EXECUTIVE SUMMARY

…….

…….

To answer to these questions, we will first review time transfer potential appli… call some basic technologies and describe some new developments (Protocol, HW, SW … me issue in time transfer: security, availability, cybercriminal resistant , resilien…

On technology side, We then identify and review pro & cons of these alte… compared to the well-established GNSS based solutions, which are still … despite its inherent and proven vulnerabilities and drawback. We will … based solutions to protocol-based fiber-based time transfer, NTP, PTP, WR… 88HA), because of the huge deployment of IP-based communication, of th… iber deployment in all and any systems, and because of the PTP activit… ivities. We will consider the impact of fiber and network configuration on t… performances. We will also introduce alternative time dissemination technolo… al dissemination LEO / RF (DCF 77 operated by PTB in Germany, WWVB opera… eLORAN (still active in some countries, S Korea, China, down by other co… on-protocol fiber based technologies (AM modulation, SDH/SONET header… ot widely deployed but technology proven, ground repeaters network , assi…

We will first describe tools and best practices in GNSS… , at code level (using OS NMA recently introduced,…,) a signal level , using a… n (beam forming, rotating, dual) antennas, and receiver protection (RAIM/T-P… k based solution (Egnos, ground references, spoofing detection software, … ce the adon technologies potential.

On market and user side, We will consider s… apacity growth demand supporting this analysis : digital traffic grow… yment and data storage, Fintech, Smart grid and Energy, time stamping …. … o growing up, driven by Fintech, telecom or Data Center synchronization … ns level, as provided by NTP, down to ***microsecond or sub-microsecond***

We consider the rapid growth of tel… , traffic gaining significant increase every year, and the introduction of wirel… ibute to the increase of transport capacity. The obsolescence of SDH equipm… ecom operators to consider network element replacement; either by similar … ough a migration to full optical OTN network. The Telecom market will be p… g based on this transport capacity expansion demand and based on the o… icant part of the installed base.

And finally, the accurate a… ested by many applications all over networks, and the deployment of remo… d, cloud computing), IaaS, *Infrastructure as a Service*, pave the way towards … oncept, which will be discussed and quantified

Main list of Industri… ne stamping, or accurate time or traceable time availability to be discussed ar…

- Fint…
- Te… s)
- D… d computing
- … tribution,
- … ed data flow,
- … re timing,
- … portation (GNSS back up or stand alone synchronization solution)

- timing in encryption
- time stamping (documents, paper free,…)
- potential new application (autonomous cars, synchroniz

A critical technical issue is the security. One of the driving forces ment of fiber-based time transfer is the acknowledged vulnerability of GNSS at mean that any and all fiber-based solution will have to be, by far, more s esistant, natural incident resistant,) than GNSS-based solutions. IP world is a d" and the generic IP security along with specific PTP/WR security issues will ***security*** is the next major "MUST" within all these deployments. As any IP b and WR are sensitive to classical IP attack , such as Packet Injection, d are sensitive to any "fake or generated" delay in the time of flight betwee all boxes carrying or transmitting time signals must be protected from a

We will conclude by a review of new applications rket deployment towards new industrial and commercial accurate time di troduce new potential activities on top of the classical area of time tr described above, such as :

- introducing time stamping of ra

- introducing the concept of "T e, aiming to disseminate time signals, traceable to a given referer d addressing time provision from local (synchronized) Data Cent , time stamp, telecom, fintech, …) . Data Center need to be synch r operation, and such synchronized Data Center might be the b ally traceable and accurate time.

Chapter A provides some basic introduce fiber-based time transfer as a main alternative to GNSS,

Chapter B provides some b WR technologies, compared to other fiber based proposed technologies (A roduce some hints of telecom network evolution, migrating SDH towards work done in Europe pointing out the need for GNSS independent timing te

In chapter C we des pplications , domains and market, requiring, or expected to require, timing, ns of each individual sectors, in ***terms of accuracy, availability, trac***, fintech Data Center, Energy, usually mentioned when dealing with ti s, but also approaching new market evolutions such as legal time stamp (t documents - patents, …-, time in encryption and security, time stamp of ra ork and introducing the concept of "Time as a Service", following the trend t e "service" tools and technologies, similar to colocation Data center, .. ys to allow us the size of these various potential markets (and their time fr

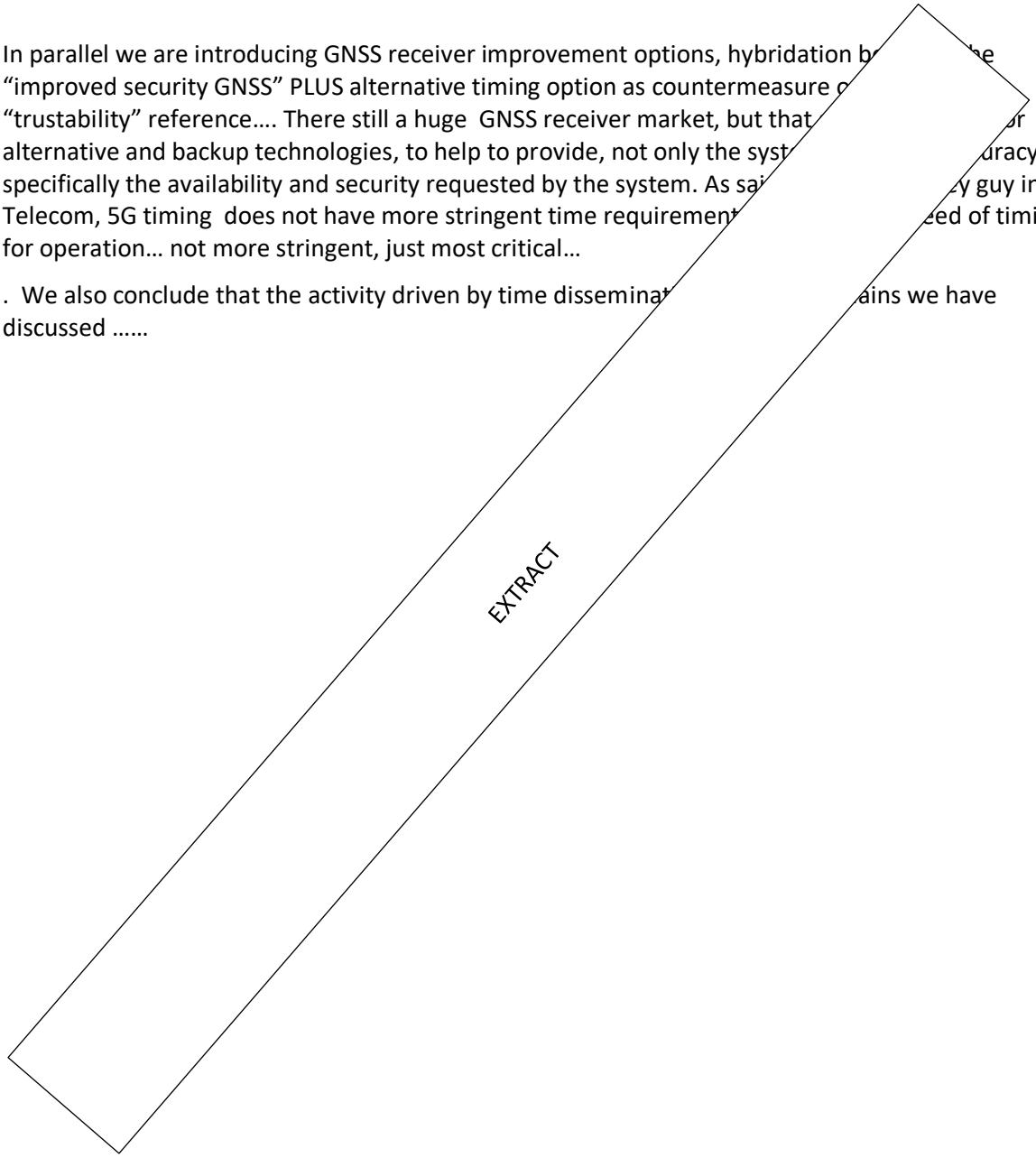
In ch ures of our estimation and simulation of the size of potential activity offe ndividual markets.

I l emphasis the fact that fiber-based timing technology is "everywhere", and m ns discussed here may relay on IP based protocols, NTP (and secure NTS) , IEEE 1588 P over traffic network or over dedicated channels, and we observe also that, due to the integra of the White Rabbit technology in the IEEE standard (as HA High Accuracy profile) our recommendation on technology targets PTP, under all standardized profile, telecom, energy, security, High accuracy,….

EXTRACT

In parallel we are introducing GNSS receiver improvement options, hybridation b… …e “improved security GNSS” PLUS alternative timing option as countermeasure o… “trustability” reference…. There still a huge GNSS receiver market, but that … …r alternative and backup technologies, to help to provide, not only the syst… …uracy, but specifically the availability and security requested by the system. As sai… …y guy in Telecom, 5G timing does not have more stringent time requirement… …eed of timing for operation… not more stringent, just most critical…

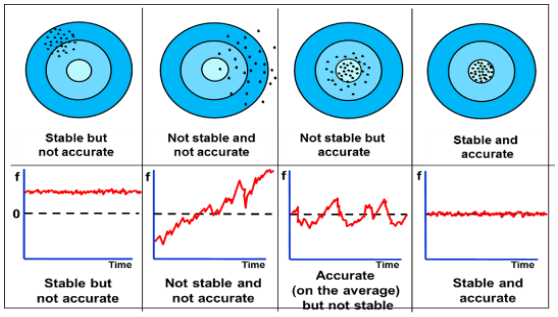
. We also conclude that the activity driven by time disseminat… …ains we have discussed ……



GLOSSARY

BIPM Bureau International de l'Heure, collecting data from NMI, performing data treatment and providing UTC time (paper time scale)
DER Distributed Energy Resource
DTP Data Center Time Procotol
GNSS Global Navigation Satellite System (includes GPS, Galileo, Glonass, Beidou,…)
IEEEE Institute of Electrical and Electronics Engineer, providing set of norms
ITU International Telecom Union, a UN agency dedicated to telecom, providing telecom norms
MiM Man in the Middle
NTP: network time protocol RFC
OTN Optical Transport Network (read *full* optical), next generation transport Network, full optical
PI packet injector
PTP : Precision time protocol, IEEE 1588
PMU Phasor Measurement Unit : performing voltage and phase measurement of electric signal
RAIM / T.RAIM : Receiver autonomous Integrity Monitoring
SDH Synchronous Digital Hierarchy, the telecom transport technology since 90's in Europe, South & Latin Americas, Africa, SEA, Asia (but Japan), Russia,..
SONET Synchronous Optical Network
TOR Top of Rack
UTC Universal Time Coordinated: it is a "paper time scale" defined by BIPM from a set of 100's of atomic clocks disseminated around the world
UTC(k) UTC local physical representation by a physical clock of lab (k)
WR : White Rabbit: synchronization protocol developed by CERN, based on PTP 1588,

Some words must in T&F metrology should be accurately defined: See VIM, International vocabulary of metrology, BIPM JCGM 200.2012
Accuracy, stability: described in the graph below, are the proper words to use in time and frequency
Precision is not commonly used in T&F. Include generally ideas of accuracy + noise



Traceability : process able to demonstrate, after use, that the time used in a time stamping or synchronization process was the proper one at time of use (non refutation)

TABLE DES MATIERES

List of figures

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