Architecture and Applications of Software GPS Receiver

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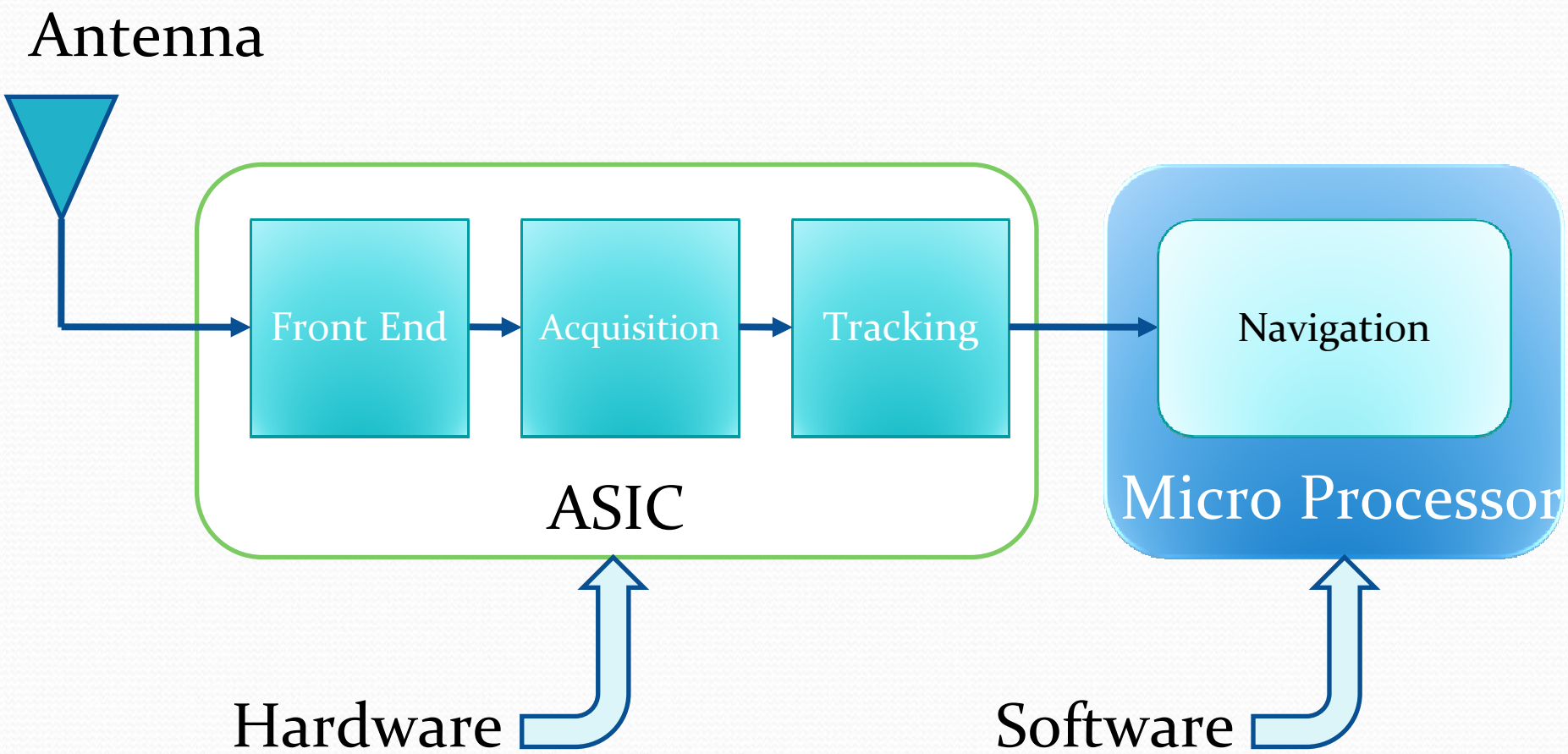
GPS Overview

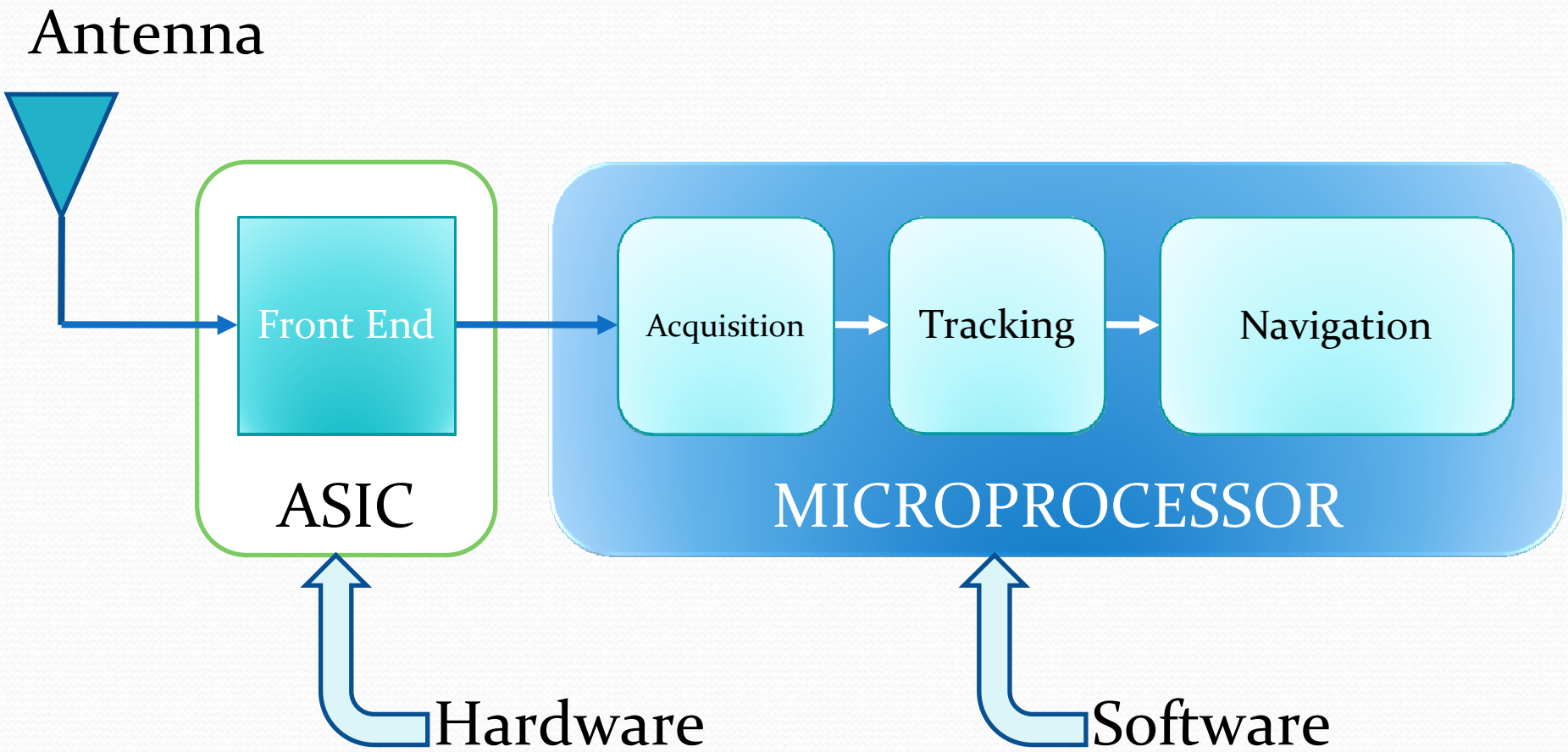
- GPS provides the position, velocity, and timing information that enabled many applications we use in our daily life.
- It includes precision agriculture, land transportation, maritime, mapping, surveying and aviation etc.

GPS Receiver Architecture



* ASIC (Application Specific Integrated Circuit)

Software GPS Receiver Architecture



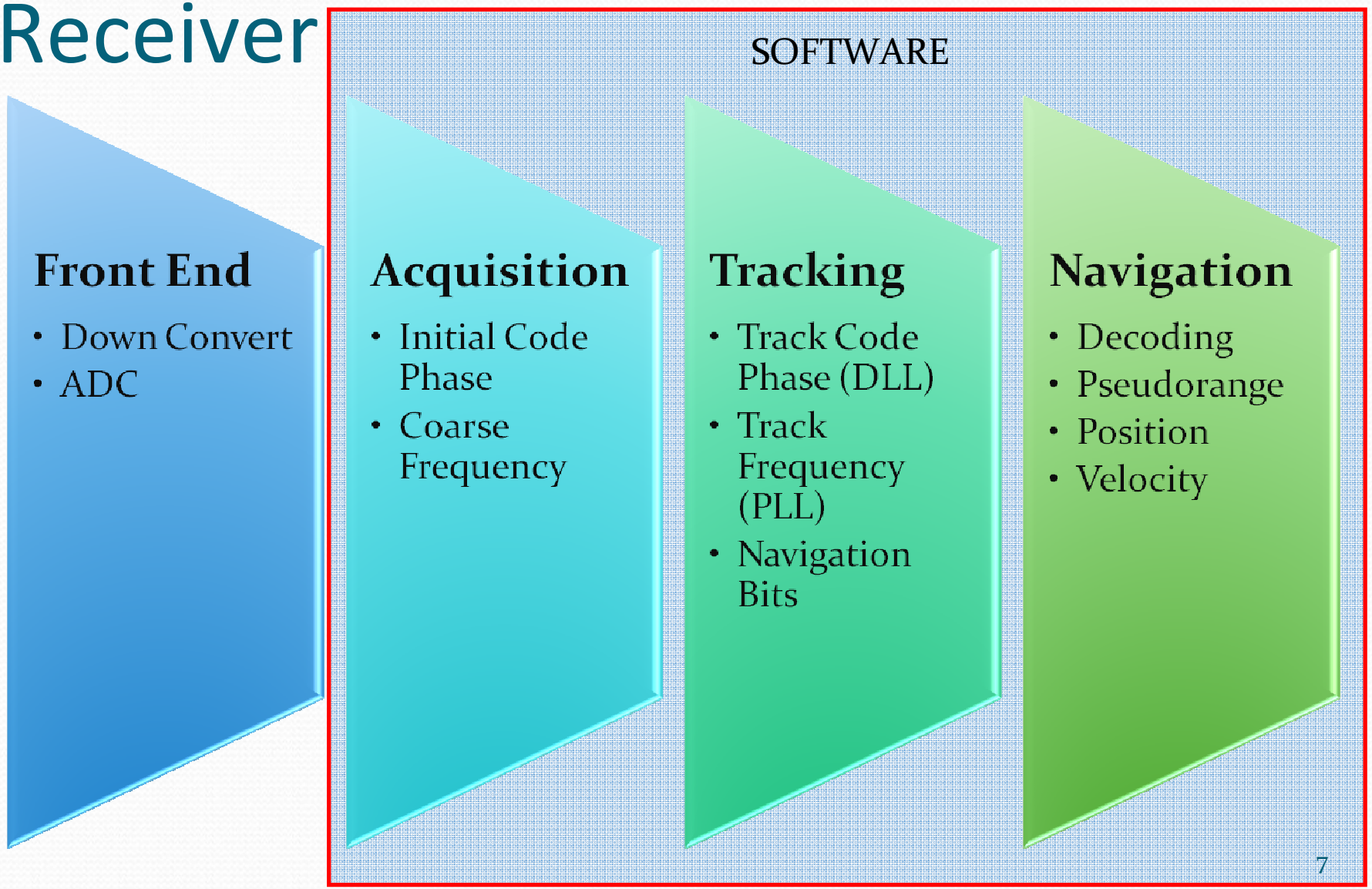
Why Software GPS Receiver?

- A generic signal processing research platform for all kind of Global Navigation Satellite Systems
- Multiple systems in single device
- Easy to reprogram for any specific environment, like:
  - Multipath mitigation
  - Weak signal acquisition and tracking
  - Interference mitigation
- Easy to reconfigure for modern GPS signals

Why Software GPS Receiver?

- Easy FPGA implementation
- Receiver performance trade off analysis
- Passive microwave signal (GPS – 1.5 GHz) analysis for soil moisture and water boundary
- Using aided navigation minimizing the data latency issue.
- Post processing of field data

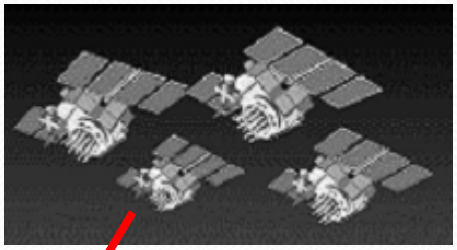
Algorithm Flow in Software GPS Receiver



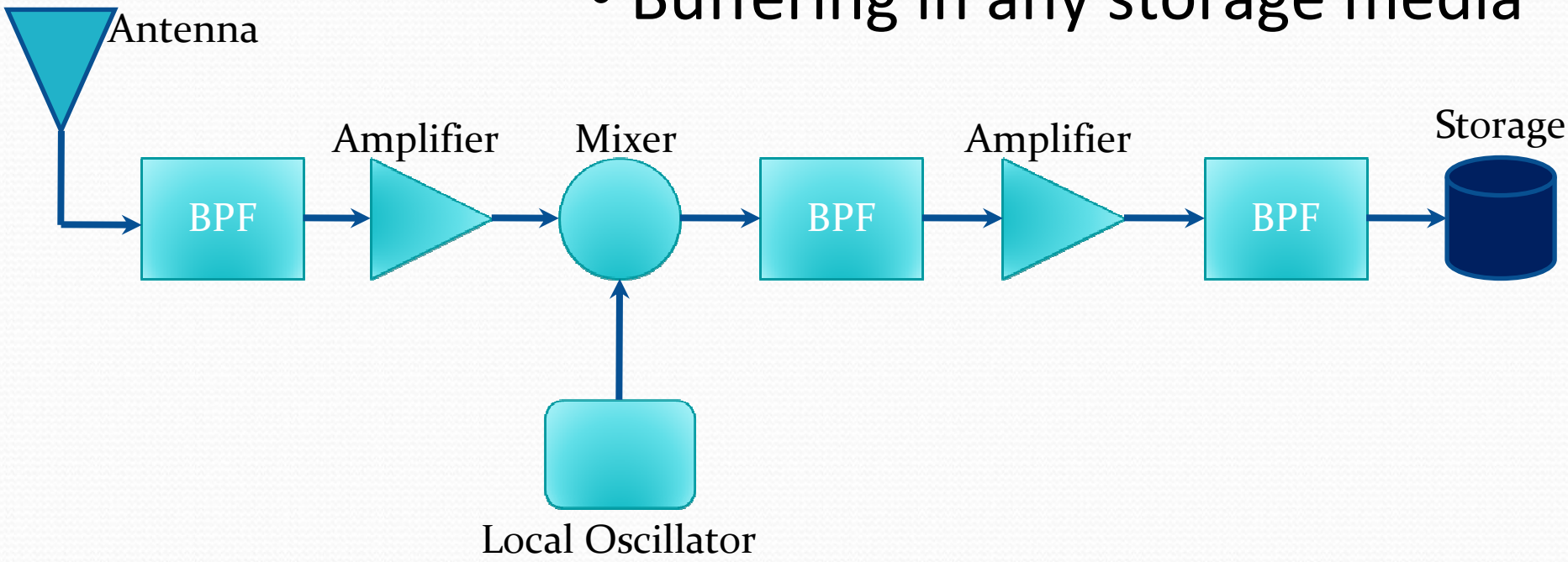
Steps in Software GPS Receiver

- Front End
- Acquisition
- Tracking
- Bit Synchronization
- Sub-frame Matching & Parity Check
- Getting Ephemeris Data
- Satellite Position using Ephemeris
- Pseudorange
- User Position and Velocity

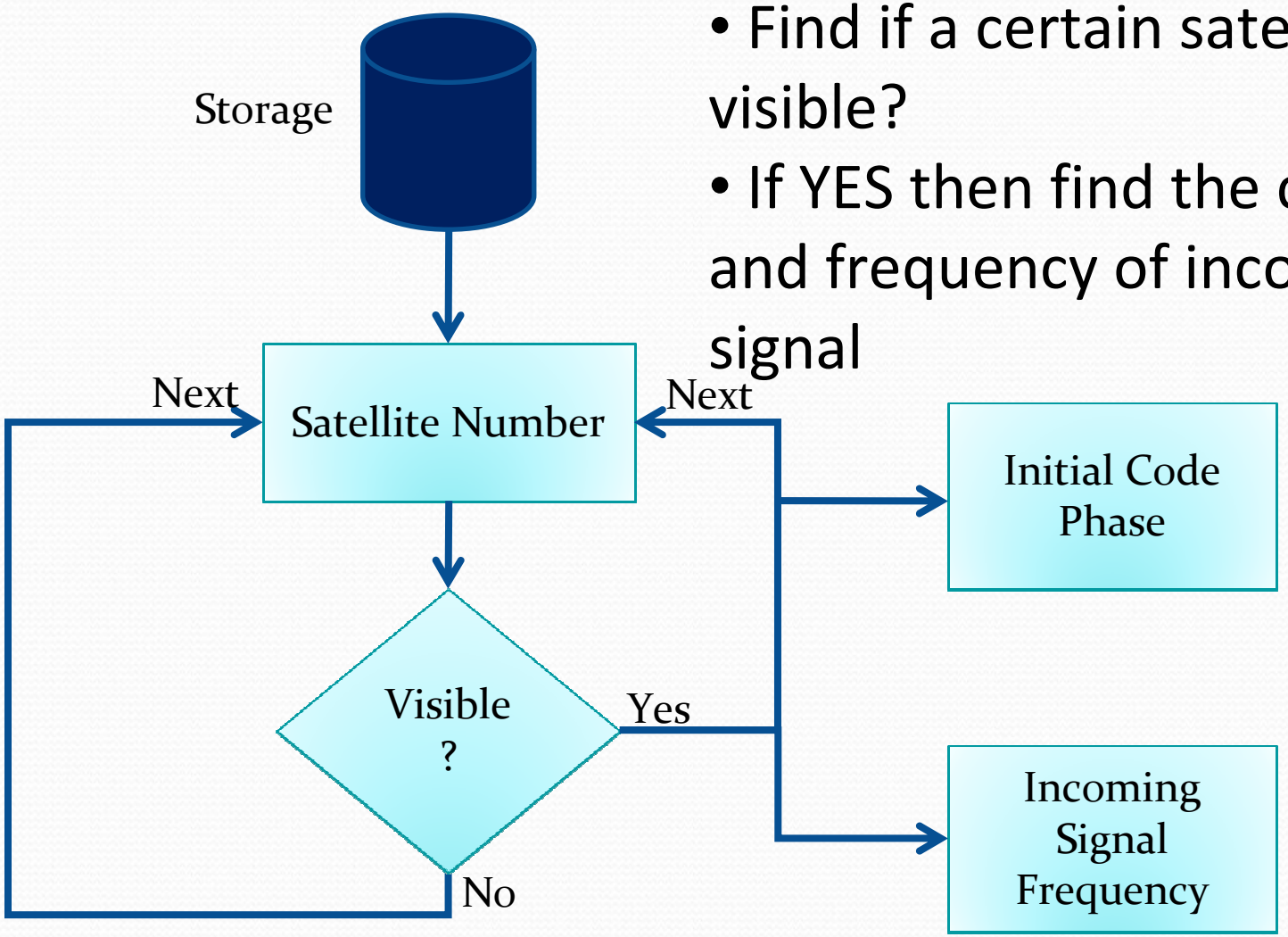
Front End



- Incoming signal is down converted
- Signal is digitized
- Buffering in any storage media



Acquisition

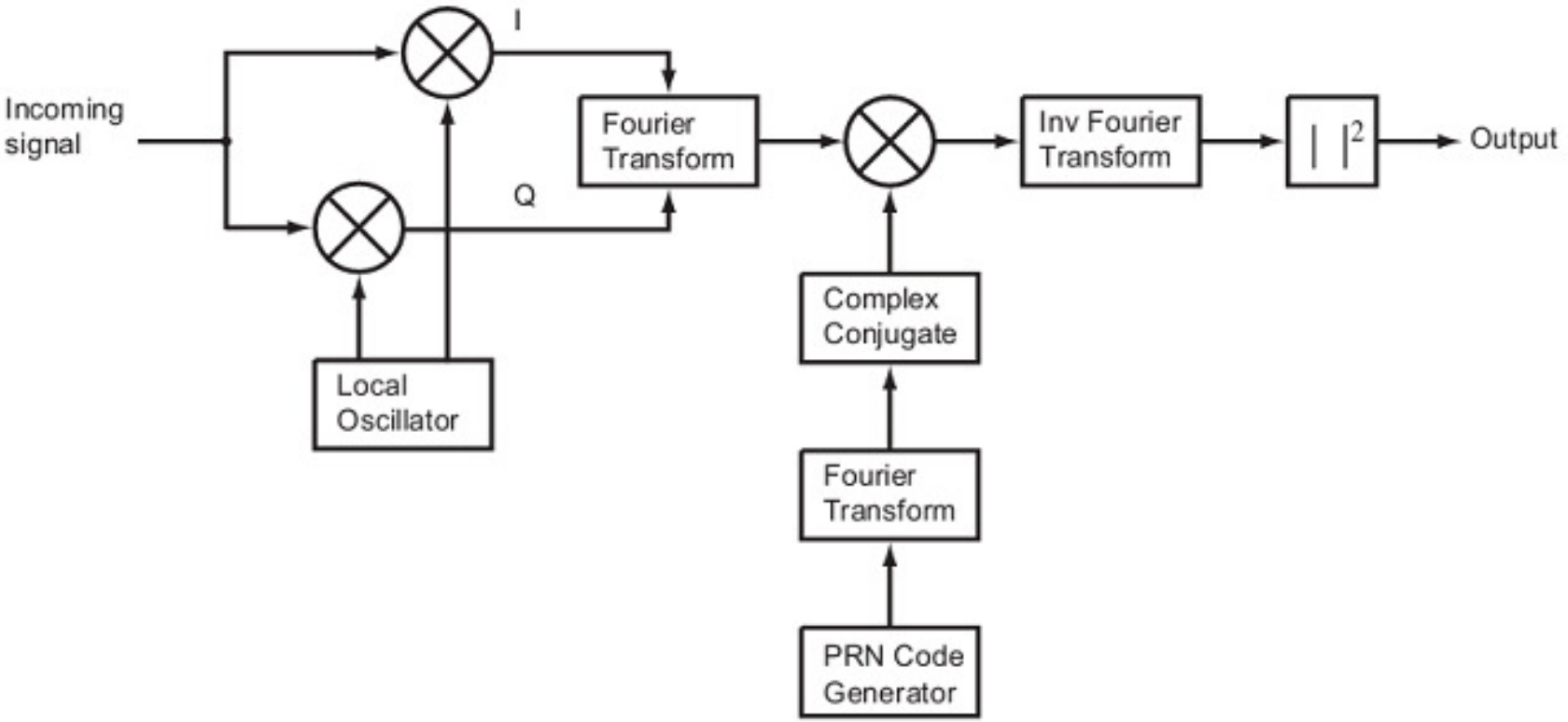


- Find if a certain satellite is visible?
- If YES then find the code phase and frequency of incoming signal

Acquisition Method

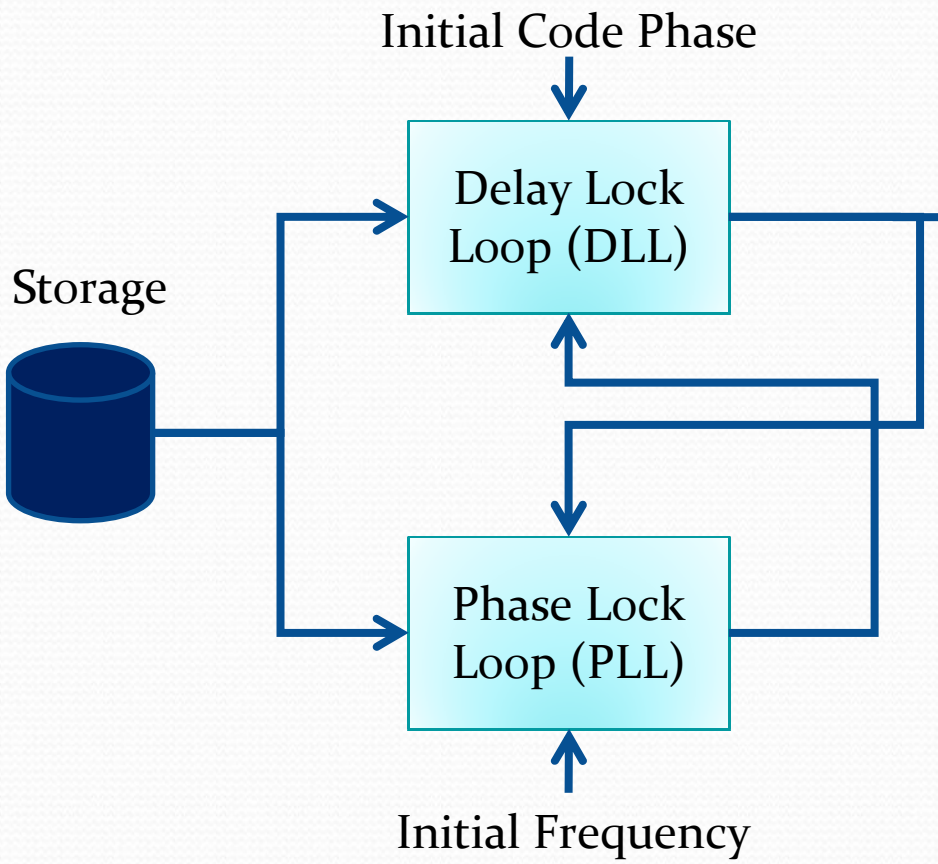
Conventional GPS Receiver	Software GPS Receiver
Conventional receiver uses correlation method, resulting less efficient computing and requiring more time to search a satellite.	Software GPS receiver uses DFT (Discrete Fourier Transform), resulting efficient computing and requiring less time to search a satellite.

DFT Based Acquisition



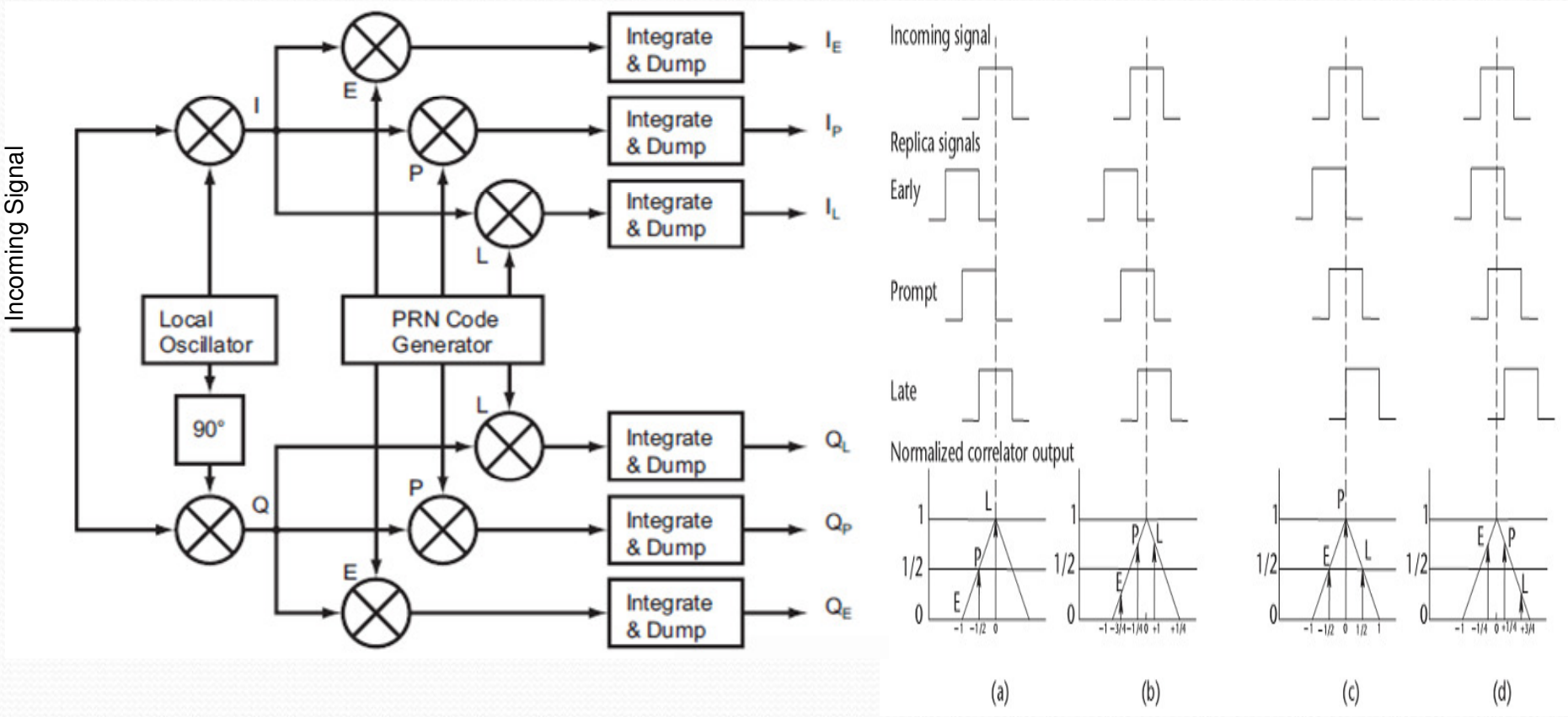
Schematic representation of FFT based acquisition

Tracking

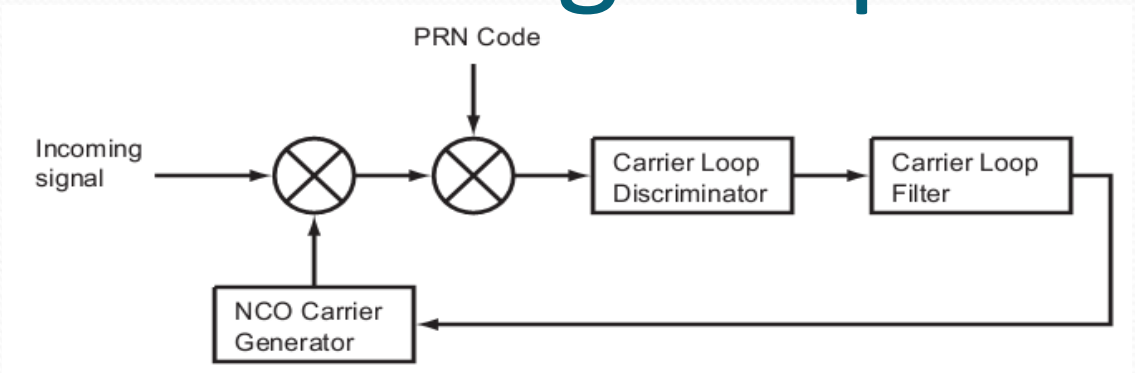


- Demodulate Navigation bits
- Track variations in the carrier Doppler and code offset due to line of sight dynamics for efficient demodulation of navigation bits

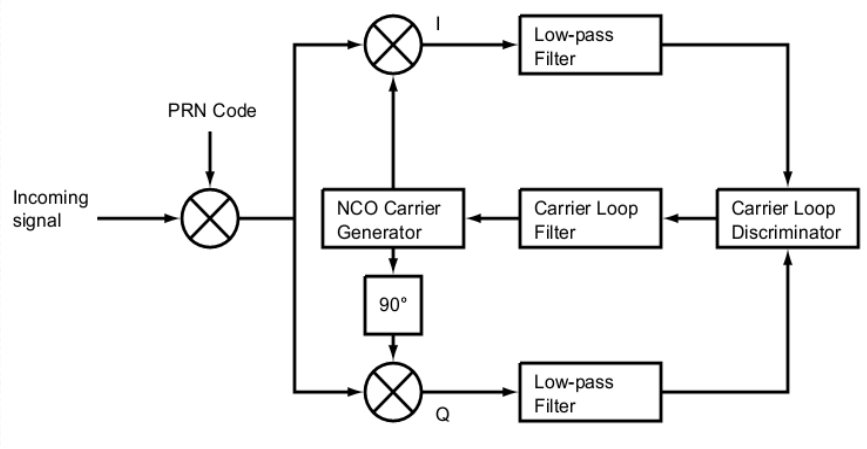
Delay Lock Loop (DLL)



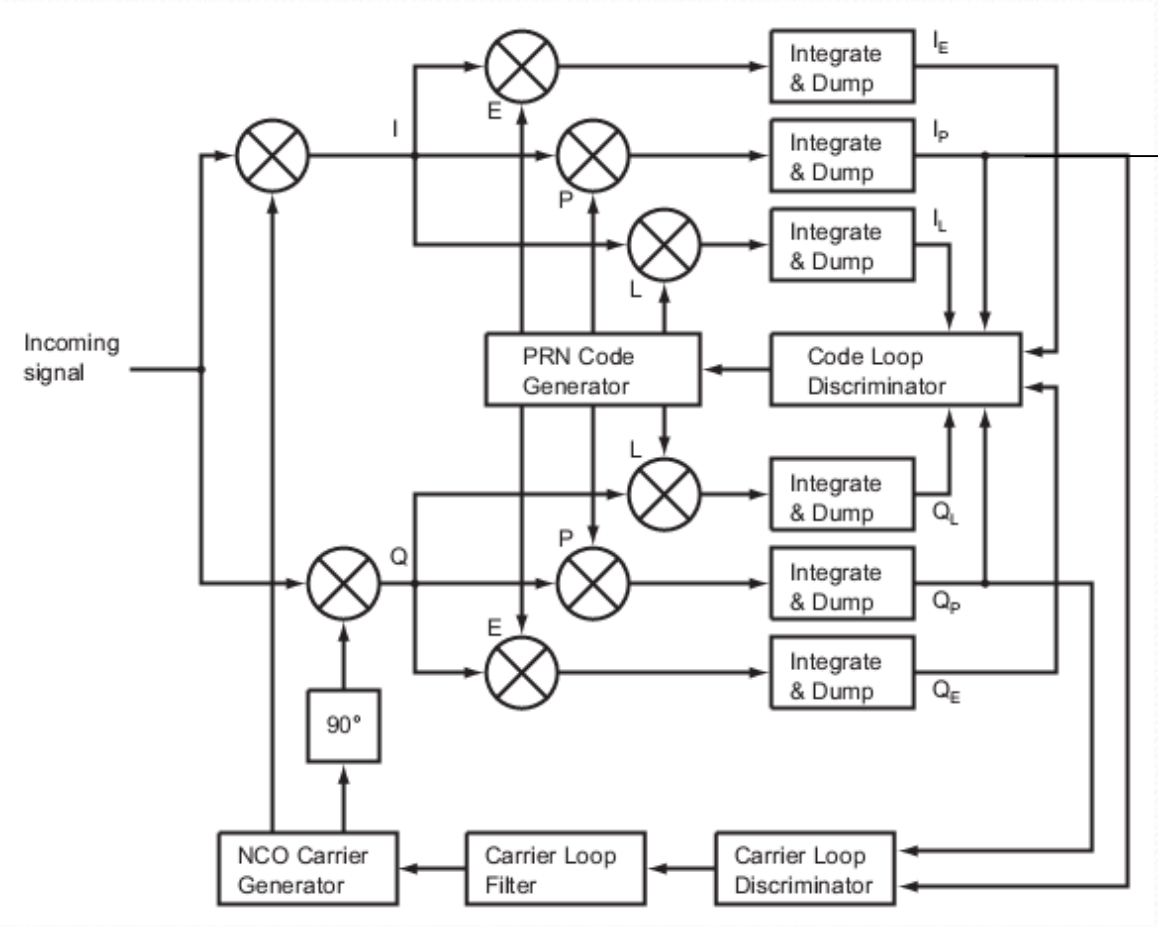
Carrier Tracking Loop



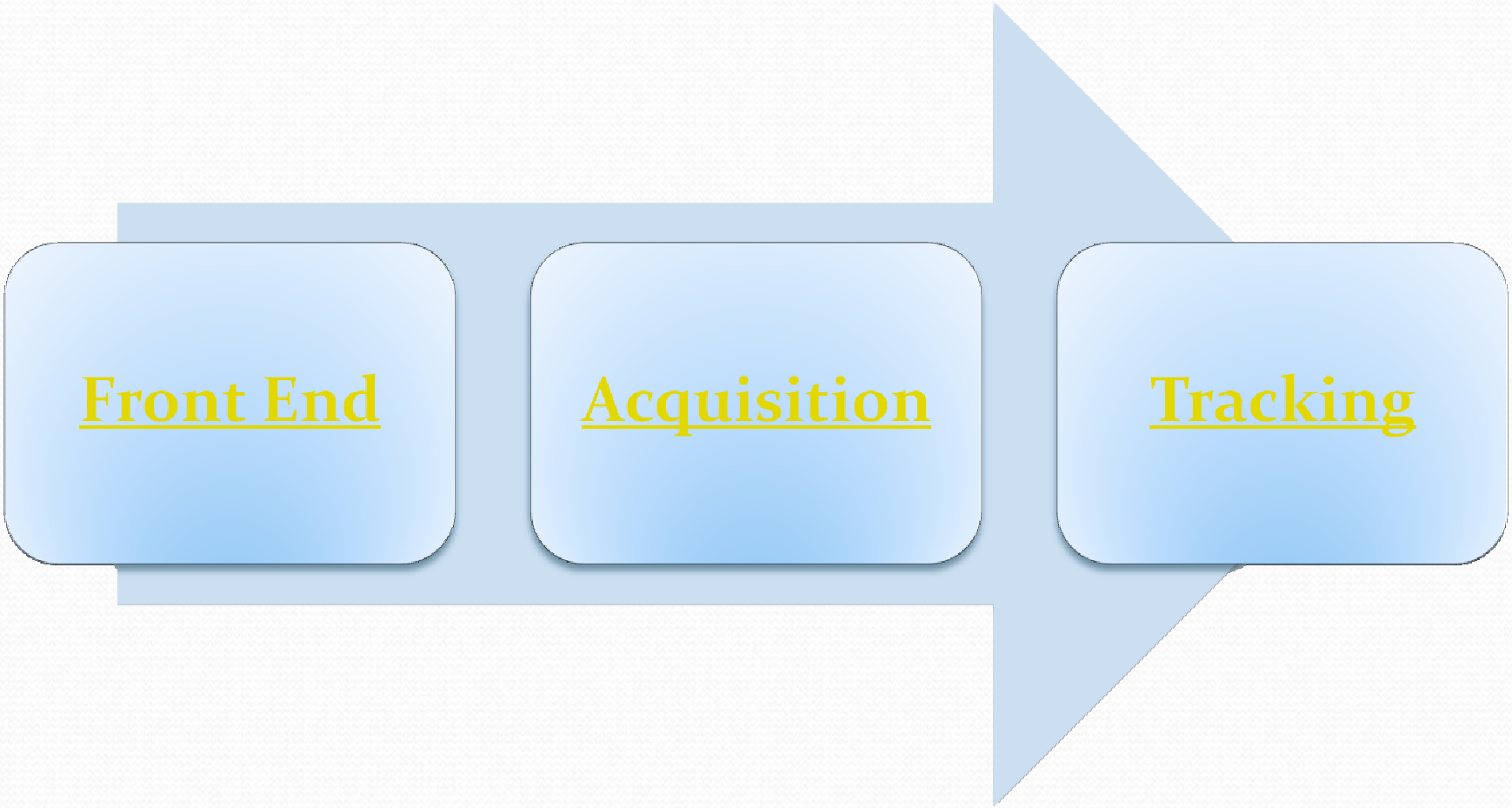
Costas Phase Lock Loop



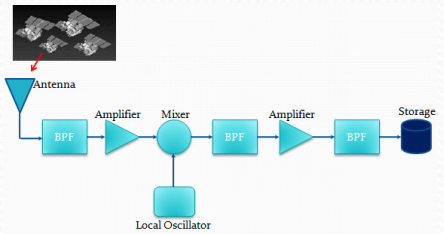
Complete Tracking Loop

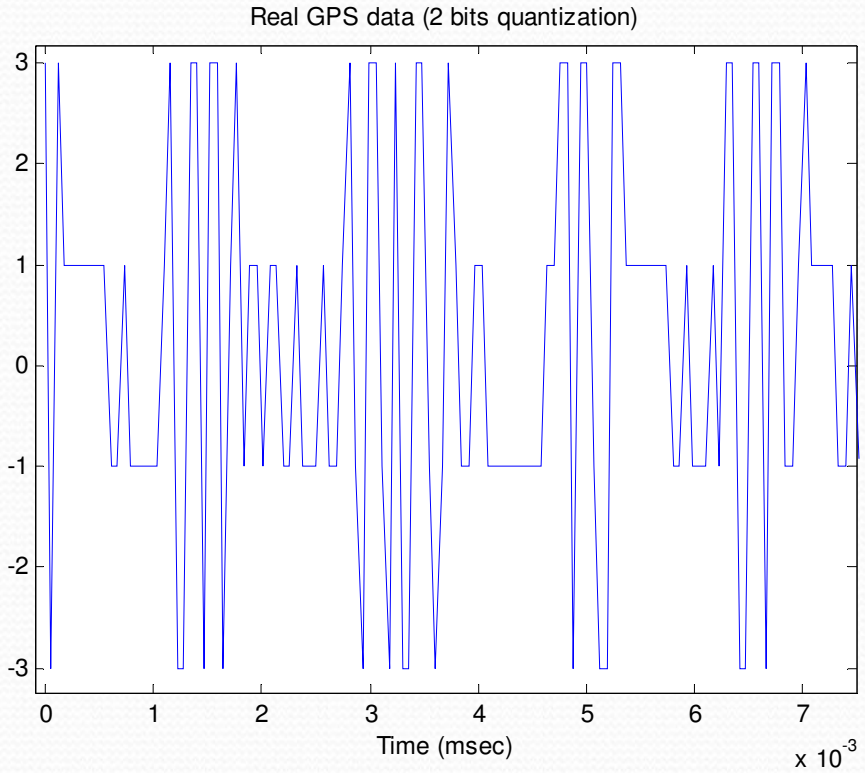


Matlab Demonstration

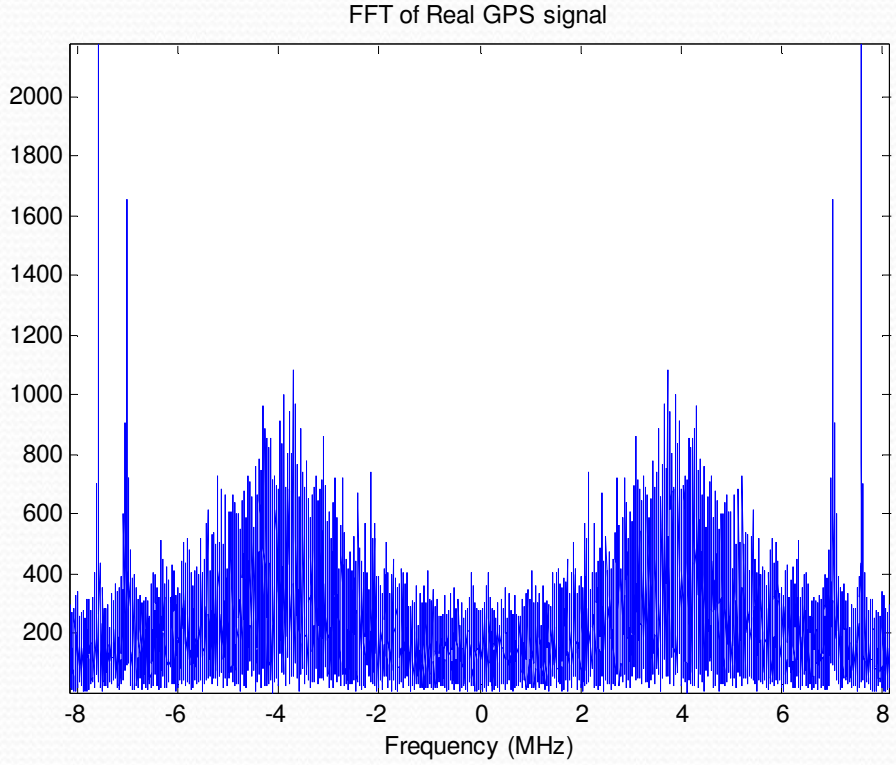


Digitized GPS Signal



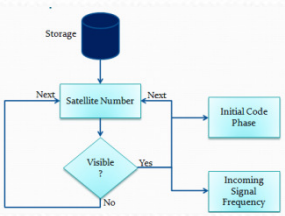


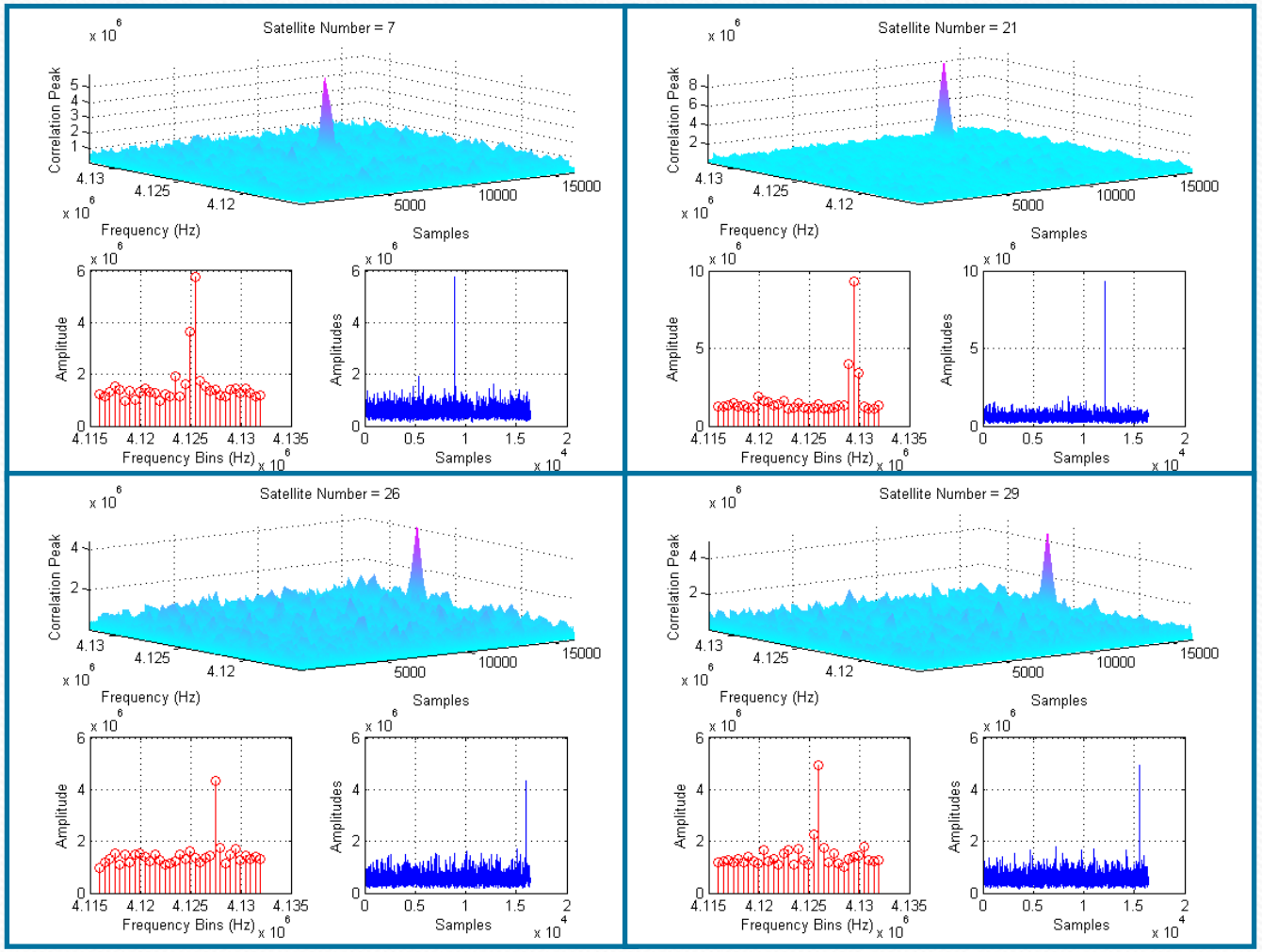
Time Domain



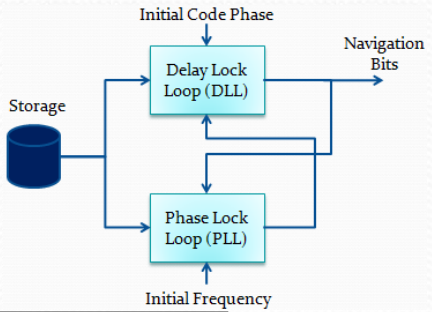
Frequency Domain

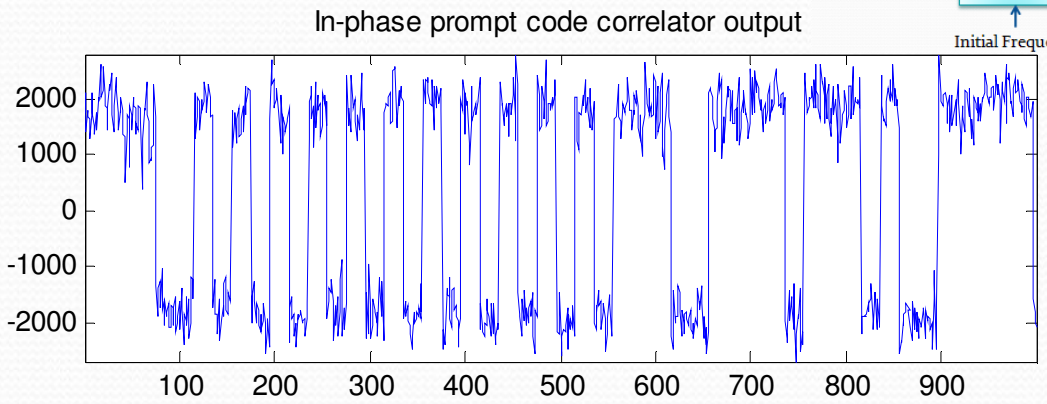
Acquisition Results

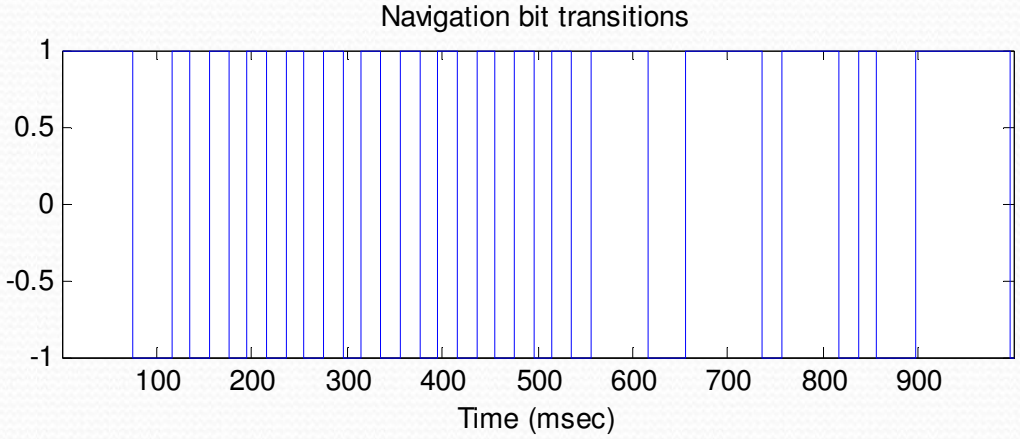




Tracking Result







Applications

- Low cost navigation solution
- In depth understanding of GPS signal structure and processing
- Modular implementation, so that every module can be independently replaced with an alternative algorithm
- Platform for evaluating novel algorithms for
  - Multipath mitigation
  - Weak signal acquisition and tracking
  - Interference management
- All type of GNSS receiver in a single unit

Thanks for your attention

www.suparco.gov.pk

Reference:
1. E. Kaplan, “Understanding GPS: Principles and Applications”, Artech House, 1996
2. J. Bao-Yen Tsui, “Fundamentals of Global Positioning System Receivers a Software Approach”, Wiley-Inter science, 2000