# eLoran: Reliable timing at the edge?

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# Contents

- Background & Motivation
- eLoran Overview
- Potential Performance
- Reliable Timing at the Edge

# Background & Motivation


Source: www.marvel.com

# Increasing reliance on GPS: a “flawed hero”

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- Global Public Service
  - Revolutionised positioning, navigation and timing
  - Performance has improved significantly
  - Our relationship with GPS is changing (enabler to enforcer)
- Known GPS vulnerabilities
  - System, signal and user
- GPS “flaws” have been a catalyst for innovation
  - Service (system, signal and user equipment)
  - Third party service providers (public and private sector)
  - Integration with other systems and sensors
  - Galileo

# GPS is vulnerable at system, signal and user levels

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| | Vulnerability Examples | Possible Mitigation |
|---|---|---|
| System | **Satellite clock failures** (e.g. SVN23, 1 Jan 2004) | **Second system or augmentation** (e.g. Galileo, eLoran, SBAS) |
| | **Poor signal quality** (e.g. evil waveforms) | **Second system or augmentation** (e.g. Galileo, eLoran, SBAS) |
| | **Design flaws** (e.g. Block IIR ranging code interruptions) | **Second system or augmentation** (e.g. Galileo, eLoran, SBAS) |
| Signal | **Intentional interference** (e.g. potential terrorism) | **Second dissimilar system** (e.g. eLoran) |
| | **Unintentional interference** (e.g. Moss Landing) | **Second system, other GNSS frequencies** (e.g. e-Loran, L2C, L5) |
| | **Ionospheric effects** (e.g. scintillation at high latitudes or equator) | **Second dissimilar system** (e.g. e-Loran) |
| User | **Equipment malfunction** (e.g. Royal Majesty, 1995) | **Second dissimilar system (e.g. eLoran)** |
| | **Signal occultation** (e.g. Urban canyons) | **More SVs &/or second dissimilar system** (e.g.Galileo, SBAS, eLoran) |
| | **Local Interference** (e.g. Manatoulin TV set) | **Improved siting &/or second dissimilar system** |

# Finding GPS (GNSS) jammers is difficult and time consuming

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- San Diego, 2006
  - US Navy jams GPS for two hours
  - Outage reported within 30 min
  - Three days needed to pinpoint the jamming source
- Moss Landing
  - Three weeks to identify the faulty television aerial as a result of door-to-door enquiries
- Trinity House Vessel “Alert”
  - Two days to isolate a faulty antenna cable that caused local jamming


Source: Trinity House

# The UK/General Lighthouse Authorities' requirement

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- Independent, dissimilar, multi-modal, complement to GPS for civil applications available during long-term GPS service outages over wide areas
  - Independent of GPS
  - Dissimilar in terms of failure mechanisms
  - Multi-modal to share costs and benefits
  - Complementary performance (positioning, navigation and timing)

# eLoran is the only option

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| Service | PNT | Multi-Modal | Independent wrt GPS | | |
|---|---|---|---|---|---|
| | | | System | Signal | User |
| Galileo | ✓ | ✓ | ✓ | × | × |
| eLoran | ✓ | ✓ | ✓ | ✓ | ✓ |
| DGPS | × | ✓ | × | ✓ | × |
| SBAS | × ✓ | ✓ | × ✓ | × | × |
| Radar | × | × | ✓ | ✓ | ✓ |

**“The ultimate compliment to GPS is that it is taken for granted … a contingency augmentation, like eLoran, is essential and would act as a deterrent to terrorism”**

Source: Prof Brad Parkinson, US National Space Based PNT Executive Board minutes, 29-30 March 2007

# eLoran Overview


Source: Reelektronika, The Netherlands

# What is eLoran?

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- Enhanced Loran is an internationally-standardized positioning, navigation, and timing (PNT) service for use by many modes of transport and in other applications
- eLoran meets the accuracy, availability, integrity, and continuity performance requirements for aviation non-precision instrument approaches, maritime harbour entrance and approach, land-mobile vehicle navigation, and location-based services, and is a precise source of time and frequency for, say, telecommunications
- eLoran is an independent, dissimilar, complement to Global Navigation Satellite Systems (GNSS). It allows GNSS users to retain the safety, security, and economic benefits of GNSS, even when their satellite services are disrupted

Source: International Loran Association. *eLoran Definition Document*. v1.0, 2007

# System characteristics

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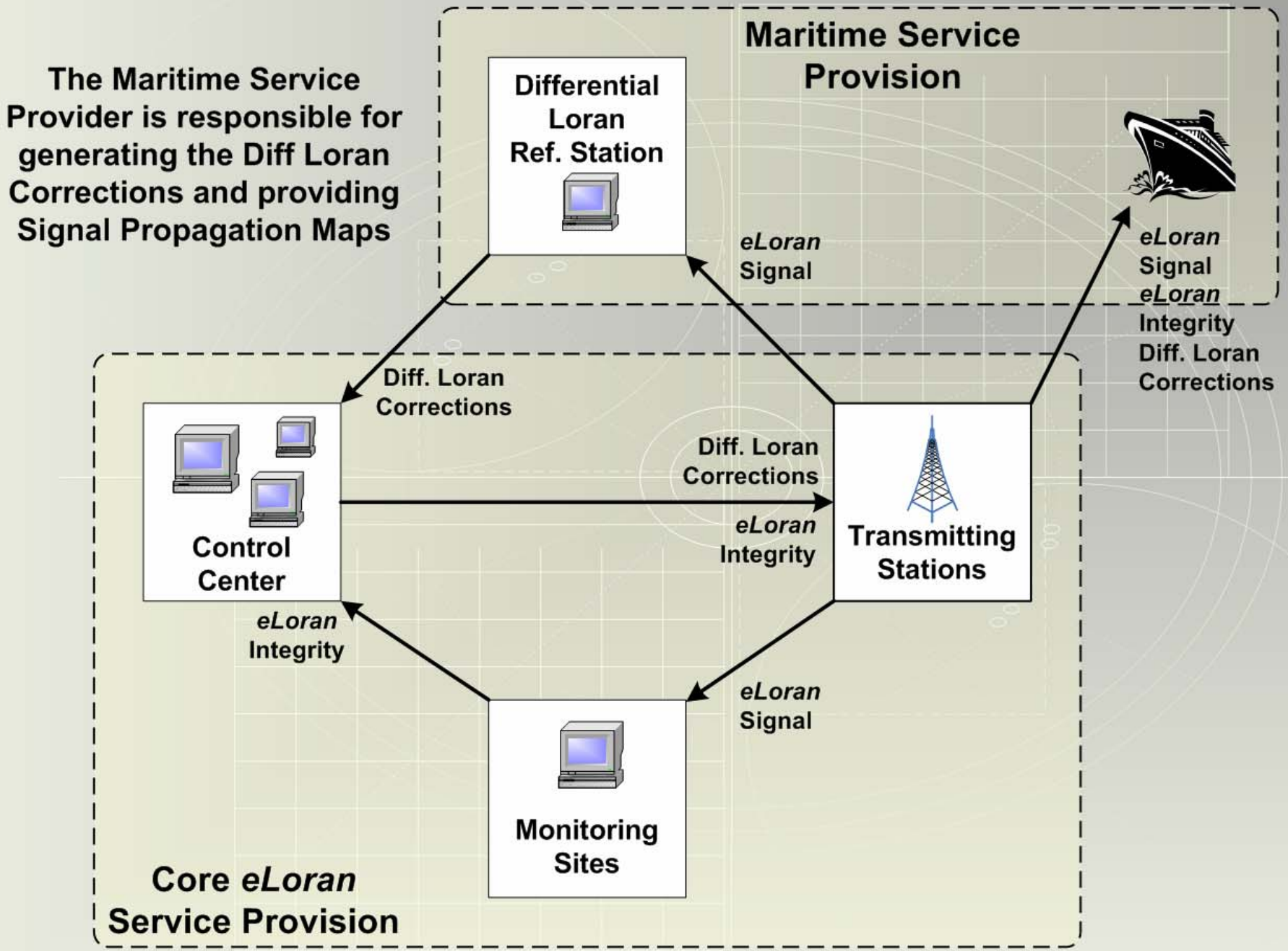
- High-power
  - Rock concert vs light-bulb
- Low frequency
  - LW audible radio (0.1MHz) compared with GPS at 1500MHz
- Pseudo-ranges that are interoperable with GPS
  - Works indoors, under canopies
- Broadcast useful information on a data channel
  - Co-ordinated Universal Time (more accurate than current LF timing services)
  - Differential Loran corrections (enhanced accuracy and integrity)
- Service model
  - Core service with application service providers




Source: International Loran Association. *eLoran Definition Document*. v1.0, 2007

# A global perspective

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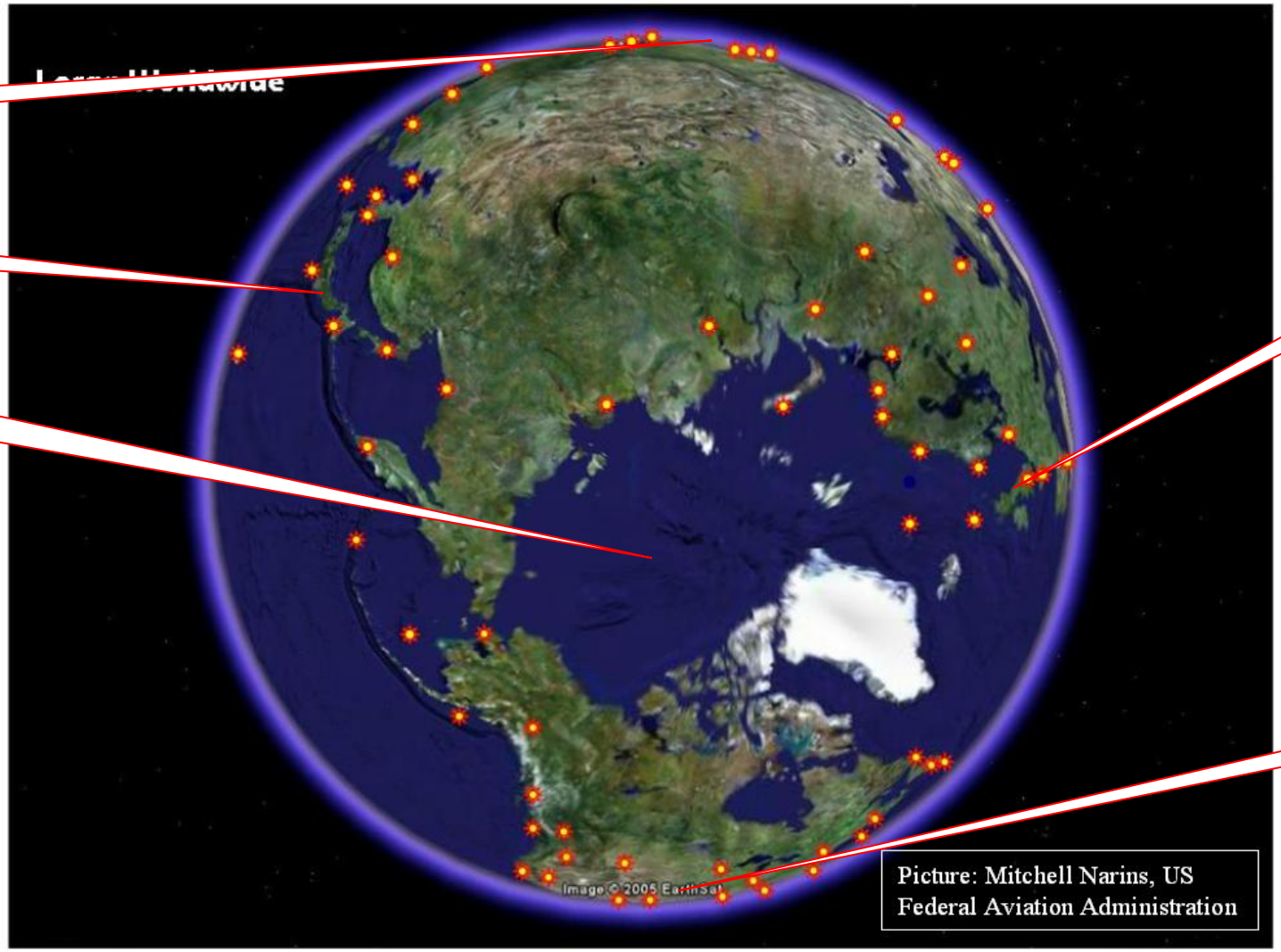

# The new UK station

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- Press Release, 30 May 2007
  - “Today, the General Lighthouse Authorities of the United Kingdom and Ireland announce the award of a prestigious fifteen-year contract to VT Communications (part of VT Group plc) for the provision of a state-of-the-art enhanced Loran (eLoran) radionavigation service to improve the safety of mariners in the UK and Ireland”
- Progress
  - 7 July 2007 – transmitter moved from Rugby
  - 1 October 2007 – first signals from Anthorn for test and verification
  - 1 December 2007 – trial signals operational
- Next Steps
  - UTC eLoran signal from Anthorn

# Site Pictures

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Source: VT Communications

# The containerised transmitter and connection to the T-antenna

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Source: VT Communications

# Potential Performance

# Telecommunication timing trials, 2006 - Proof of concept

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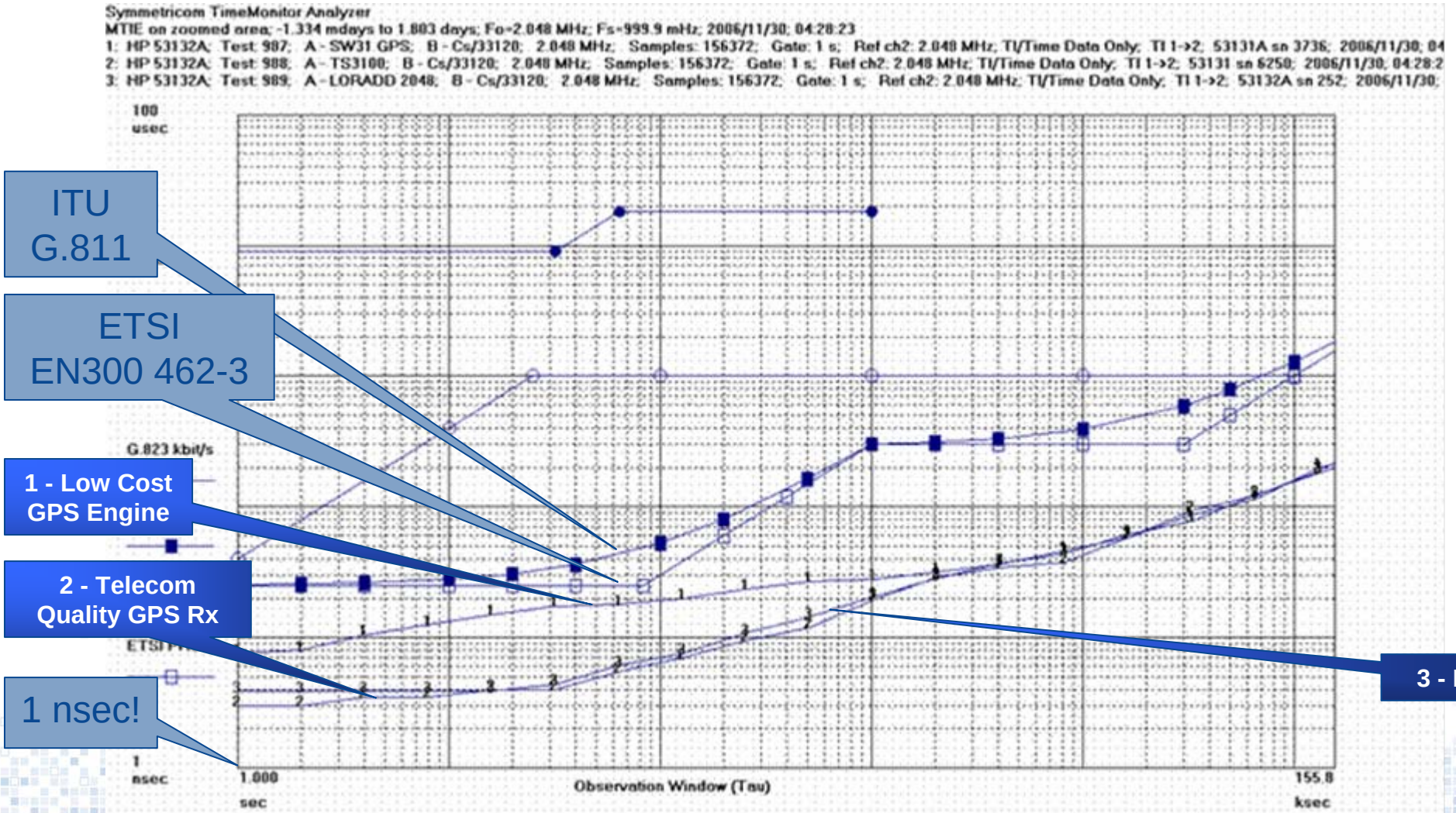


ITU G.811

ETSI EN300 462-3

1 - Low Cost GPS Engine

2 - Telecom Quality GPS Rx

3 - Loran

1 nsec!

# Timing trial results
# - Proof of concept

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- eLoran meets the telecommunications requirements for:
  - Input to Synchronisation Supply Unit
  - Inclusion in a Primary Reference Clock
  - A low-cost timing source where ever GPS is currently employed in network
- Critically, the antenna may be mounted indoors – even ‘buried’ indoors!

# Reliable Timing at the Edge

# Next generation networks need reliable timing at the edge

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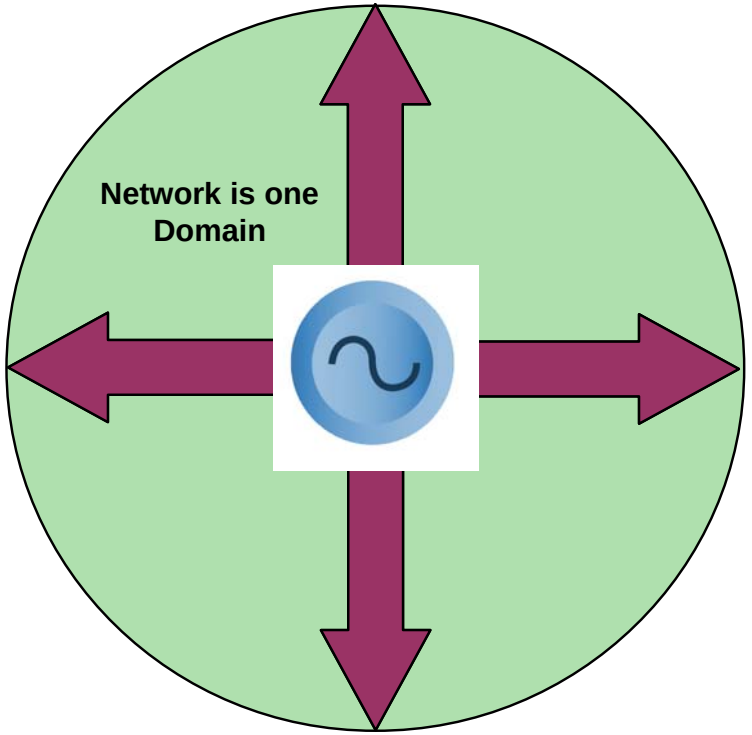
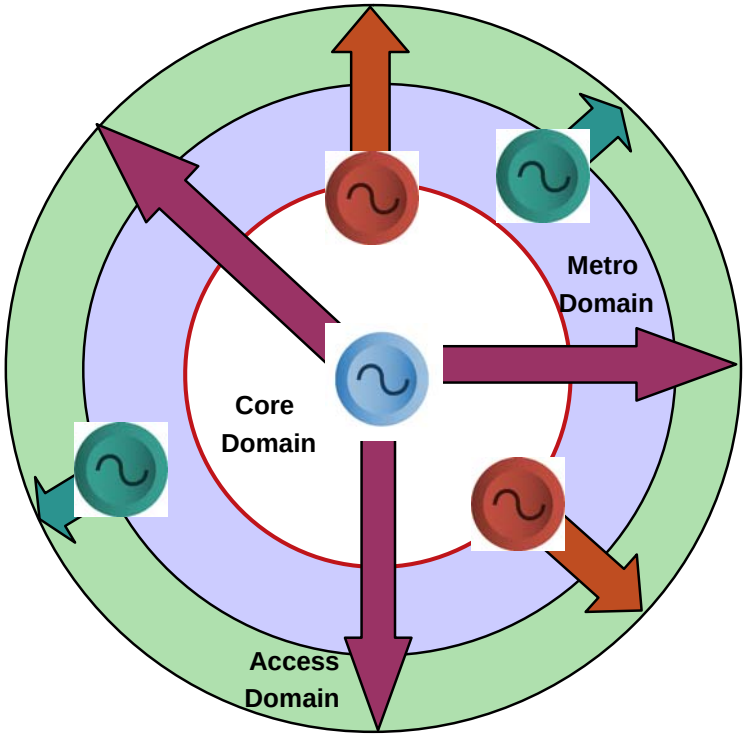
**END TO END UNIFIED MODEL IS REPLACED BY DOMAIN SPECIFIC MODEL**




**CLASSICAL SYNC MODEL:**
**DISTRIBUTION FROM CENTRAL SOURCE**
**INTEGRATED IN PHYSICAL INFRASTRUCTURE**




**NEW SYNC MODEL:**
**DIVERSE TECHNOLOGIES**
**MANY DIFFERENT CLOCKS**
**DIFFERENT PLACES IN NETWORK,**
**OVERLAYS TRADITIONAL MODEL**
**ADDS COMPLEXITY**

Source: Mike Gilson and BT

# Imagine … indoor availability

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- Imagine … all those lonely planners and facilities managers
  - No need for antennas on roofs
- Imagine … all those happy finance directors and project managers
  - Reduced capital and operational costs
- Imagine … all that time for real engineering
  - Reducing the time needed to deal with complex interference issues

Source: BT

# Independent, authenticated timing

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- Imagine … a level playing field
  - An new technology available to all
  - Time when and where you want it
  - Independent of backhaul partner and technology
  - No need for timing traceability through the network
- Imagine … bringing UTC traceability into a metal cabinet at the edge of the network
  - Protected from prying eyes and busy hands!
- Imagine …authenticated timing
  - A firm foundation for the future

# Now is the time for wanton experimentation

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- eLoran – the Cuckoo in the nest?
  - Out go traditional methods
  - Out go complex protocol methods
- Further proof of concept trials at typical telecom deployment locations
  - Large telephone exchange
  - Local exchange
  - Cabinet
- Understand fully the availability, integrity and continuity issues
  - Transient phenomena seen


When you want to know more:

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