Software Radios for Cellular/PCS Base Stations: Fact or Fiction
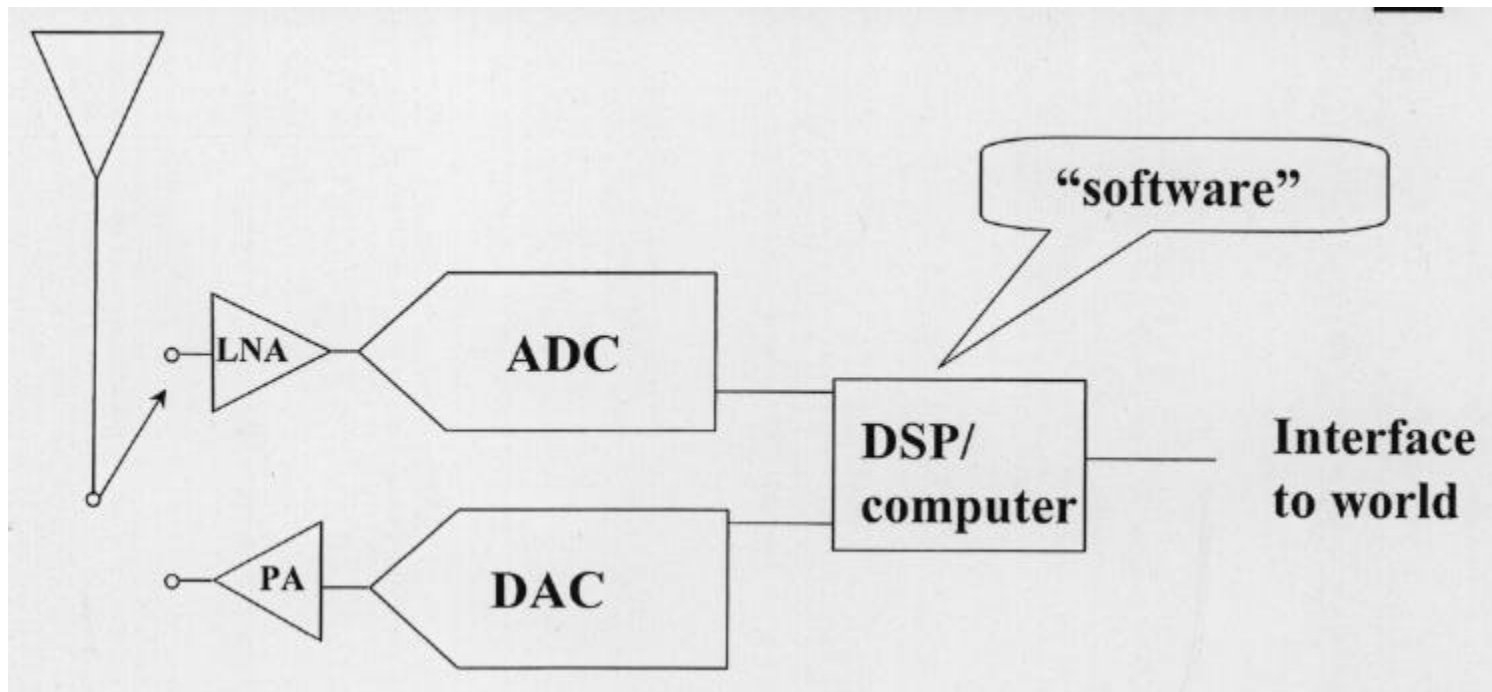
presented by:

Tom Gratzek

Analog Devices Inc.
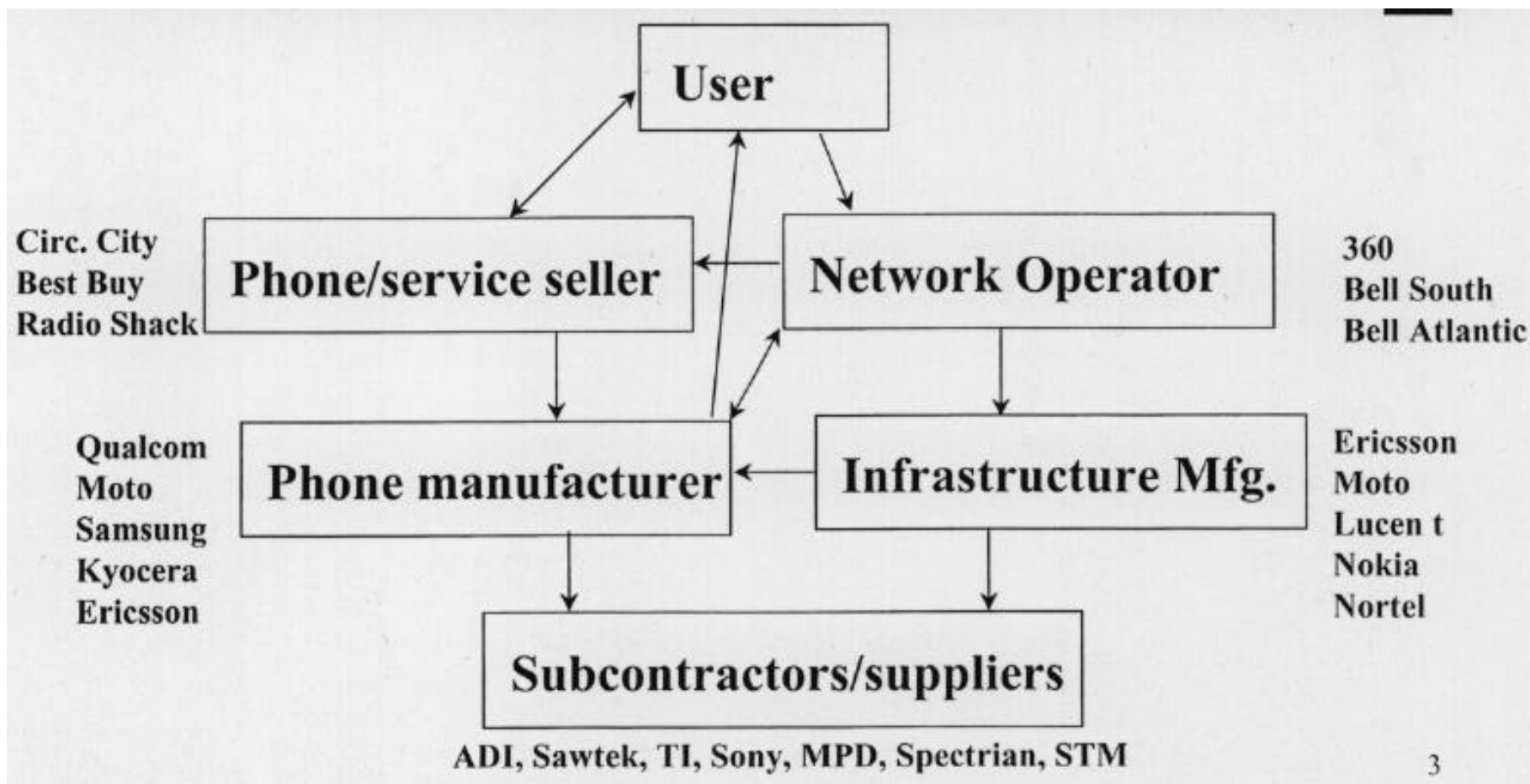
Communications Division

1

(very) Simple Software Radio

# "Follow the Money"
Cellular/PCS Market Structure

Circ. City / Best Buy / Radio Shack — Phone/service seller

Qualcom / Moto / Samsung / Kyocera / Ericsson — Phone manufacturer

360 / Bell South / Bell Atlantic — Network Operator

Ericsson / Moto / Lucen t / Nokia / Nortel — Infrastructure Mfg.

User

Subcontractors/suppliers

ADI, Sawtek, TI, Sony, MPD, Spectrian, STM

3

Radio Owner Needs

- **Handset -**
  - **long battery life (talk/standby)**
  - **small size, low cost**
  - **clear voice**
  - **features: handsfree, messaging, voice activation, etc.**
- **Infrastructure**
  - **low initial cost**
    - **BOM, size, site coverage, time to revenue, spectrum utilization**
  - **low lifecycle costs -**
    - **low utilities, site rental, radio reliability,**
    - **inexpensive upgrades - frequency planning, vocoder change**
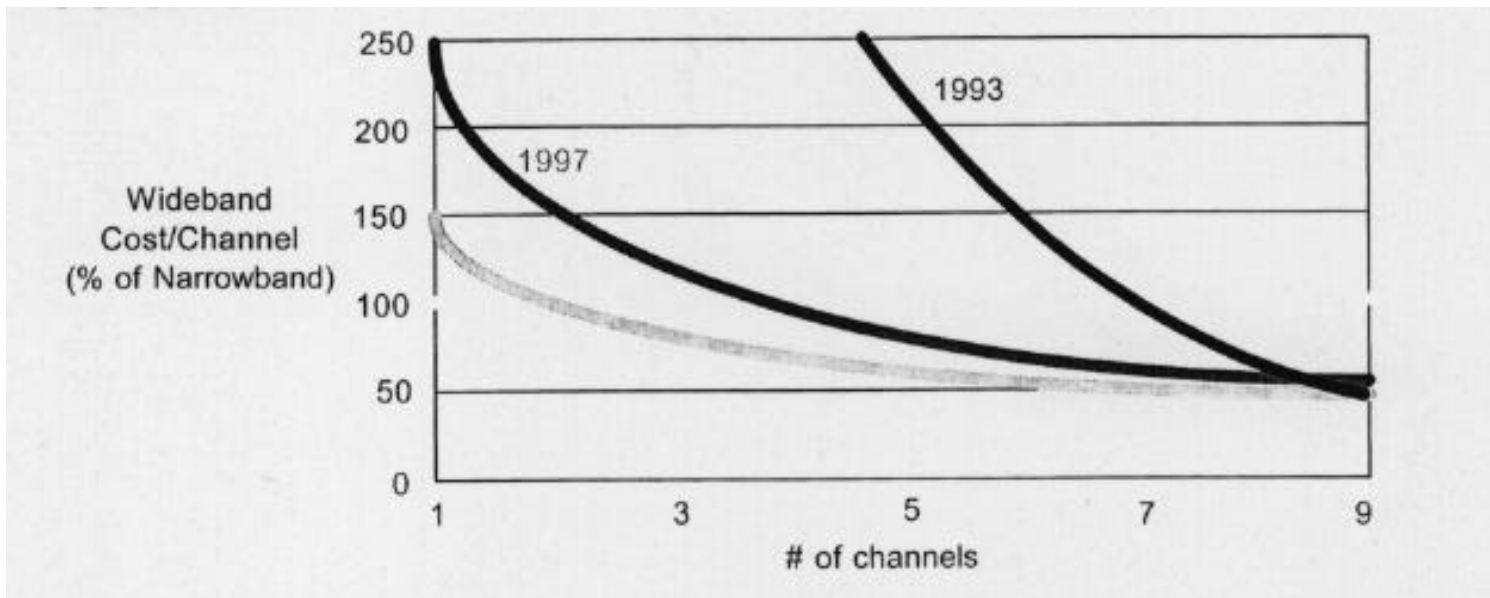 - **network reliability - uptime/service**

Software Radios: Marketing Slide
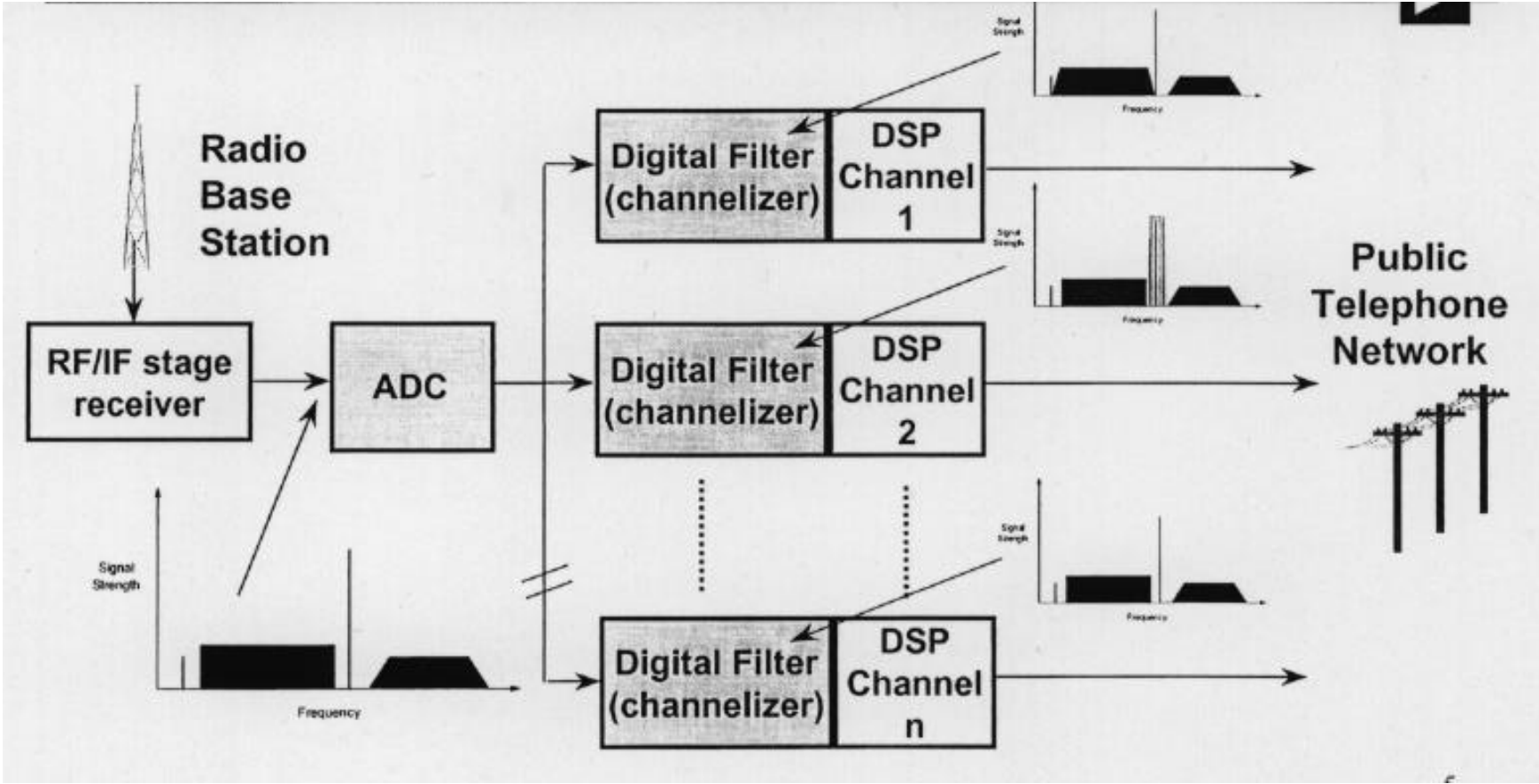
Cost Implications

- Single radio for all RF channels
- Cost per channel decreases with Wideband solution

Cellular Standards Evolution

- 1st Generation - FM - AMPS, NMT, TAC
  - 30 KHz channels - 1 call per channel
- 2nd Generation
  - IS-136 - 3 users/channel - 30KHz channels
  - GSM; 8 users/channel - 200 KHz channels
  - IS-95 CDMA; 16+? Users/channel - 1.25MHz chan.
- 3rd Generation
  - in standardization process
  - 5 + MHz channels; capable of high speed data

GSM Requirements: tough job

BTS

-13 dBm

-16 dBm

-26 dBm

+41 dBc

.4 MHz
.6 MHz
.8 MHz

3 MHz

-104 dB

GSM Channels
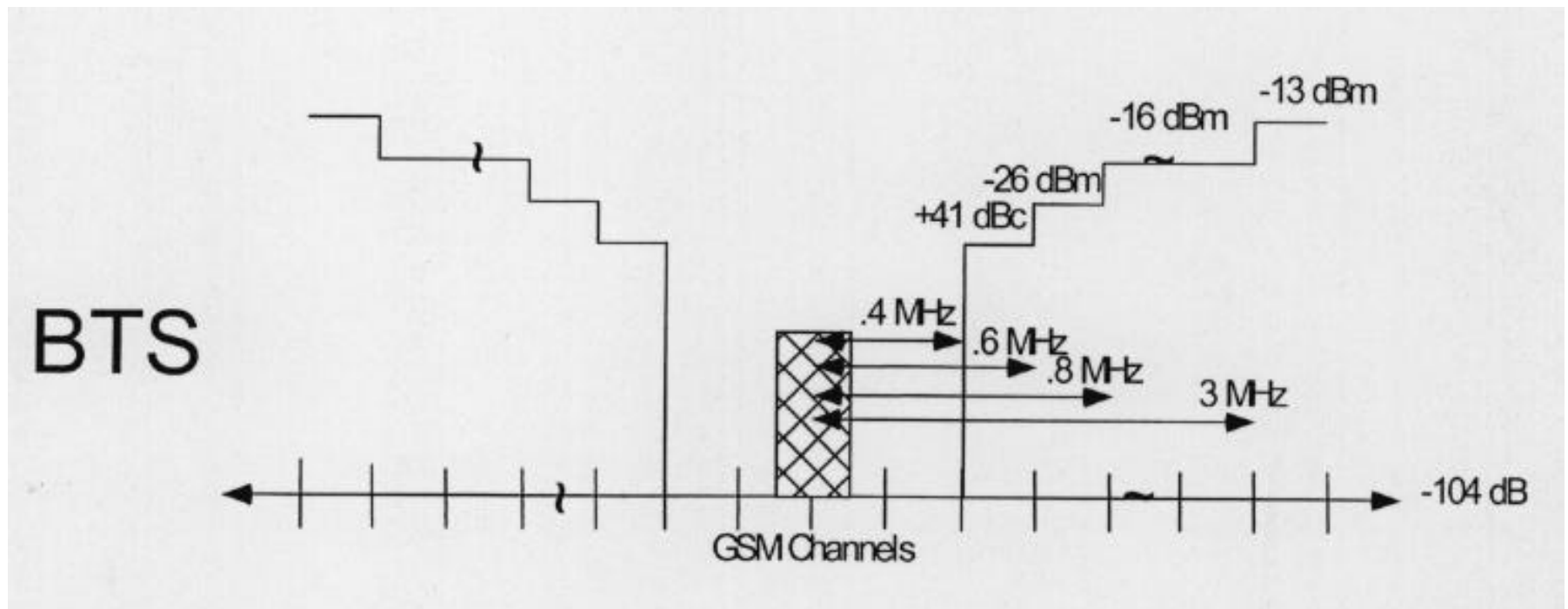
Software Radio Business Cases

- Steinbrecher -
  - sold to Tellabs
  - 1998 getting out of wireless; focus on fiber apps
- Watkins Johnson -changing commercial strategy
  - System "Base2" wideband software base station
- Airnet - changing company message
  - mixed success in market; management changes
- Arraycom - changed early technology focus to concentrate on customer needs - WLL/PHS

Software Radio: *the vision*

- Build one radio for all standards (gsm, amps, cdma,…)
  - required performance can't be obtained
  - not much practical need for multi-standard radios
- Software radios are "future proof"
  - what are future requirements?
- Software radios are smaller/lower cost
  - RF channel count/base station declining
- Software radios can fit into your network
  - the value is the network, not the radio
  - Who cares about the network…we need financing?

Multi-Carrier Wide Band Radio Architectures

- "Holy Grail" of System and Converter Designers, offers the promise of…

  – Eliminating redundant RF signal paths (cost, size, complexity, yield, adjustments)

  – Single "software radio" is re-programable for different air interface standards

  – permits incremental channel or standards changes

- However, there are challenges to implementation…...

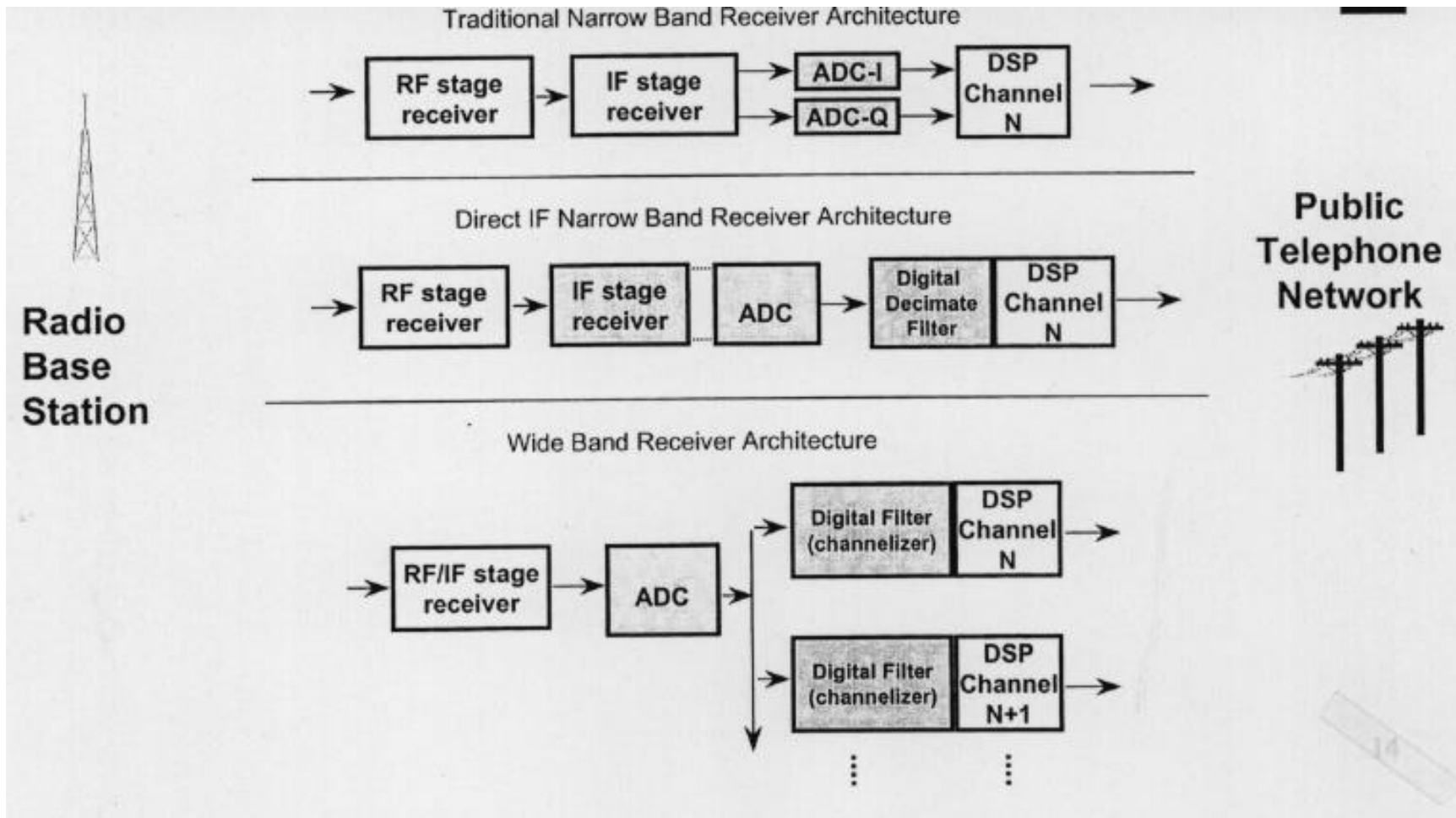# Multi-Channel RX Challenges
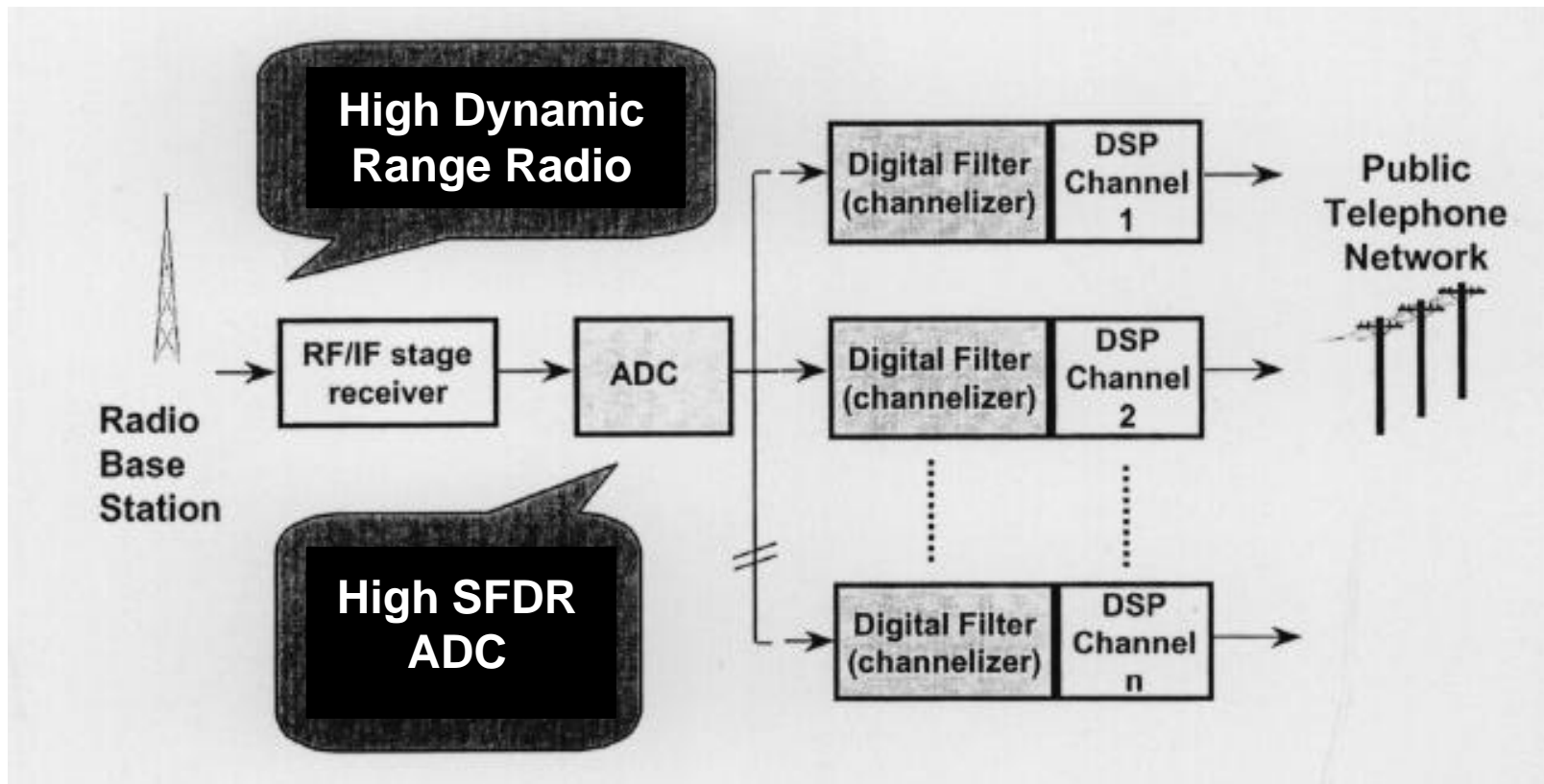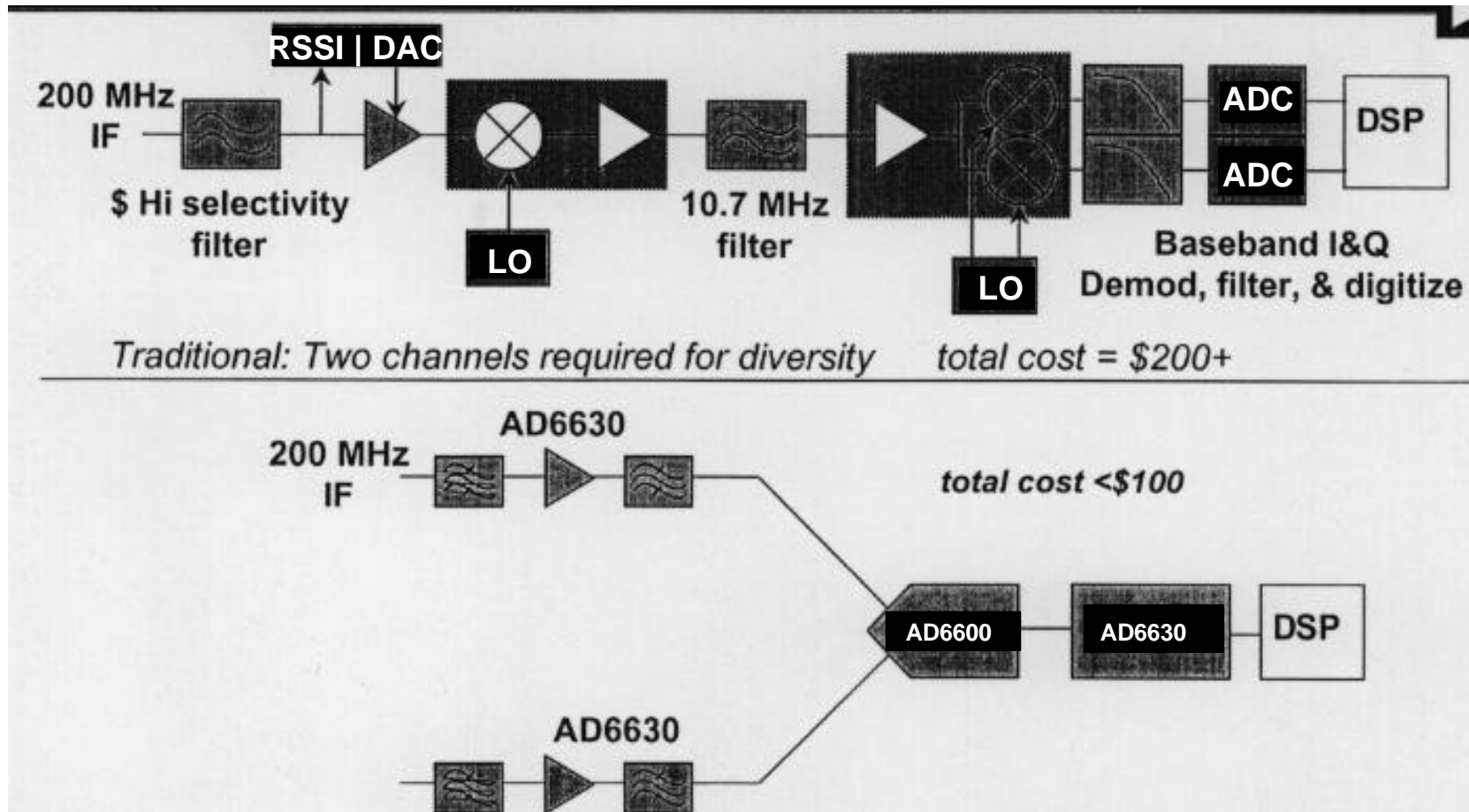
Multi-Channel Receivers need...

- Very large dynamic range (SFDR)
  - No analog channel filter to attenuate blockers
  - Mixers, amplifiers, ADCs need excellent IMD
- Systems with compatible blocker requirements
  - GSM 900 very difficult to implement with current technology…-13 dBm blocker versus -104 dBm floor
  - DCS1800/PCS1900 can be implemented with current technology
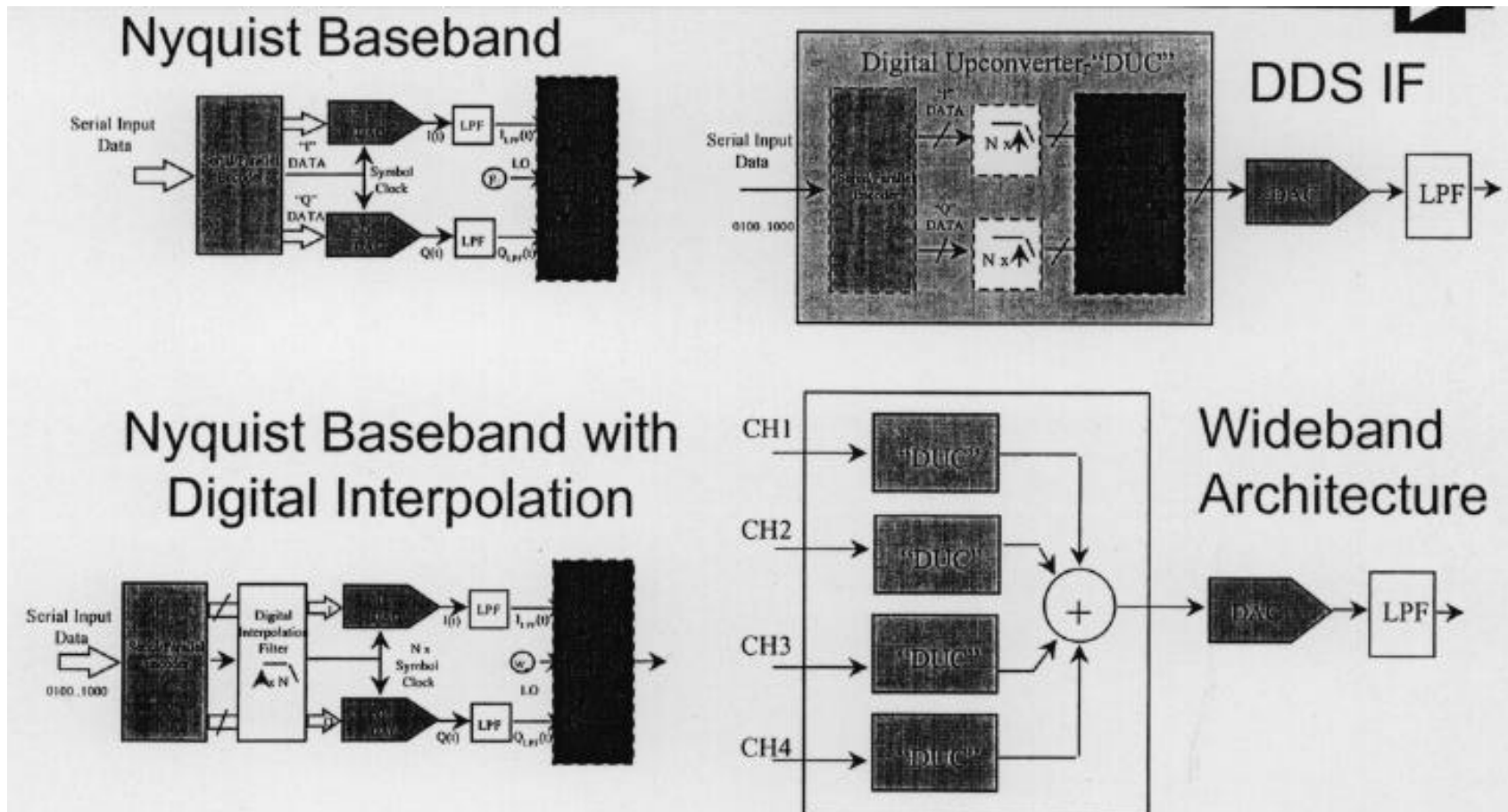- Compelling economic reasons to replace existing solutions
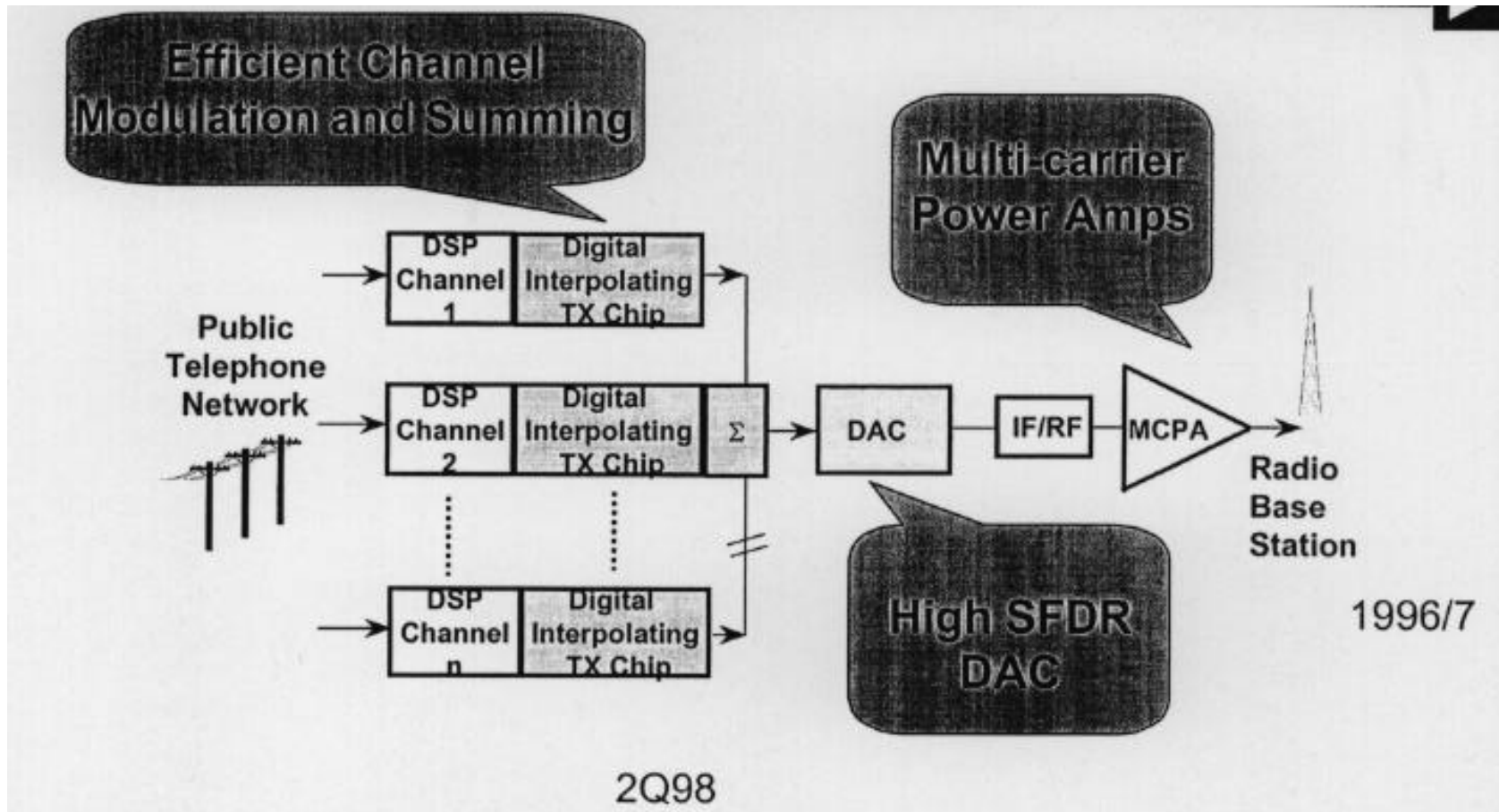
Receiver Architectures

Traditional Narrow Band Receiver Architecture

Direct IF Narrow Band Receiver Architecture

Wide Band Receiver Architecture

Radio Base Station

Public Telephone Network

Narrowband Chipset comparison *(IF to digitizer(s))*

15

Transmit Architectures

Wideband TX Challenges

Military roots; commercial needs

- Radio Standard - IS-136, GSM, CDMA, prop., etc.
- Cell Coverage - Macro, Micro (5W), Pico (1W)
- Commercial applications have bounded requirements
- Must meet cost goals and have business reason
  - Component and architectures
  - ADCs, amplifiers, DACs, DSPs, etc. Have all dramatically improved
- Software radio techniques used to *fill niches*
- Must find channel to *network supplier*

Multi-Channel Applications
## Phased Antenna Arrays

- Increase cell range using beam forming technology to control antenna array pattern (may be dynamic)

- Changes the cost content of Basestation

    - Transmit Power amplifers are expensive. Power and cost are reduced for each element n transceivers *per RF channel...*

    - An ideal candidate for a Wideband Architecture!

- Simplifies design

    - One Local Oscillator for complete system

    - All tuning done digitally, all NCOs are phase synchronized

    - low incremental cost for added capacity

Transmit Phased Array
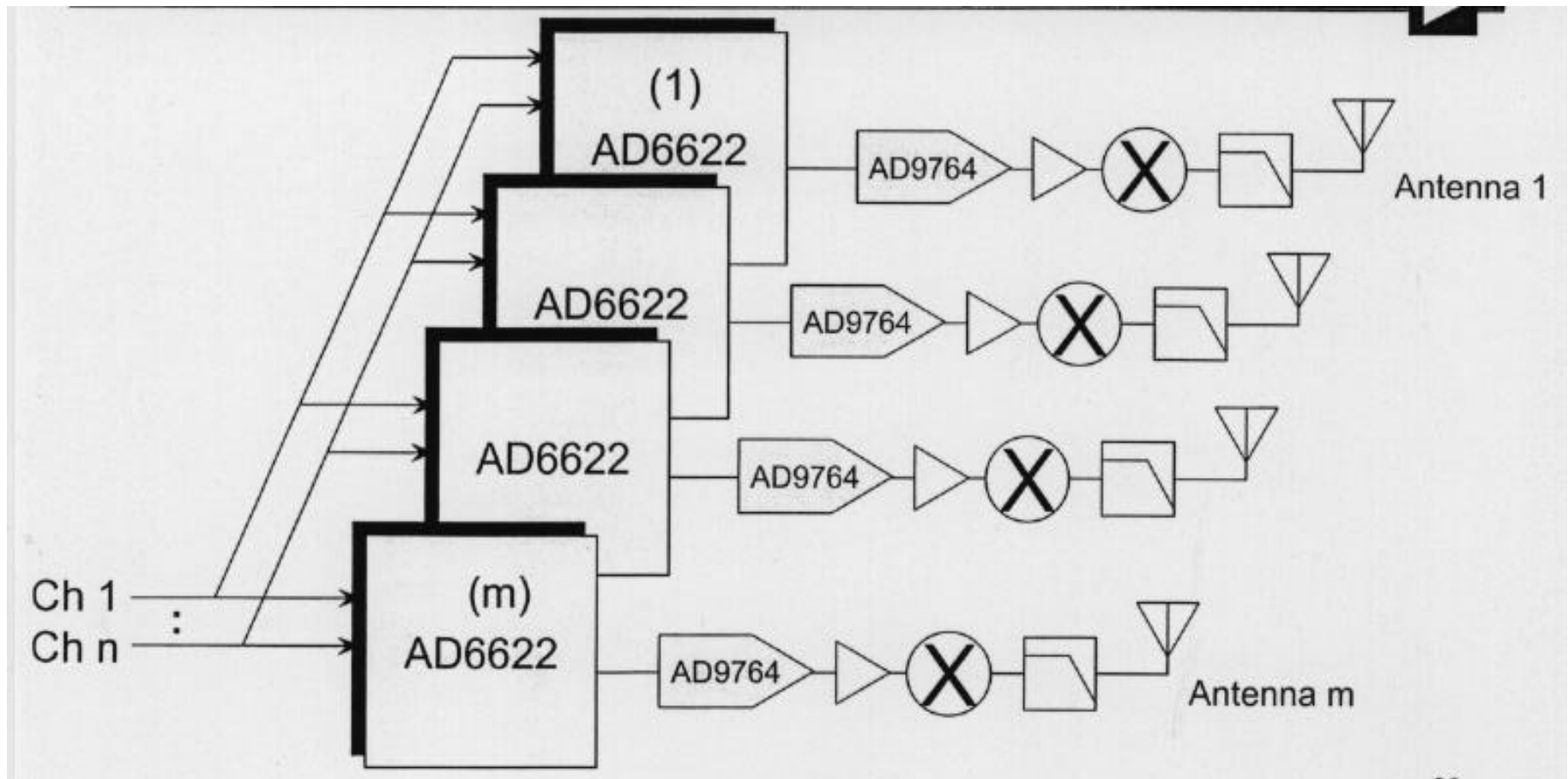
Receive Phased Array
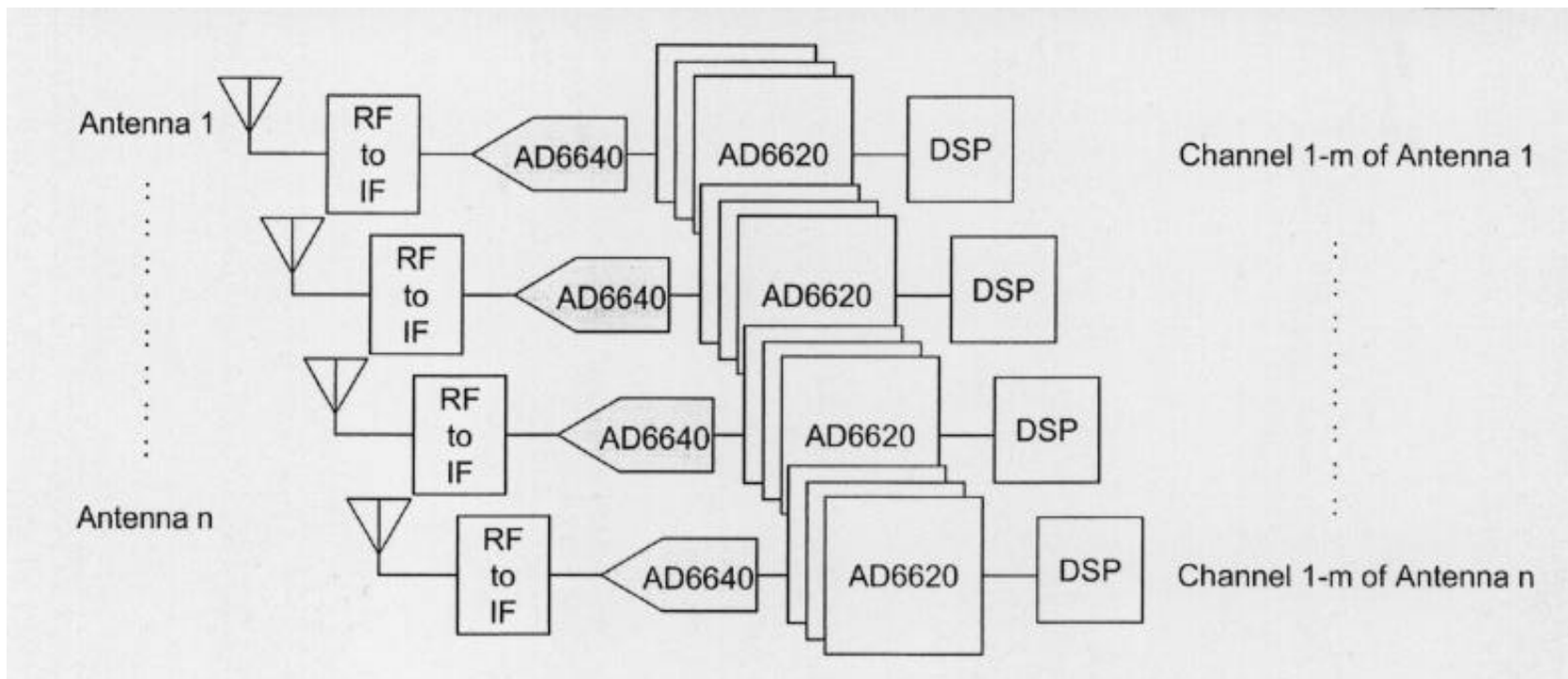
Dataquest: "Market forces"

- Replace single channel PA with MCPA
- More robust signal processing algorithms
- Process more base band channels through fewer DSPs
- Move the digital processing of RF/IF signals closer to the antenna
- Increased demand for pico/micro cells and repeaters to fill dead spots in networks

Analog Devices Experience

- Much greater focus on commercial markets…
- "Democratization" of Military Radio technology
- Key application area
  - phased array systems - frequency utilization
  - new radio architectures - lower cost, smaller size
  - new single channel, high IF sampling chip sets
    - lower RF BOM, less factory tweaking,
    - higher factory yields, less development costs
    - dramatically smaller radios
    - predictable digital vs. analog filtering