

A Resilient National Timing Architecture

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Session on: Strengthening Resilience and Integrity in Timing

Outline

- Summary
- Considerations
- Proposed Architecture
- Conclusions

Summary: Why, What and How?

- Civilization is at risk due to over-dependance on GNSS
- There are inexpensive technologies available for alternate PNT
 - Layers of technology can provide assured PNT
 - Time is fundamental to PNT
 - Different technologies can have orthogonal vulnerabilities and strengths
- A phased approach could make it a reality quickly
 - Minimal cost investments in each phase
 - Learn from challenges and improve before large investments
 - Each phase uses readily available technologies
- US example, generalizes to other nations

We tend to not fix problems until there is a disaster!

We knew for years a malodorant should be added to natural gas so leaks could be detected early, but it wasn't done until after an explosion killed 295 school children and teachers in New London, Texas. 1937



The United States and Europe have done little to reinforce our positioning, navigation, and timing architecture to help mitigate the consequences of a systemic failure, the results of which could make the pandemic look like a mere warmup act.



Considerations

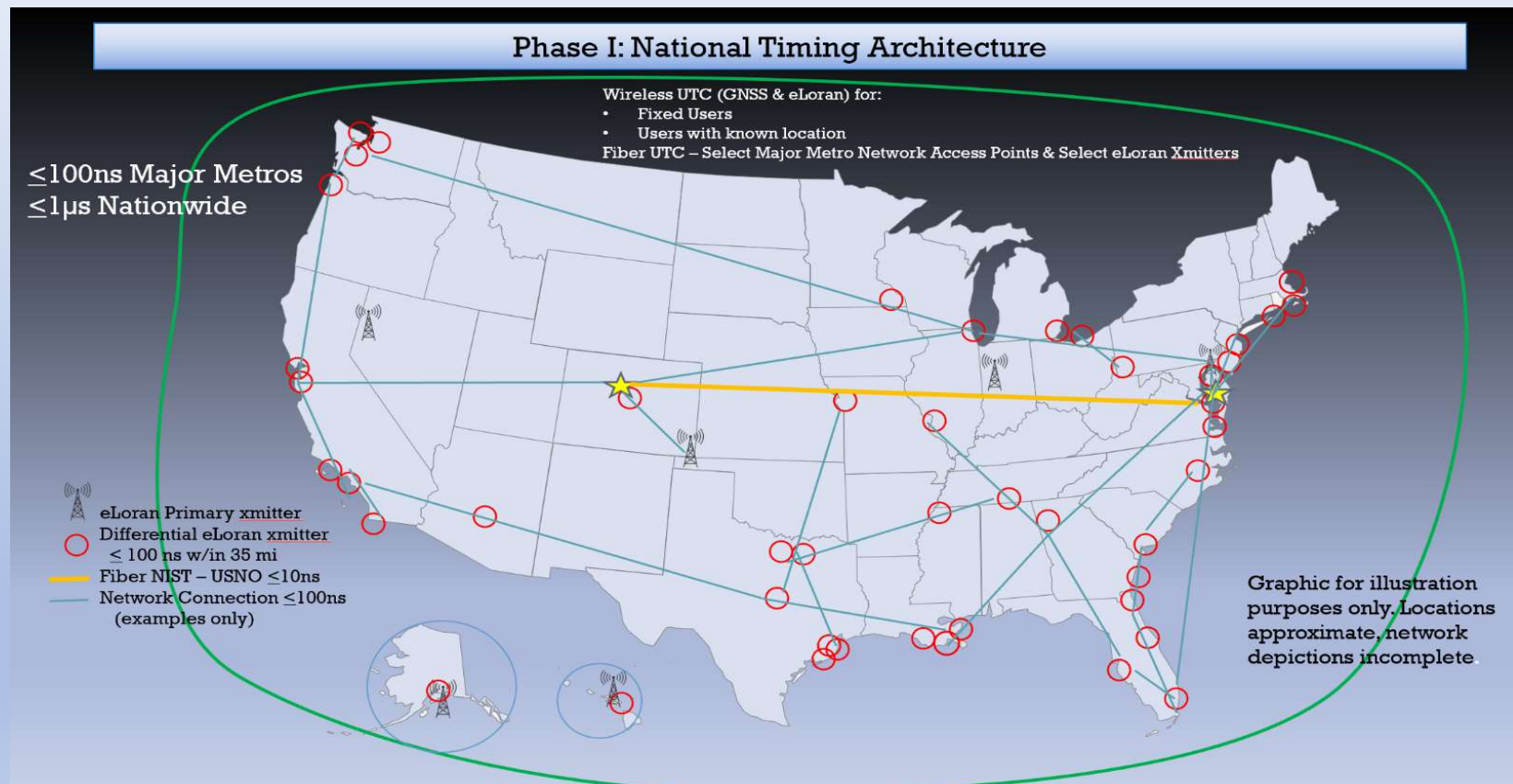
- Time resilience across land, air and coastal areas
 - Trusted and Assured Time via redundancy and diversity
 - Failure modes orthogonal to GNSS
 - Timing is core to PNT: achieve 500 ns with 100 ns in cities against UTC
- Meet Major User Requirements
 - 5G, autonomous (land, air and sea) vehicles, electric grid, financial services
- Technologies (among others)
 - GNSS, fiber networks, LEO PNT, eLORAN, Clocks, Time network management
- Public-Private Policy
 - Partnerships, Government stimulates adoption

Proposed Architecture

- Structure and Implementation
 - Implement by increments
 - Higher demand and ROI in urban centers
- Technologies
 - GNSS, eLORAN, fiber, clocks, Network Access Points (NAPs)
 - Diverse, mature, can lead to other options
- Network Control and Performance
 - Management is key to success
- Notional Phases – see next slides

Phase I National Timing Architecture							
	<i>Global Layer</i>		<i>Continental Layer</i>		<i>Local Layer</i>		
	GNSS 78ns	LEO PNT	eLoran ≤1 μs 6 sites	N. Clock Ntwk ≤100 ns	Df eLoran ≤100 ns	NAP ≤100 ns	User Clocks
<i>Fixed Users w/ntwk access</i>							
Across land, air, coastal waters							
Major Metro					Selected	Selected	
<i>Fixed Users w/ <u>No</u> ntwk access</i>							
Across land, air, coastal waters							
Major metro					Selected		
<i>Mobile Users</i>							
Across land, air, coastal waters			*				
Major Metro			*		*Selected		
Govt sponsored/PPP, No/low barrier to entry				Available, commercial, fee based			

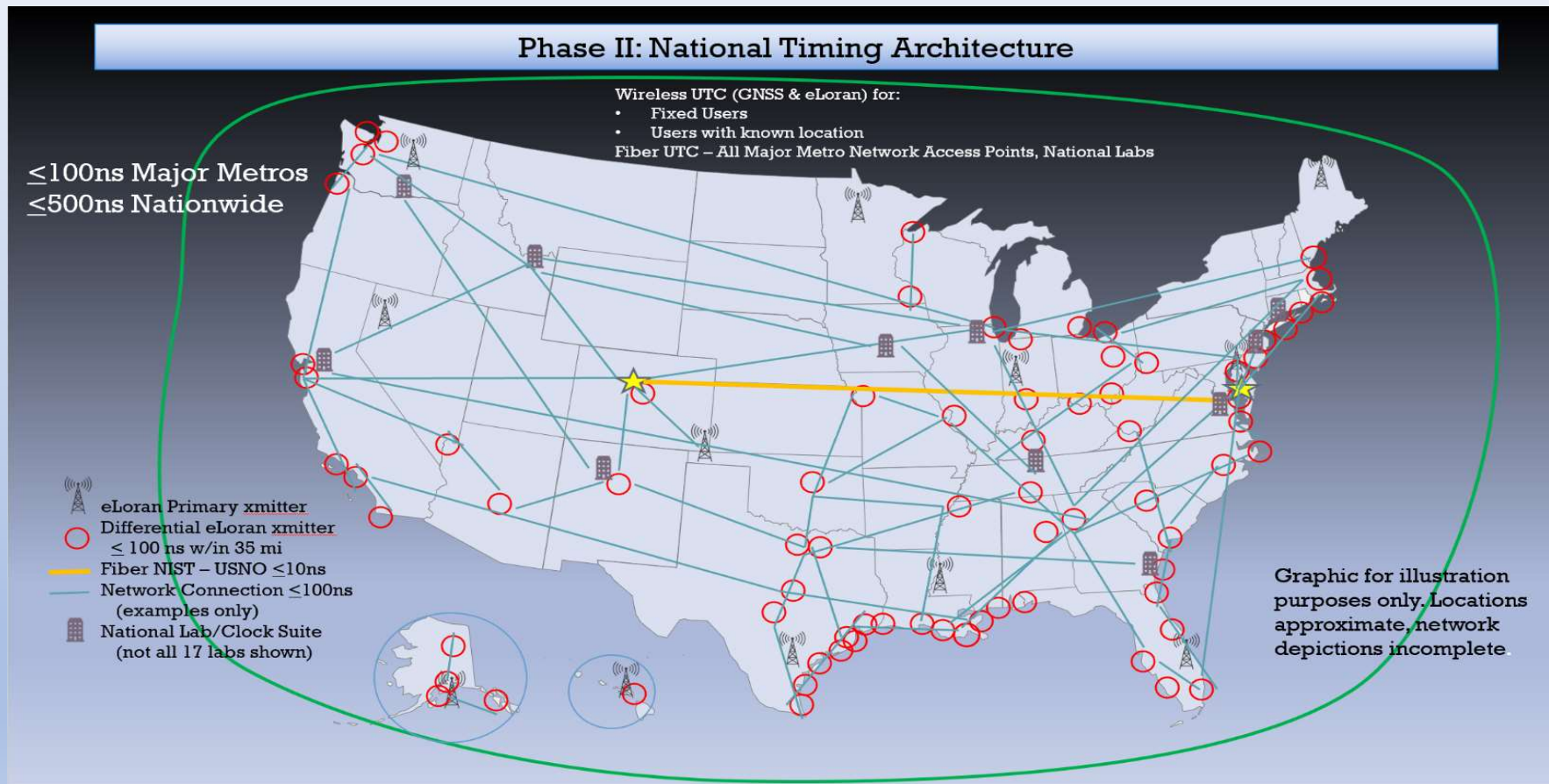
Phases: US Example



Phase II National Timing Architecture

Phase II National Timing Architecture							
	<i>Global Layer</i>		<i>Continental Layer</i>		<i>Local Layer</i>		
	GNSS 78ns	LEO PNT	eLoran ≤500 ns 12 sites	N. Clock Ntwk ≤100 ns	Df eLoran ≤100 ns 75 sites	NAP ≤100 ns	User Clocks
<i>Fixed Users w/ntwk access</i>							
Across land, air, coastal waters	Green	Yellow	Green	Green	White	Yellow	Yellow
Major Metro	Green	Yellow	Green	Green	Green	Green	Yellow
<i>Fixed Users w/ <u>No</u> ntwk access</i>							
Across land, air, coastal waters	Green	Yellow	Green	Blue	Blue	Blue	Yellow
Major metro	Green	Yellow	Green	White	Green	Green	Yellow
<i>Mobile Users</i>							
Across land, air, coastal waters	Green	Yellow	*	White	White	Blue	Yellow
Major Metro	Green	Yellow	*	White	*	*	Yellow
Govt sponsored/PPP, No/low barrier to entry				Available, commercial, fee based			

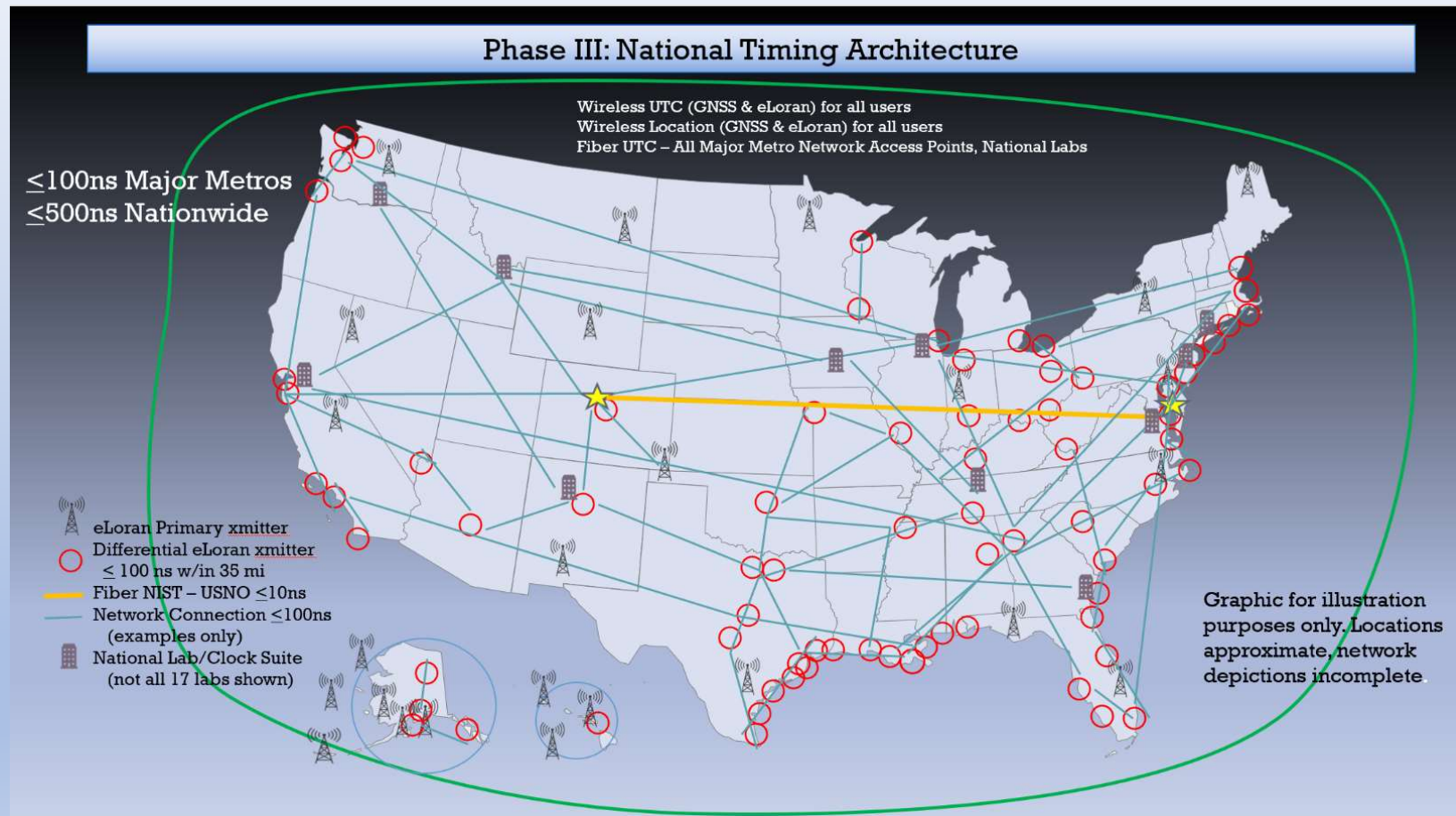
Phases: US Example



Phase III National Timing Architecture

Phase III National Timing Architecture							
	<i>Global Layer</i>		<i>Continental Layer</i>		<i>Local Layer</i>		
	GNSS 78ns	LEO PNT	eLoran ≤500 ns ≈25 sites	N. Clock Ntwk ≤100ns	Df eLoran ≤100 ns 75 sites	NAP ≤100 ns	User Clocks
<i>Fixed Users w/ntwk access</i>							
Across land, air, coastal waters	Green	Yellow	Green	Green	White	Yellow	Yellow
Major Metro	Green	Yellow	Green	Green	Green	Green	Yellow
<i>Fixed Users w/ <u>No</u> ntwk access</i>							
Across land, air, coastal waters	Green	Yellow	Green	Blue	Blue	Blue	Yellow
Major metro	Green	Yellow	Green	White	Green	Green	Yellow
<i>Mobile Users</i>							
Across land, air, coastal waters	Green	Yellow	Green	White	White	Blue	Yellow
Major Metro	Green	Yellow	Green	White	Green	White	Yellow
Govt sponsored/PPP, No/low barrier to entry				Available, commercial, fee based			

Phases: US Example



Conclusions

- Civilization is at risk due to over-dependance on GNSS
- Time is fundamental to PNT
- GNSS, eLORAN and Time over fiber networks are inexpensive technologies available now for alternate PNT
 - Other technologies are also possible (local broadcast, other LF, ...)
 - Redundancy and diversity can create Assured PNT
- A phased approach could make it a reality quickly
 - Ensure success at each step
 - Include management functions

Thank you for your attention!