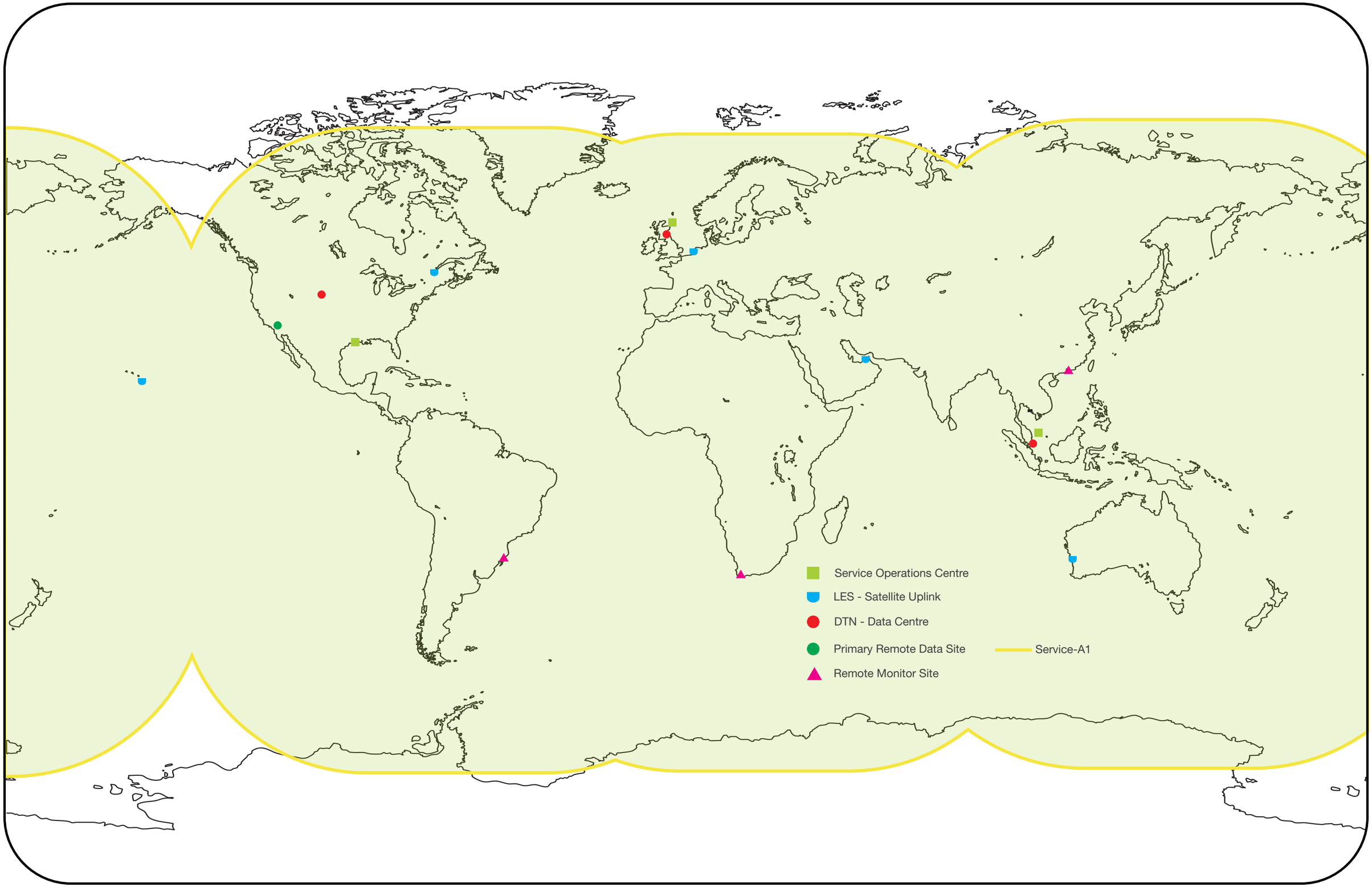
Element	Target Performance	Implementation
Performance Availability:		
Position Accuracy	0.50m (6σ / 99.9997%)	P1 Primary accuracy : 0.05m (2DRMS) S1 Primary accuracy : 0.25m (2DRMS)
Position Latency	< 150ms	Embedded processing in CPM hardware (No external QC/processing software)
Position Validation	Spike-Free Position	Integrated Iterative Data-Snooping in CPM
Augmentation Signal Performance	BER > 9	Optimised signalling for service
Physical Availability:		
Position Availability	100%	High Accuracy/Avail (P/S) position combination
Augmentation Service Availability	100%	100% reserve signal at coverage extents Distributed high-resilience architecture Multiple service paths Multiple independent resilient data sources High quality installation design

Practical Example

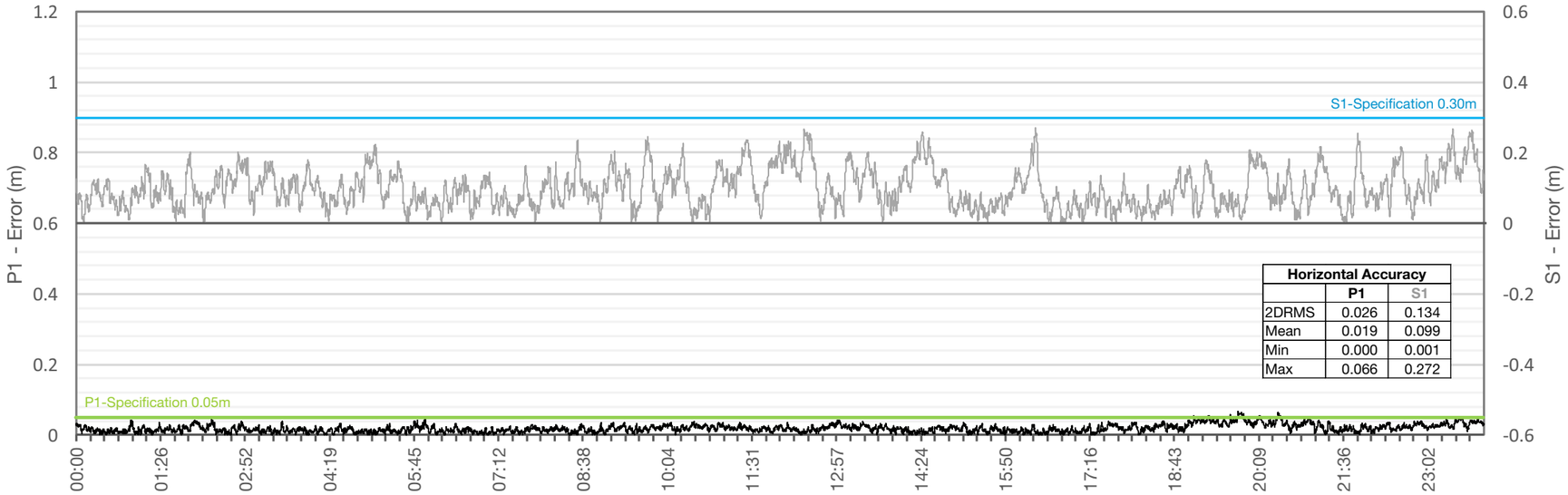
The chart below shows real data from an installation of a typical solution from another provider that provides 0.10m position accuracy with standard-accuracy fall-back solution of 1-3m accuracy. In the case below a source of interference was experienced causing unavailability of the second (L2) GNSS frequency required by high-accuracy solutions. This is a generic issue rather than a specific failure of the system, however the result is that the position provided to the user reverted to the fallback. The effect can be clearly seen and in this case would have a real impact on the operation of say a Dynamic Positioning system. Positioneering’s Service-A1, operating is operating alongside in the same circumstances and whilst the Primary solution was actually unaffected, to demonstrate the benefit of the P/S approach, the Positioneering solution was forced to the S1 solution at the same times as the other system fell back. The target performance of 0.5m was easily achieved and in fact the 2DRMS value was 0.15m. The benefit is clear to see. Introducing a second high-accuracy system to overcome this has limited benefit as at best it will be relying upon the same components that failed and at worst will be relying upon the same positioning technique.



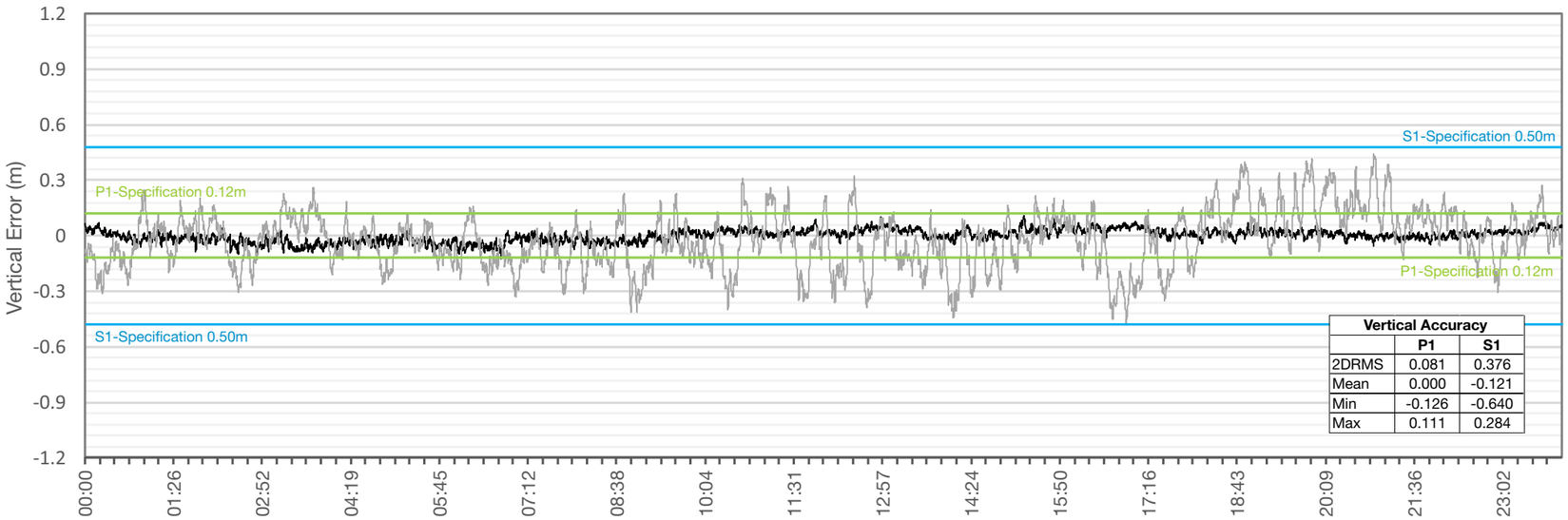
[SERVICE-A1 COVERAGE AND AVAILABILITY]



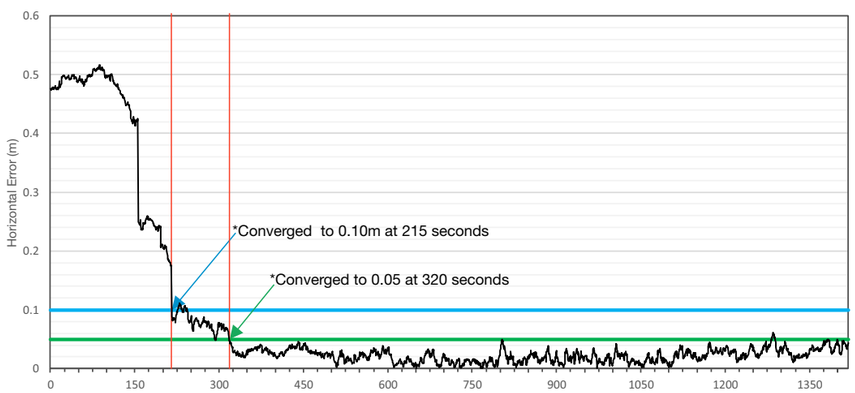
[Horizontal Accuracy]



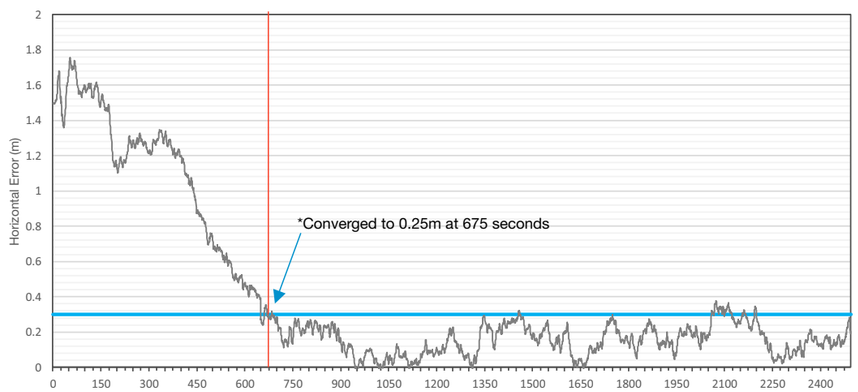
[Vertical Accuracy]



[P1 -Convergence]



[S1 -Convergence]



Service-A1 - Performance

Service Delivery

Signal Acquisition

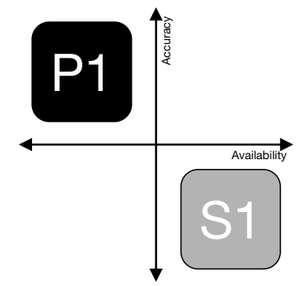
Cold / Warm Start:	< 1 PRBS cycle (99.9%) <10s
Nominal CNo	42dB.Hz.
Nominal Eb.No.	14dB
Bit Error Rate	9 (1 bit in 10^9)
Signal Reserve at extent of coverage footprint	3dB (100%)

Augmentation Data

Position Type:	Type-1 (PPP)
GNSS Constellations:	GPS, GLONASS, COMPASS, GALILEO
Data Type:	SV Orbit and Clock Corrections SV residual ambiguity biases Earth Rotation, DCB and other supporting data
Update rate:	Orbit Corrections: <60 seconds Clock Corrections: 1 second Auxiliary Data <90 seconds

Position Solutions

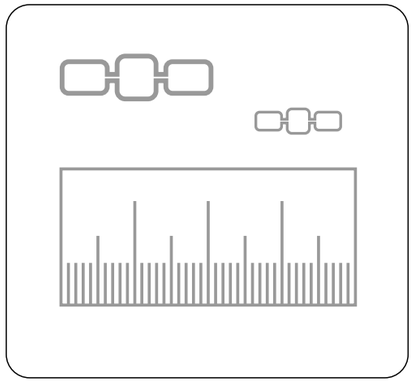
Combination:	Primary-P1 / Secondary-S1
<u>Primary-P1</u>	
Solution:	P1 (Primary Type-1)
Observations:	Multi-Frequency Carrier Phase / Multi-Constellation
Accuracy (95%):	0.05m (Horizontal) 0.12m (Vertical)
Accuracy (6σ /99.9997%)	0.12m
Convergence:	< 5 minutes (GPS and GLO) to reach 0.10m < 10 minutes (GPS and GLO) to reach 0.05m
Position Latency:	<100ms (for typical GNSS constellation)
Quality Control:	Full iterative data snooping to minimum satellite set
<u>Primary-S1</u>	
Solution:	S1 (Secondary Type-1)
Observations:	Single-Frequency Code and Phase Multi-Constellation
Accuracy (95%):	0.25m (Horizontal) 0.50m (Vertical)
Accuracy (6σ /99.9997%)	0.52m
Convergence:	< 10 minutes (GPS and GLO) to reach 0.25m
Position Latency:	<100ms (for typical GNSS constellation)
Quality Control:	Full iterative data-snooping to minimum satellite set



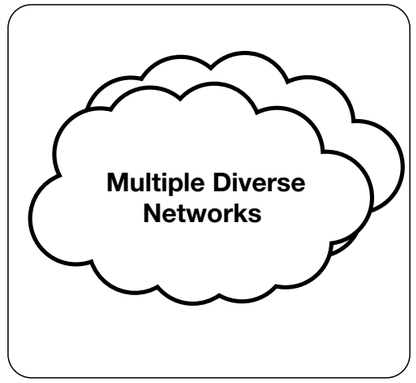
***Convergence**
Is the point in time after switch on when a position solution reaches its specified accuracy and remains there at the specified level of probability. For the 2DRMS accuracy this equates to 95% of subsequent positions being within the stated accuracy. Convergence time will vary according to the number of available satellites, configuration and operating environment. The quoted specified convergence for P1 and S1 solutions is an empirically derived value observed over a large population of samples and wide range of operating locations and environments.

[Data captured at an independent control point over a random 24-hour period (Observation Rate 2Hz) - environment mostly clear with some partial obstructions and reflectors]

[Key System Components and Features]



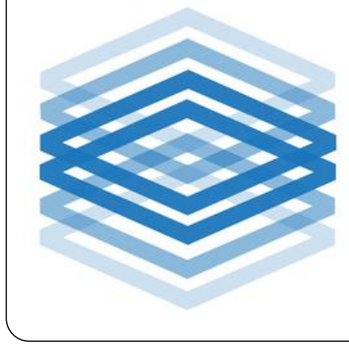
[Multiple Independent GNSS Observation Sources]
[Multiple source networks
Multiple processing locations
Multiple processes]



[DTN - Data Transport Network]
[Multiple core fully managed networks
Secure with no Internet usage on primary
Seamless low-latency connectivity
Total remote access to all sites, devices and software
Network monitored and managed 24/7 by dedicated network engineers]

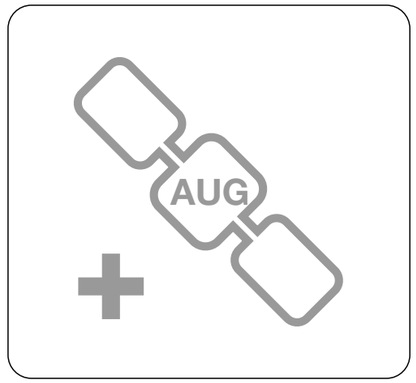
[Multiple Diverse Data Processing Sites]
[System is fully distributed and is not dependent upon any single site or component
Seamless and secure remote access to all hardware, software and services
Multiple data centre providers to further enhance diversity]

[DPS - Generation of Service Data Products]
[System process, routing and distribution software
Distributed architecture - multiple hardware, processes, connections
X^{n} Resilience with transparent fail-over and self healing
Optimum implementation of network communications technologies => Reliable and resilient]

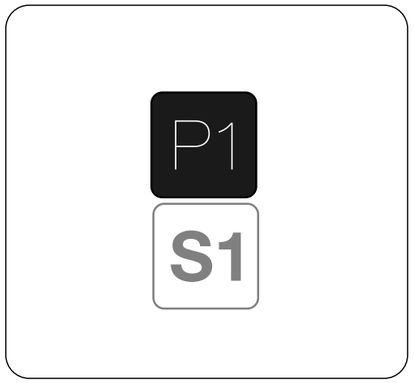


[Common Hardware Solution]
[All system hardware standard, solid-state, maintenance free
All hardware is installed to 400% redundancy at every site
All DTN hardware is fully redundant latest Cisco equipment supported directly by Cisco with 4-hour global replacement policy => Unsurpassed system resilience, monitoring and support]

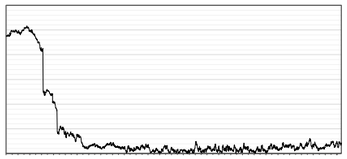
[Into Orbit]
[To ensure maximum reliability and resilience multiple diverse satellite uplink sites are used
Each site has multiple paths of data and signal with intelligent monitoring and automatic changeover to ensure seamless operation]



[Multiple Satellites]
[Multiple Providers
Diverse Signalling]



[The Right Position]
[Multiple resilient solutions
Different observation combinations
Diverse algorithms and dependencies]



[Maximising Availability]
[Any interruption to positioning can be very expensive in lost availability. Positioneering's position solutions offer significant steps forward in reducing initialisation [convergence] periods substantially to just a few minutes]

[Staying in Touch]
[Global remote access to positioning hardware via proprietary point-to-point satellite link - Service Management Channel allowing
remote control, diagnostics, monitoring, tracking etc..
Online and in Person 24/7 support]

For further information contact us at:

info@positioneering.com

www.positioneering.com

Tel: +44 (0)1224 946546

Positioneering Limited
53 Abbotswell Road
Aberdeen
AB12 3AD
United Kingdom
+44 1224 946546

GNSS PRECISE POSITION SOLUTIONS AND AUGMENTATION SERVICES

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