Dependable Timing in Power Systems

WSTS

March 26th, 2019 – San Jose, CA

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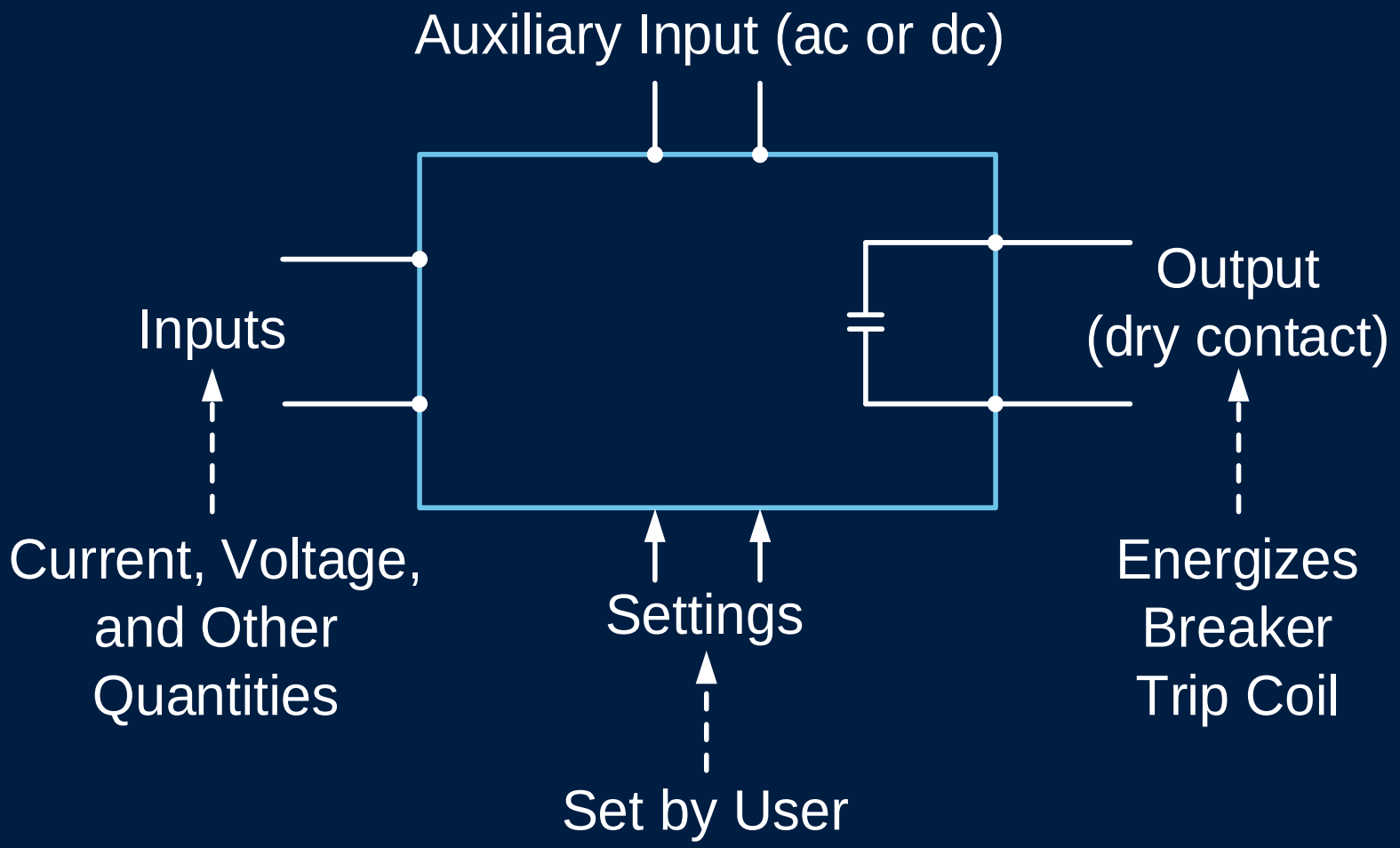
Agenda

- Power system applications and timing requirements
- Overview of present challenges and vulnerabilities
- Characteristics of dependable clocks
- Dependable time distribution systems to mitigate GNSS vulnerabilities

Protective Relays Basics



Protective Relays Can Function Without Precise Time

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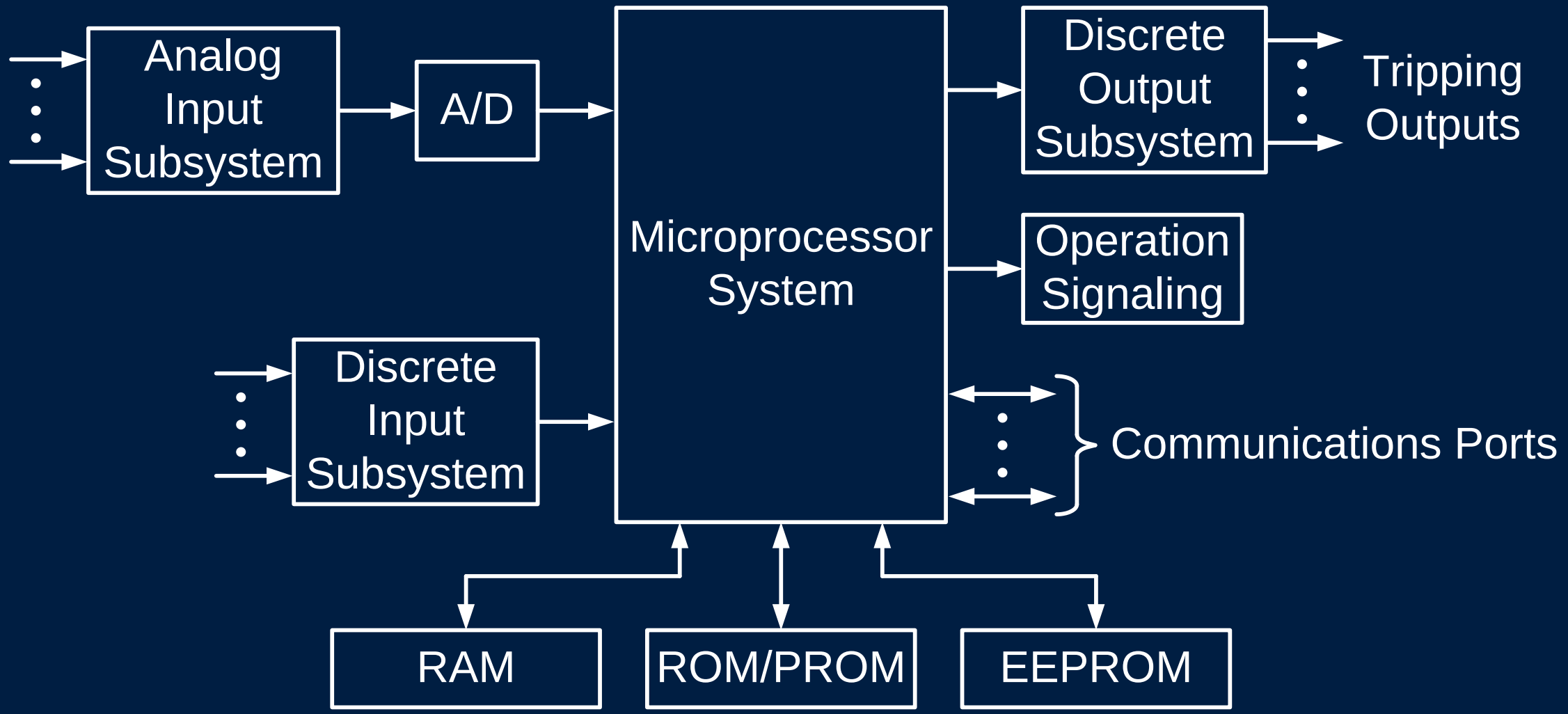
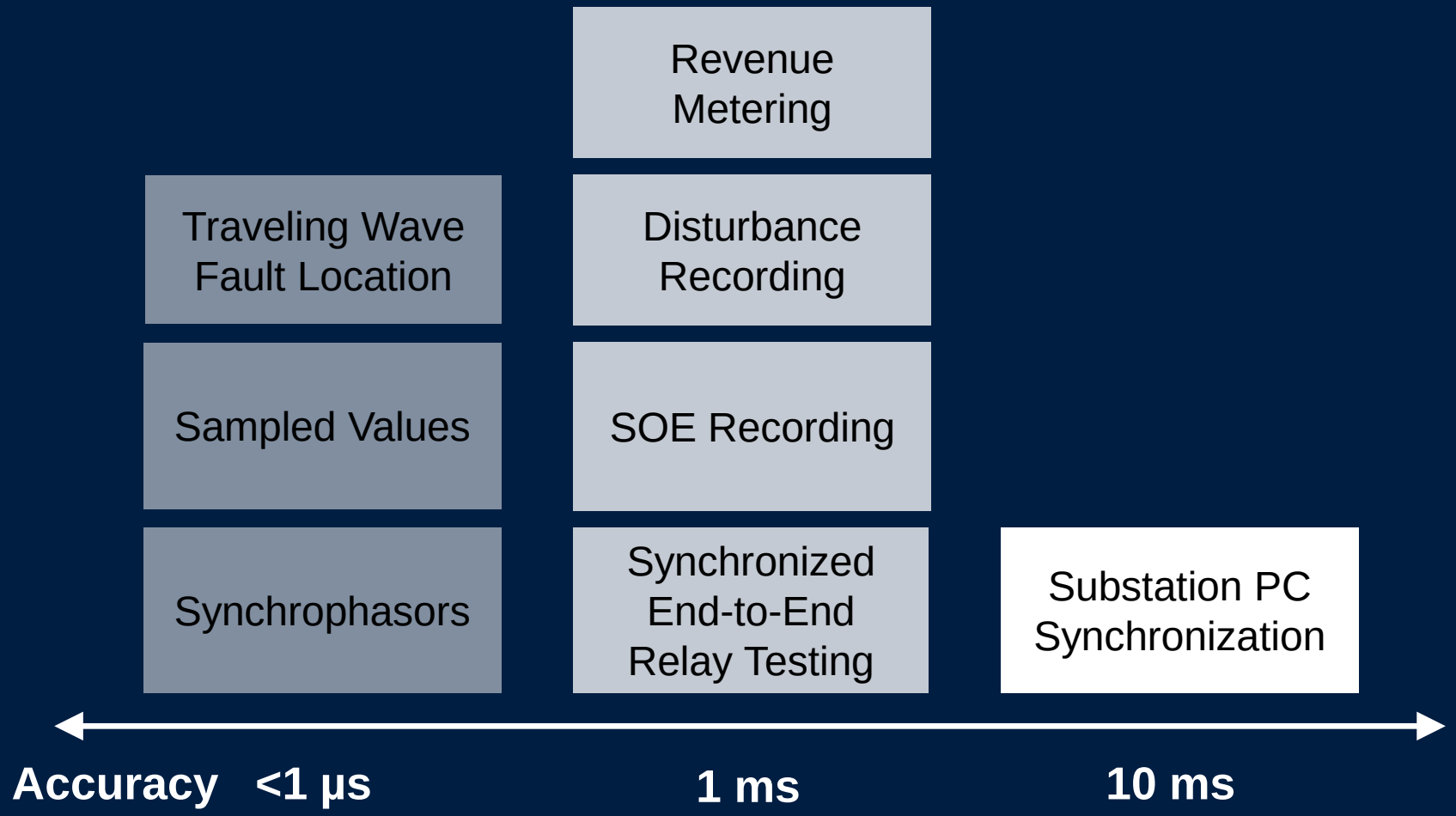
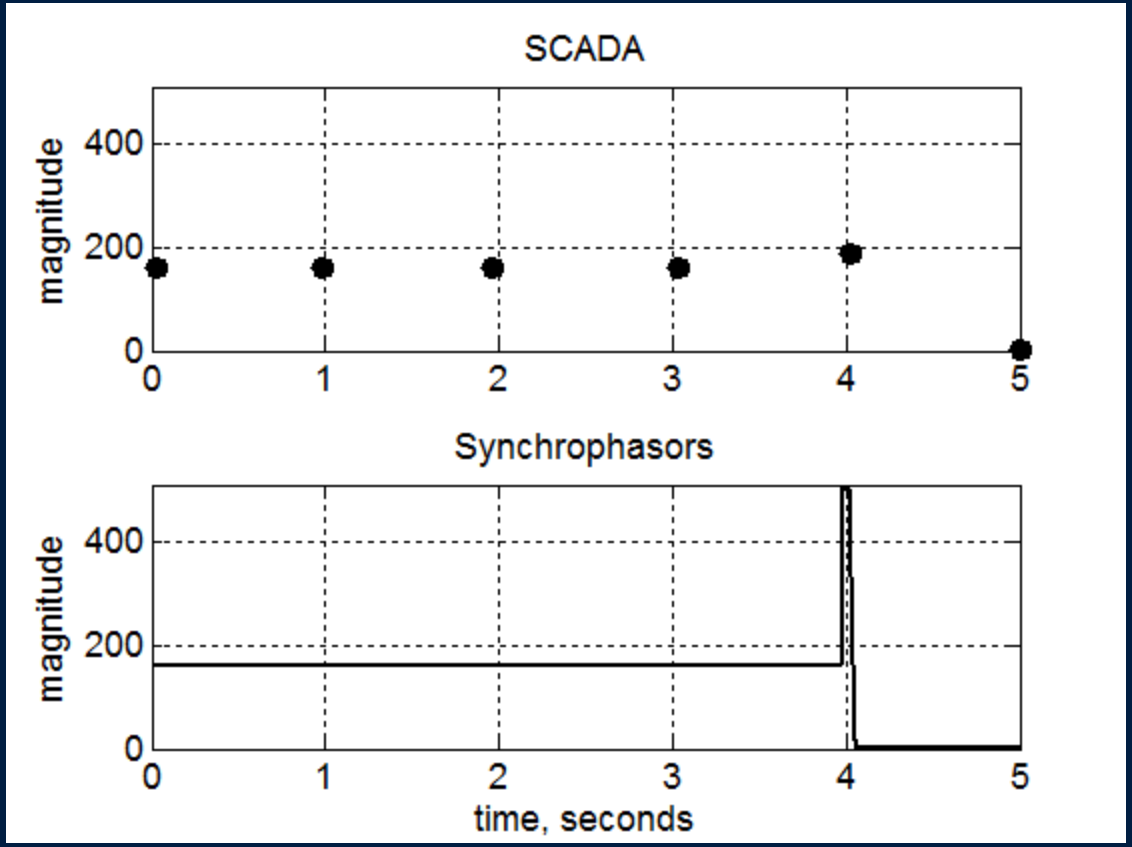


Time Synchronization Is Important for Power Systems



SCADA vs. Synchrophasors

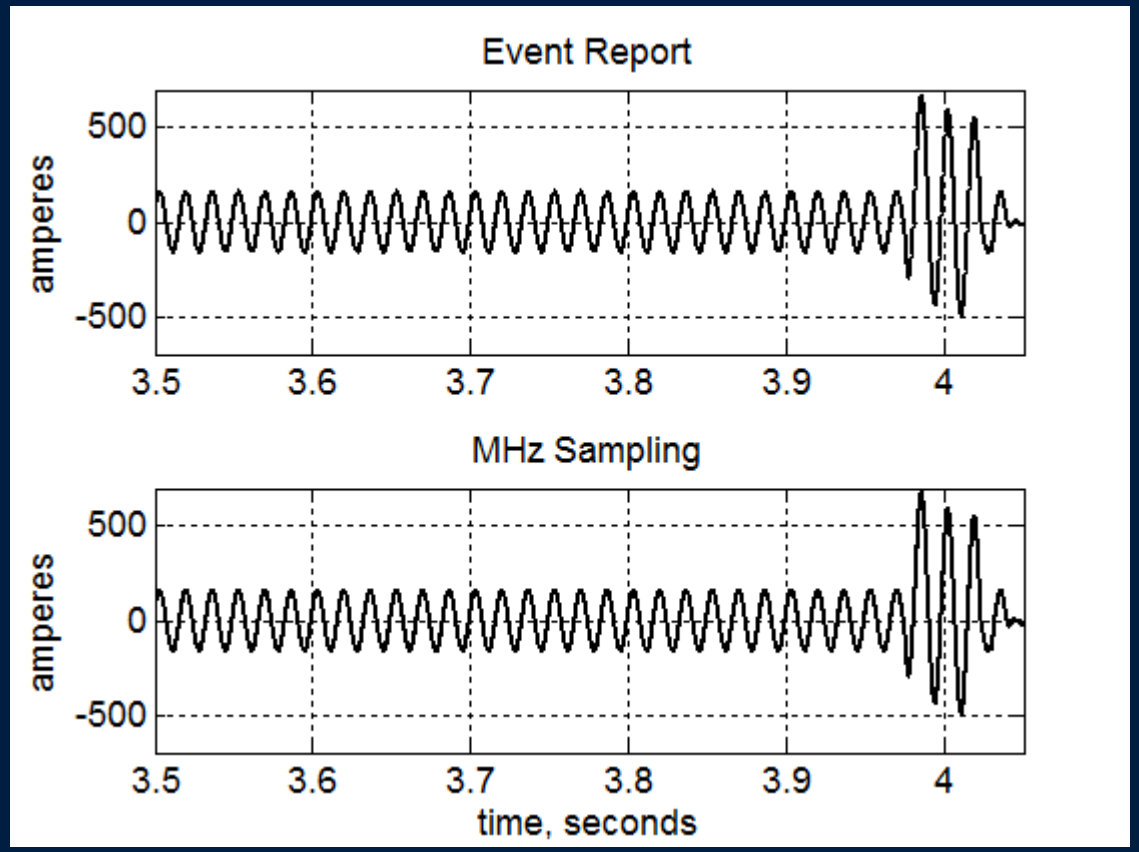


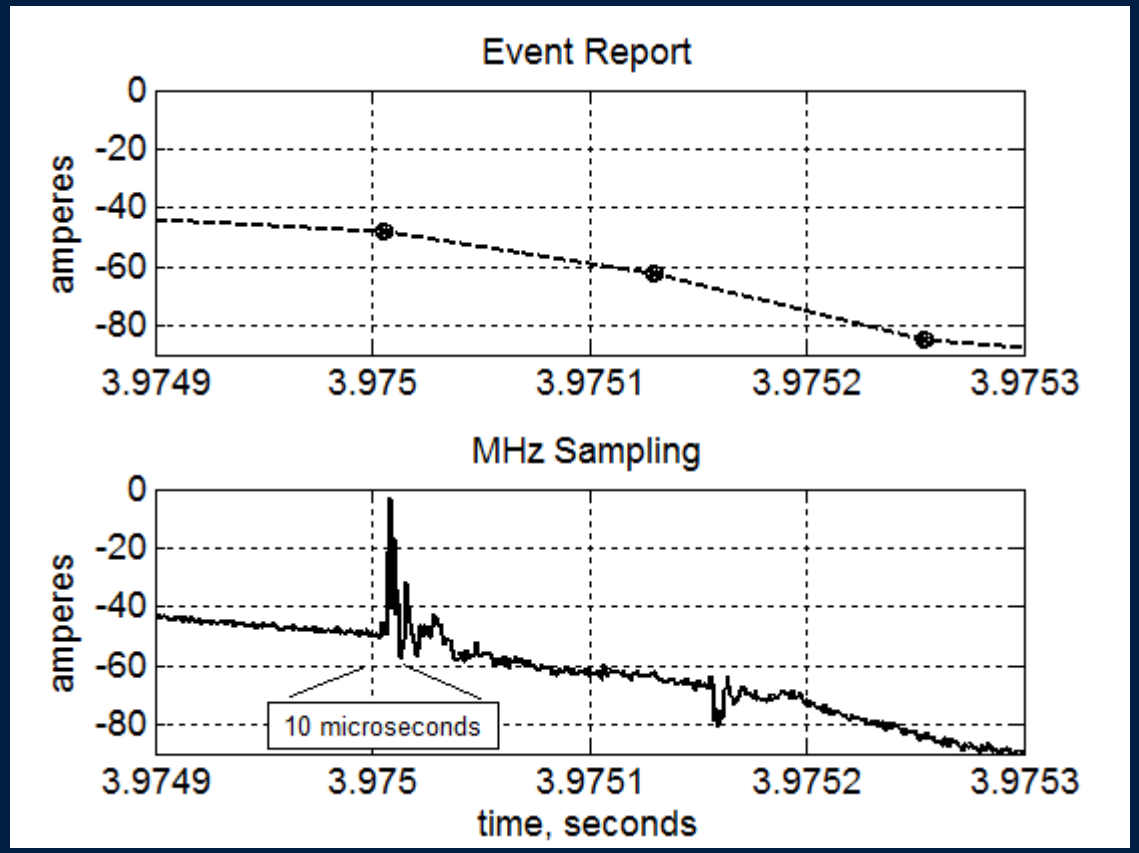
(Only magnitude shown for ease of comparison)

<1Hz vs. 30-240 Hz

Source: E. O. Schweitzer, III, D. E. Whitehead, G. Zweigle, V. Skendzic, and S. V. Achanta, “Millisecond, Microsecond, Nanosecond: What Can We Do With More Precise Time?” proceedings of the 42nd Annual Western Protective Relay Conference, Spokane, WA, October 2015

Direct Time-Domain Sampling

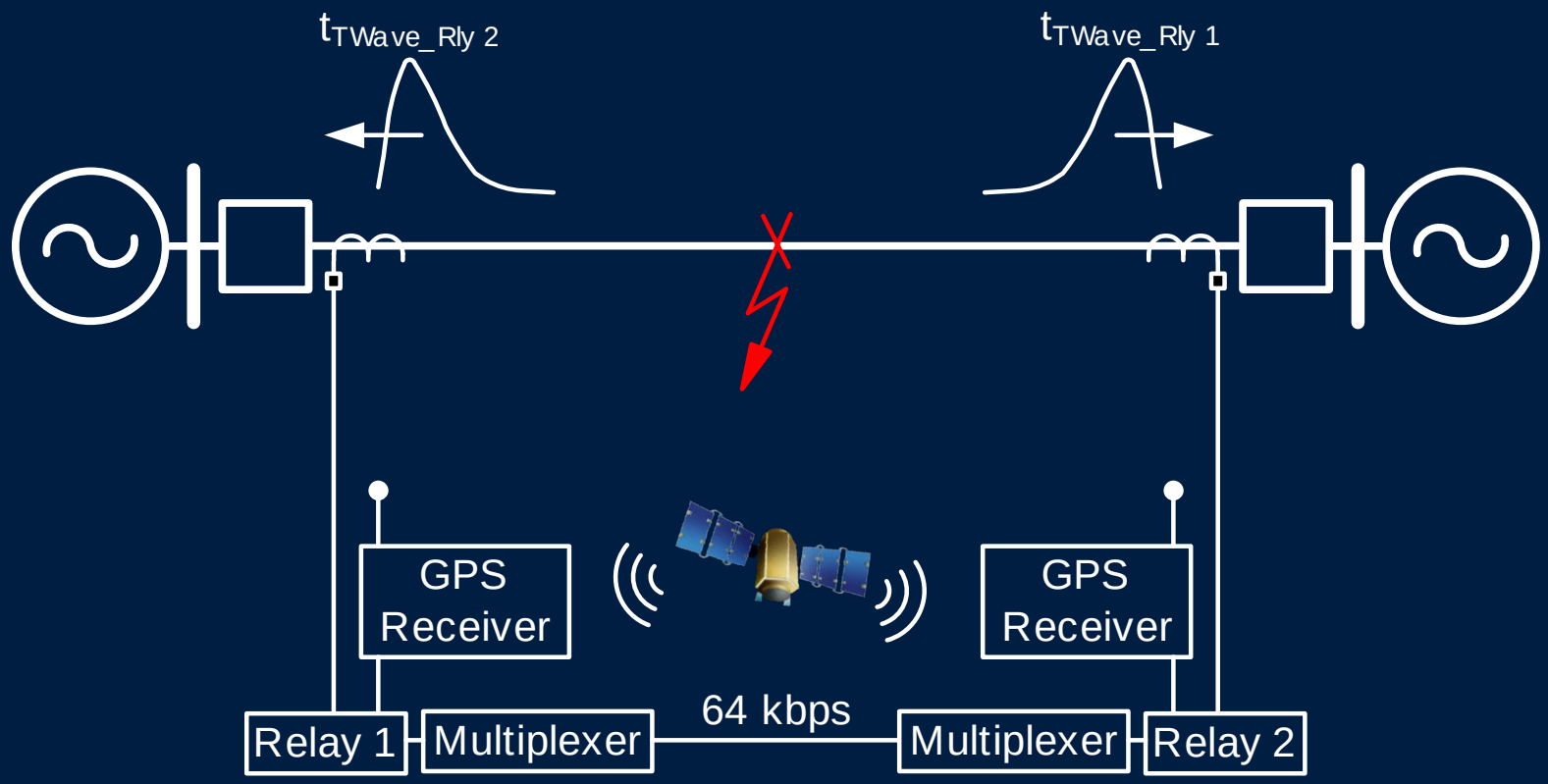




Few kHz vs. MHz

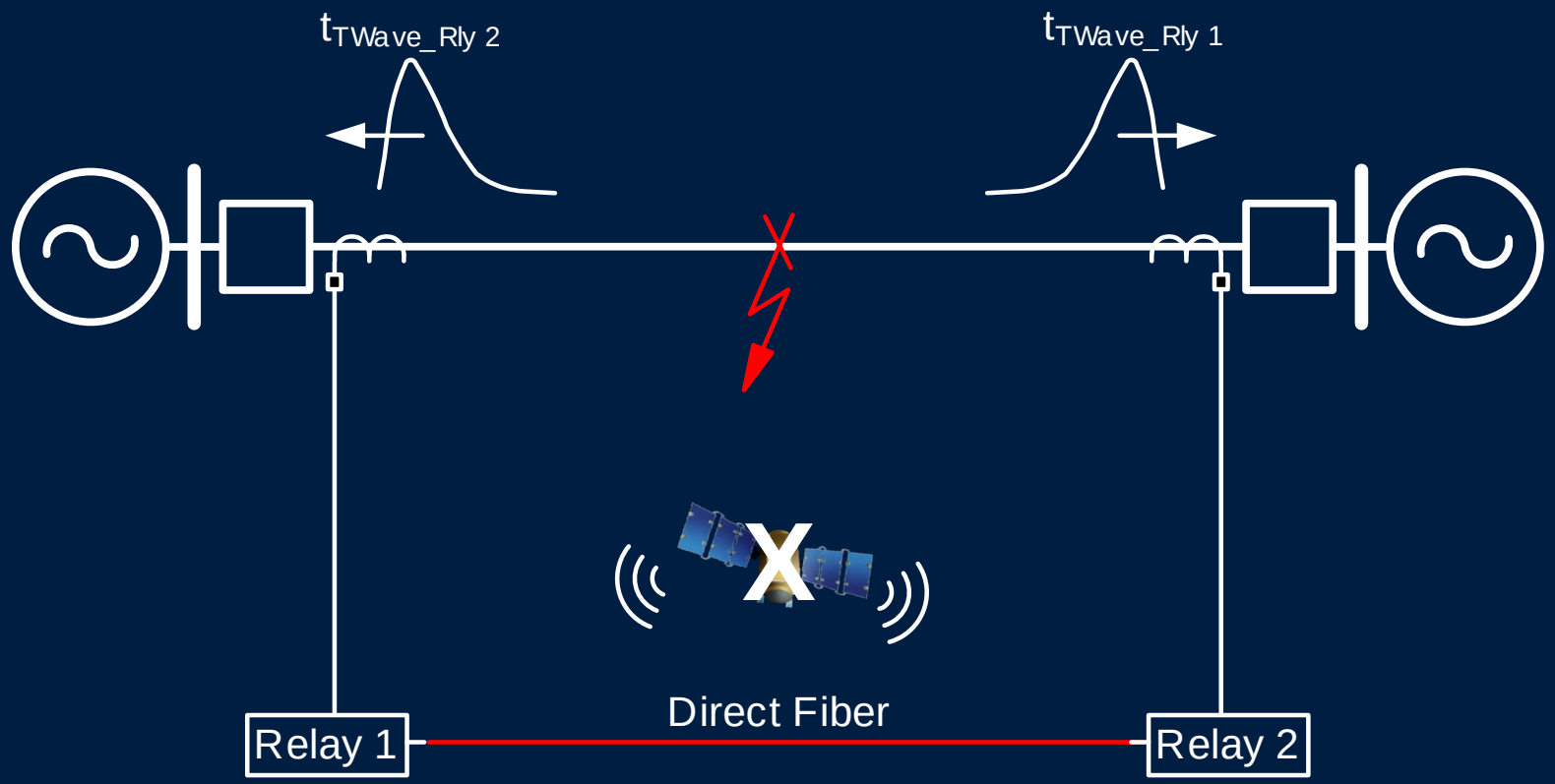
Source: E. O. Schweitzer, III, D. E. Whitehead, G. Zweigle, V. Skendzic, and S. V. Achanta, “Millisecond, Microsecond, Nanosecond: What Can We Do With More Precise Time?” proceedings of the 42nd Annual Western Protective Relay Conference, Spokane, WA, October 2015

Traveling Wave Fault Location



System 1: Independent clocks at each end

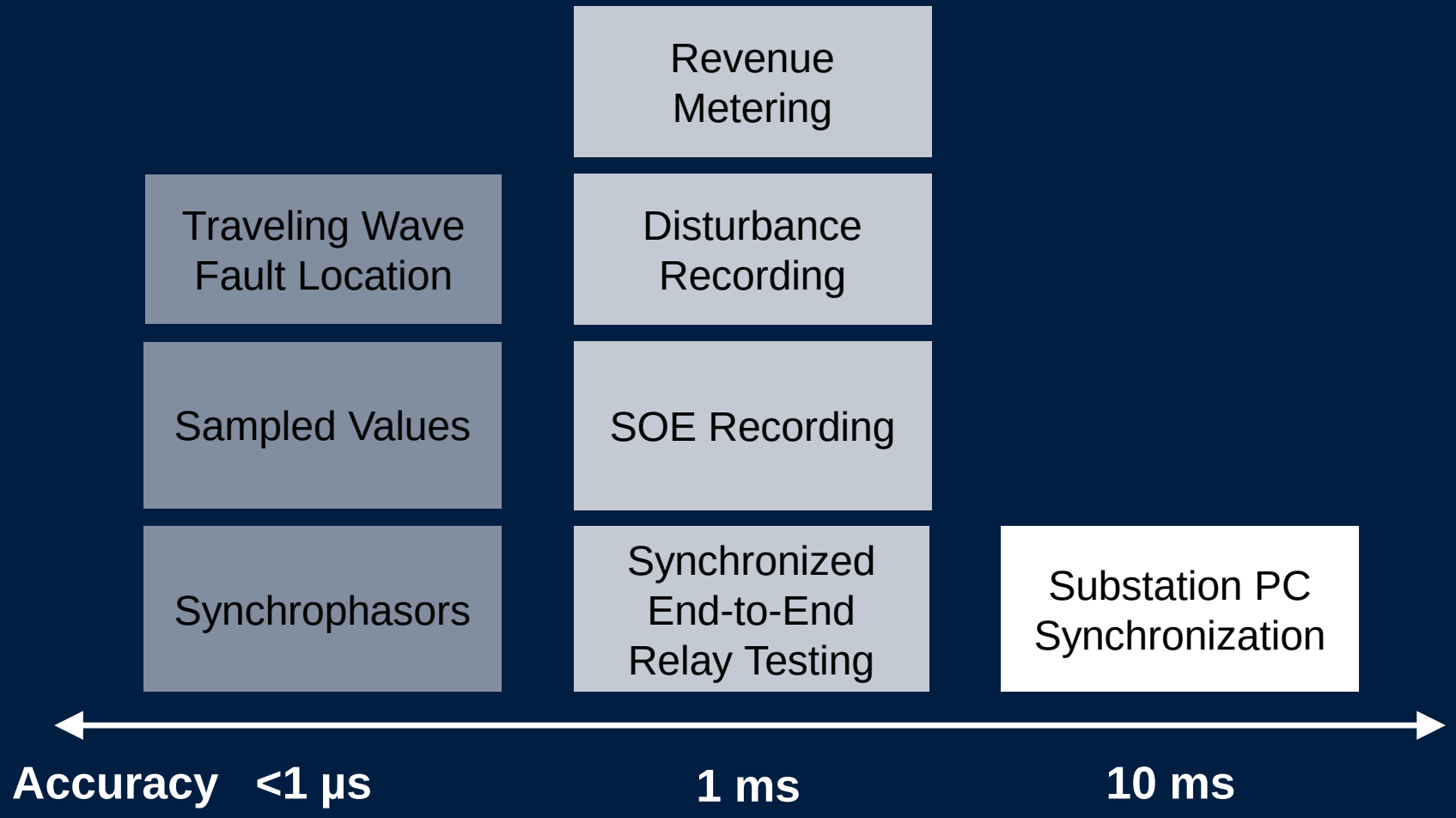
Traveling Wave Fault Location



System 2: Direct synchronization

No dependence on external time

Time Synchronization Is Important for Power Systems



Consider Potential GNSS Vulnerabilities

- Antenna failures
- Device failures
- Multipath errors
- Solar flares
- Jamming
- Spoofing

Secure and Dependable Operation

Security

"Provide accurate, uncompromised timing"

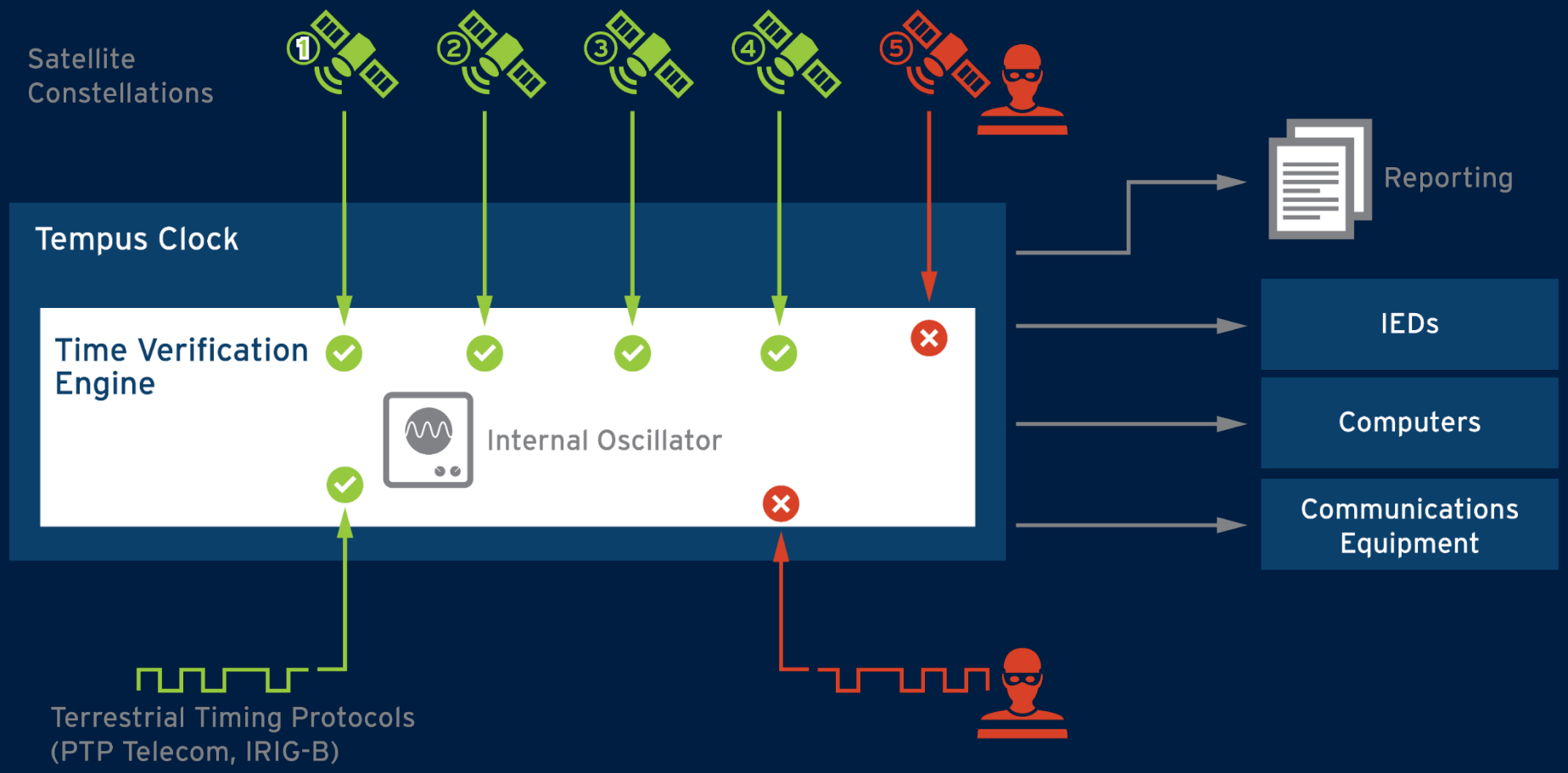
Dependability

"Continuously provide secure and reliable timing"

What Makes a Secure and Dependable Clock?

- **Quality:** Fit for use, free from defects
  - Rigorous design, testing, and manufacturing processes
- **Reliability:** Dependable operation through harsh conditions, expected and unexpected:
  - Environmental: Temperature, EMI, IEEE 1613 Class 2, etc.
  - Leap seconds, week number rollovers, and similar expected events
  - Holdover: accurate time *and* time quality estimate
  - **Resiliency**: maintain time despite harsh conditions

Clock Resiliency



Multiple inputs from diverse sources, time verification engine, advanced diagnostics!

Multi-Input Timing with Verification

- Independently track and analyze multiple input sources
- Verify each input source independently
- Compare and verify multiple sources against each other
- Fail-over without interruption
- High-stability holdover

Advanced Diagnostics

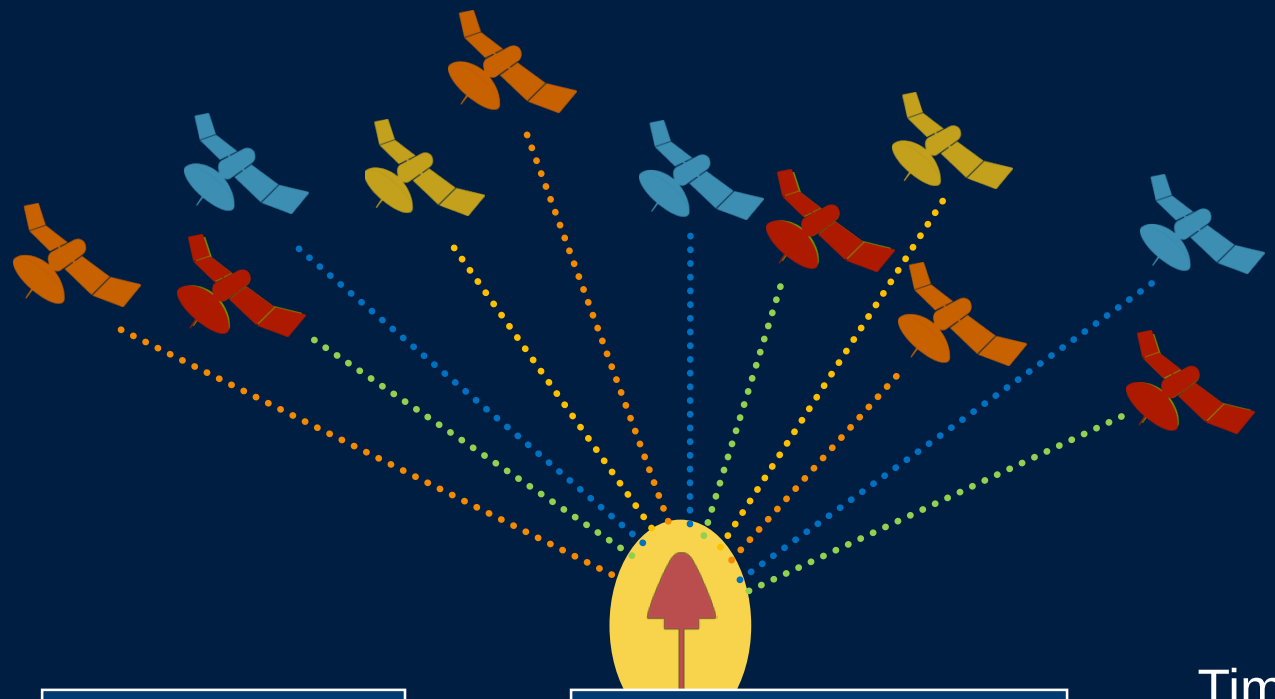
- Quality and health estimations and logging
  - Input time source diagnostics
  - Detailed information for GNSS troubleshooting
  - Device status, available holdover performance
- Reporting and logging of timing events observed
- Logging, alarms, Syslogs, and other standard features
- Traceability information

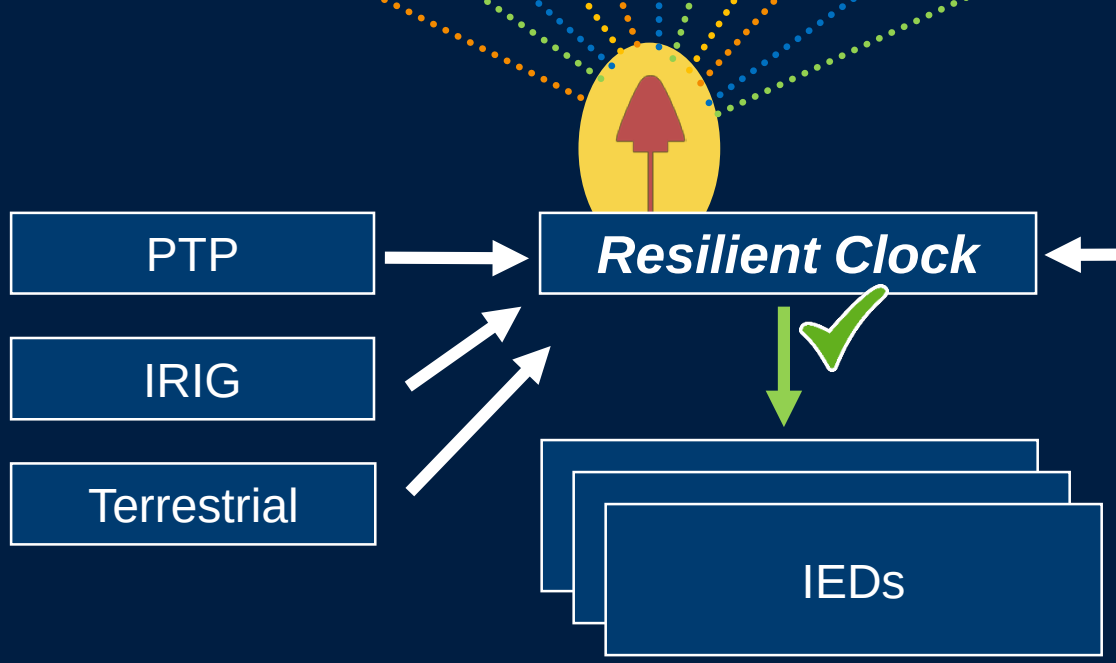
User-definable Modes

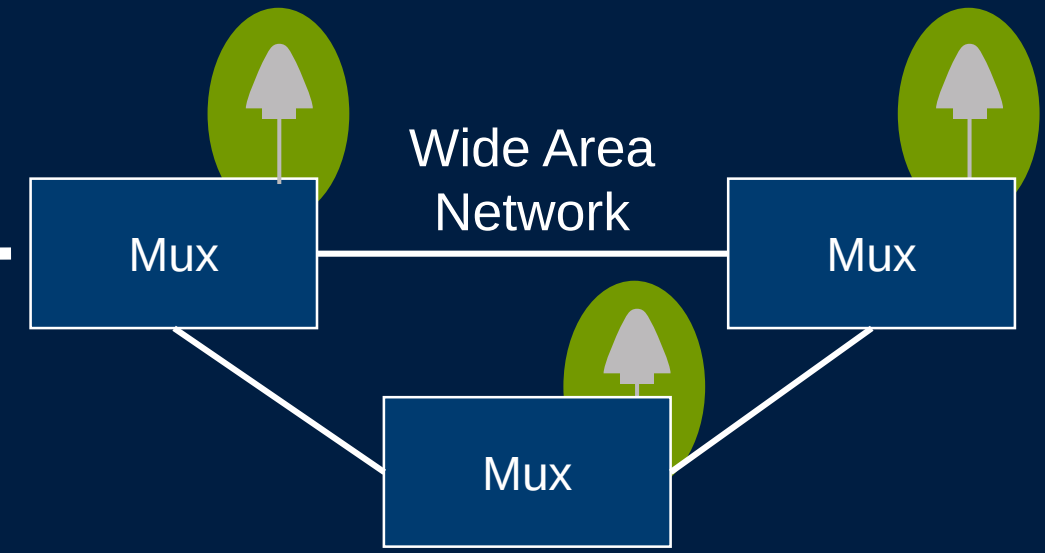
- User-defined priority list
- Multi-input, automatic source selection
- Manual source selection

Dependable Timing Systems

- Multiple inputs
- Diverse sources
- Geographic diversity
- Time verification
- Terrestrial failover







Conclusions

- Timing is increasingly important in power systems
- Secure, dependable, accurate timing is **available now,** and new timing products and features are on the horizon
- Understand timing challenges and design and implement robust systems to improve system integrity