BGAN Satellite Communications in a Software Defined Radio Context

SDR Forum Technical Conference

December 2009

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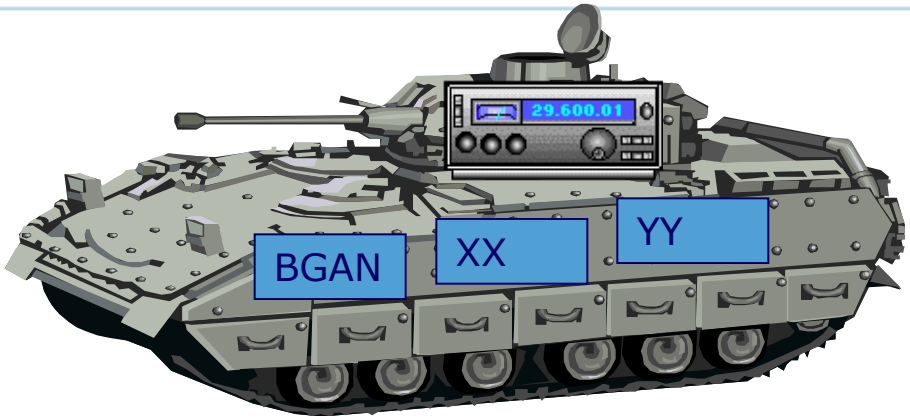
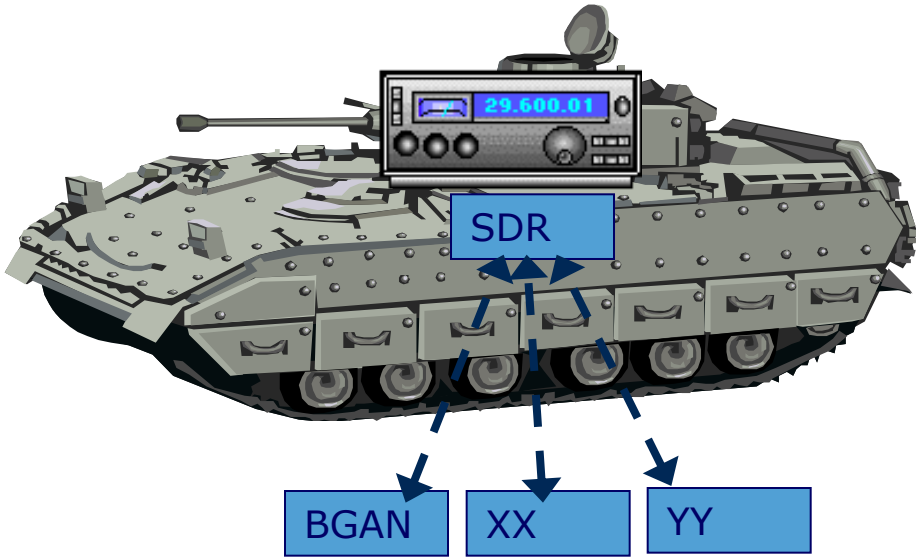
Traditional vs. SDR view on communications



- Specific purpose hardware
- Stovepipe system



- One radio – several communication means
- Flexibility is key

Benefits of commercial SatCom for military use

- SATCOM communication link available as needed
  - Greatly improved interoperability
  - Independence of geographic location
  - Allows for global, on-demand, high data rate BLOS capacity
  - Back-up solution in order to ensure constant connectivity
- Is there a simple way to include SATCOM in communication portfolio without adding equipment?

GateHouse in Brief

- A Danish Company
- Technical Software and System Engineering
- Established 1992
- 70 employees
- Cooperation with Inmarsat since 1999
- Specialized in technical software development and system integration for advanced communications systems
  - Supplier of BGAN embedded protocol stack and BGAN testing software
  - GateHouse has supplied the protocol stack to 8 terminal manufacturers
- BGAN SDR programme since 2007

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Inmarsat

inmarsat
Total Communications Network

- Inmarsat A
- Inmarsat B
- Inmarsat C
- Inmarsat D+
- Inmarsat E
- Inmarsat M
- Inmarsat mini-M
- GAN (M4)
- Aero C
- Aero H/H+
- Aero I
- Aero L
- Aero GAN (Swift 64)
- Fleet 33/55/77
- BGAN

- Extensive experience with Mobile Satellite Services using **Geostationary Earth Orbit** (GEO) satellite constellations
- Established 1979 – 30 years anniversary
- 3 generations of own satellites – 11 satellites
- The BGAN investment is around 1.5 billion US$:
  - New fleet of satellites (Inmarsat-4)
  - New satellite access stations
  - New terminals
- BGAN began operation in December 2005
- Global coverage from January 2009

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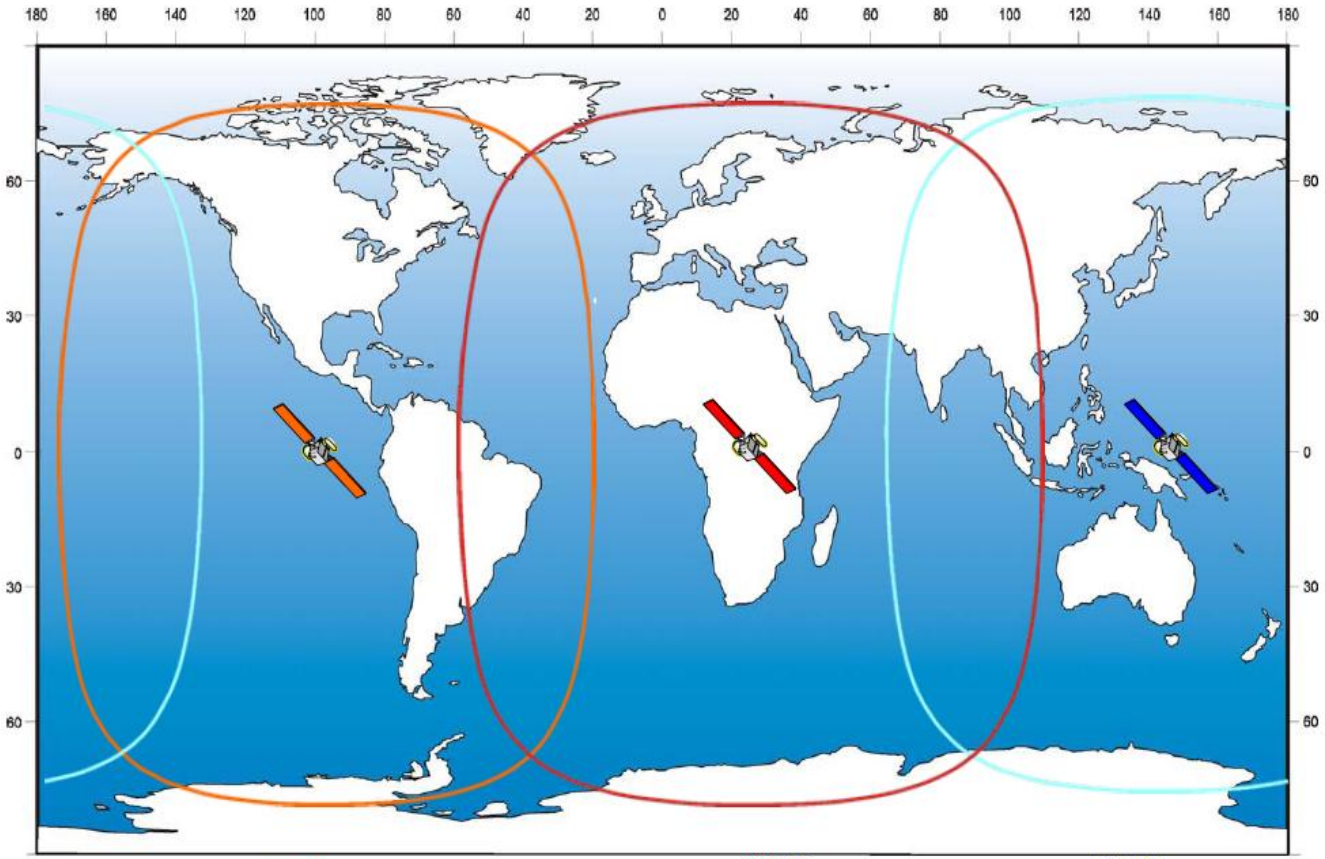
Inmarsat Broadband Global Area Network



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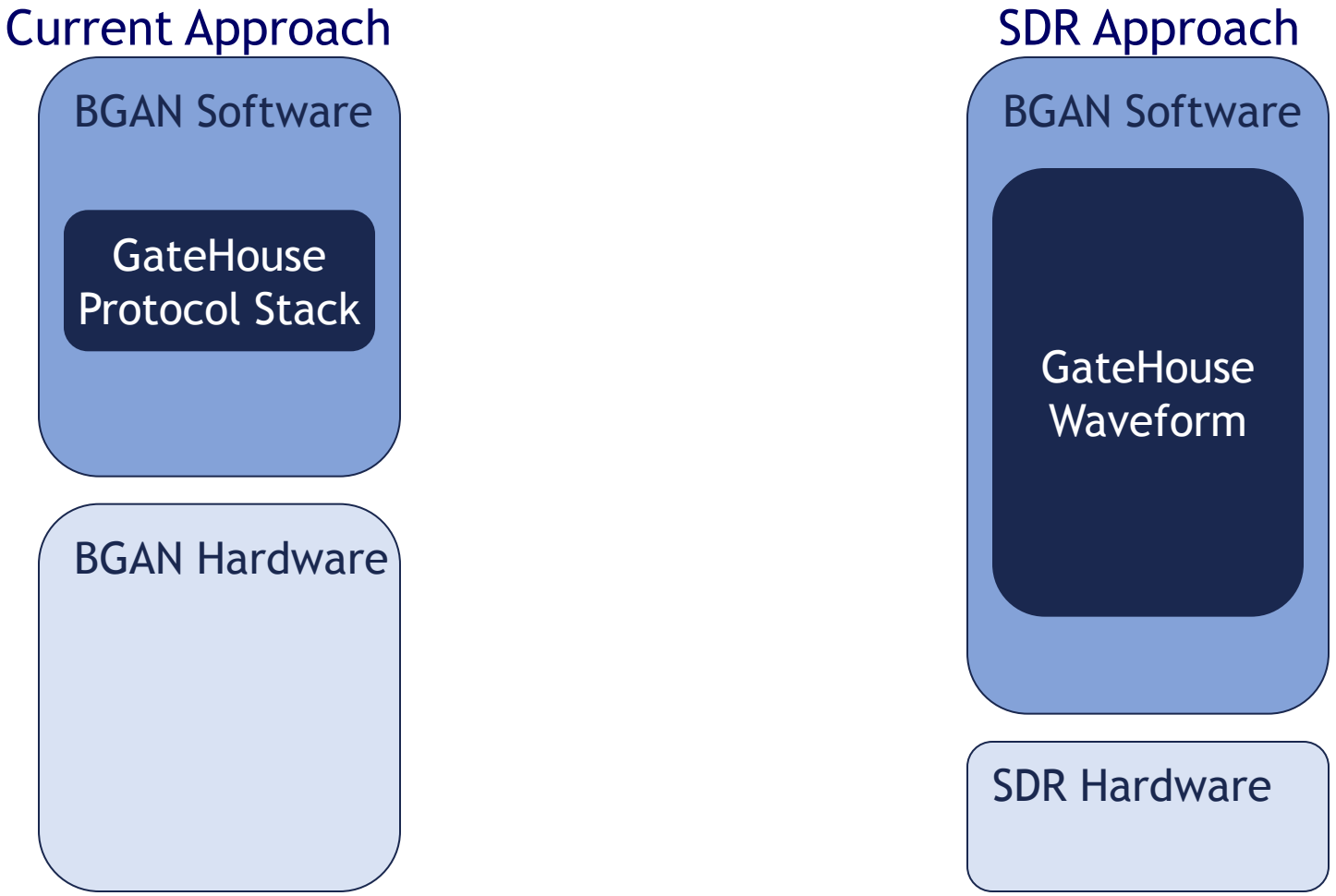
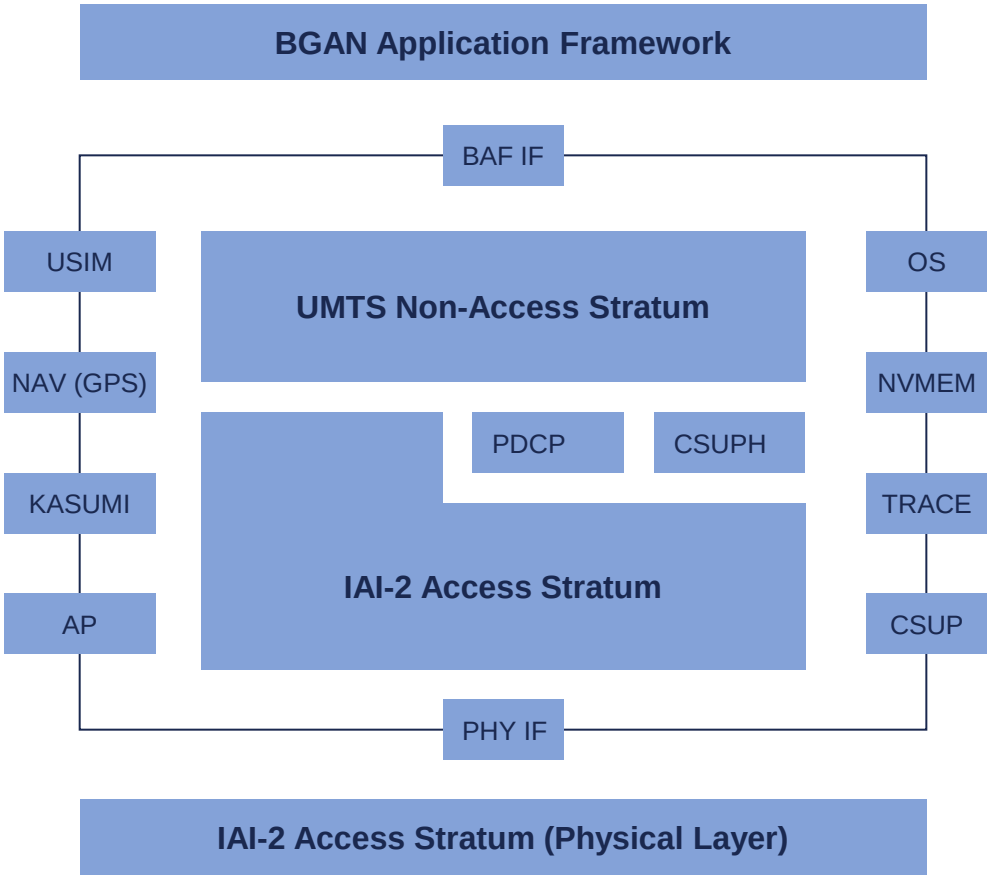
What you can do with BGAN

	Data	• Standard IP (TCP) • Variable bit rate service • Up to 492kbps (send & receive)
	Streaming	• Guaranteed bit rate service • Available on demand • 32, 64, 128, 256 kbps (send & receive) • UDP support • ISDN support
	Voice	• 4kbps circuit-switched service • Voicemail • Enhanced services: call waiting, forwarding, barring, holding • Broadcast quality voice 3.1kHz
	Text	• Send and receive text messages via your laptop • 160 characters SMS

BGAN Software Defined Radio



BGAN Waveform Architecture



Software Defined Radio Waveform - Requirements

- For terminal/radio manufacturers:
  - Easy to integrate
  - Flexibility in addressing customer requirements
  - Reduce time to market
  - Decrease total cost of ownership (TCO)
  - Simplify bug fixes and upgrades

Waveform Complexity

BGAN waveform figures from past experience:

- Waveform design and development: 30 man-years
- Matured and approved product: additional 10-20 man-years
- Plus additional expenses for
  - Test equipment
  - Certification and field campaigns

The Porting Process

1. Evaluate and select platform (SDR-4000)
2. Select L-band Up/Down converters and antenna
3. Write code for interfaces
   a) The Operating System (INTEGRITY)
   b) The Antenna
   c) The USIM reader
   d) The Up/Down converter
4. Build GPP, DSP code and FPGA image
5. Load executable code and check the boot-up sequence
6. Use a physical layer simulator and run initial test scripts (on the GPP) against the Inmarsat protocol tester (TCM)
7. Activate real physical layer and start receiving from the BPLT/BNE

The Porting Process – Cont'd

8. Perform signal acquisition and start transmitting bursts to the BPLT/BNE
9. Execute Inmarsat MTRs for pre-conditional case approval
10. Test for high symbol rates (full bandwidth)
11. Physical layer MTRs test for
    a) Out-of-band emissions
    b) Timing control
    c) Power control
12. Perform receive only test using antenna pointing to the Inmarsat-4 satellite
13. Perform registration, attach and context activation
14. Check for data throughput on-air using FTP file transfers

BGAN Platform Requirements

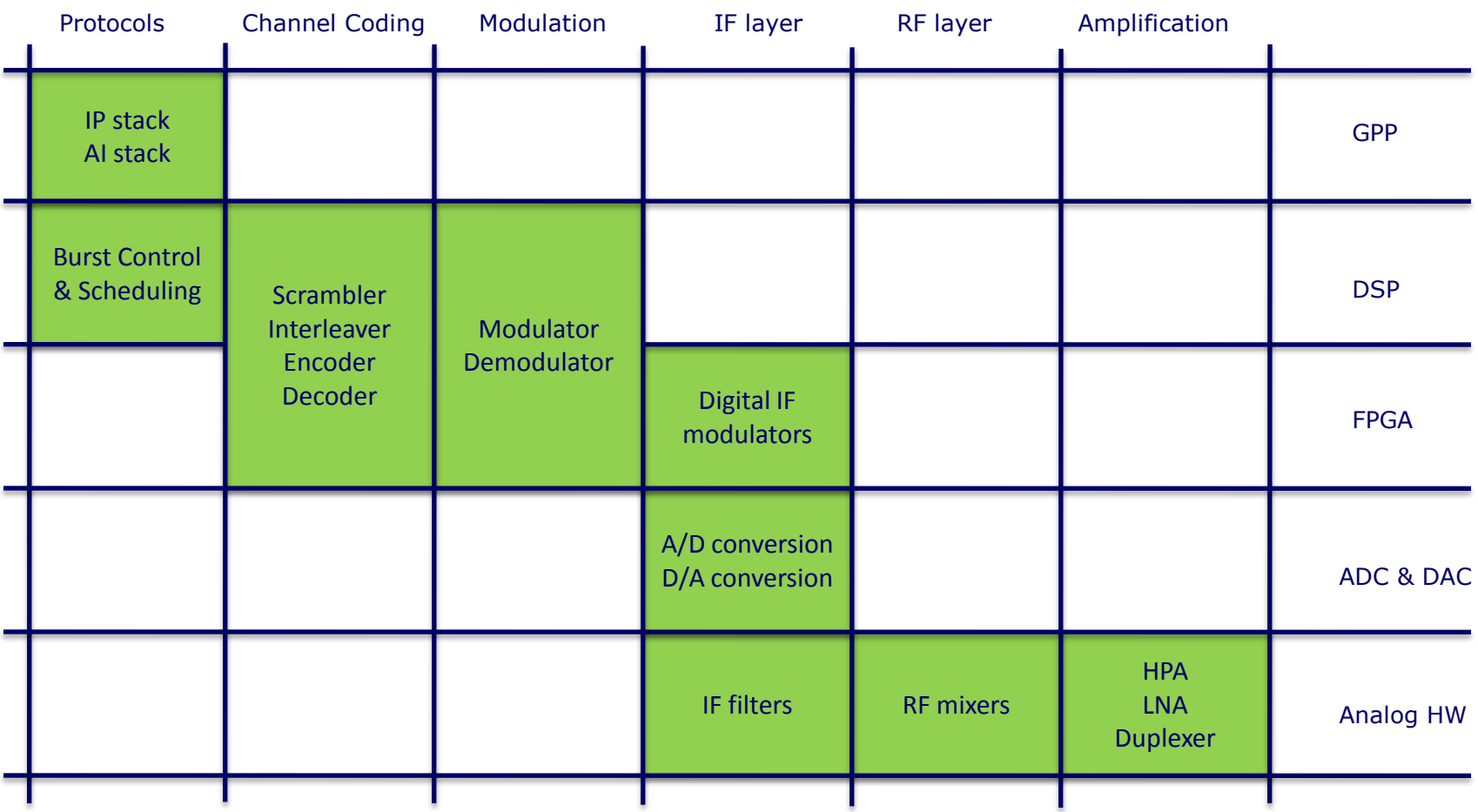
Protocol Stack and Applications:

- GPP
  - MIPS: 300, for full bandwidth, all UE classes, both CS and PS
  - RAM: 16MB (32MB recommended)
  - ROM: 8M

Physical layer:

- FPGA (Field Programmable Gate Array):
  - Altera: Better than or equal to Cyclone II with approx. 50.000LE
  - Xilinx: Better than or equal to Spartan-3 with approx. 50.000LC
- DSP (Digital Signal Processor):
  - Fixed point, 16bit or better
  - C compiler support required
  - 1Mbyte memory
- RF (Radio Frequency circuits):
  - Support for BGAN carriers, RX: 1.525 - 1.559GHz, TX: 1.6265 - 1.6605GHz
  - Transmitter power and receiver sensitivity depends on antenna gain
  - IF bandwidth: 34 MHz or more
  - Min. 12 bit ADC and DAC
  - Full duplex (Concurrent operation of transmitter and receiver)

Mapping Matrix



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Spectrum Signal Processing in Brief

- A Canadian Company
- Established 1987
- 70 employees
- Provides integrated solutions for advanced satellite, video, and communications systems
  - Developed 5 generations of SDR solutions for commercial and defense applications
- Part of Vecima Networks Inc.,
  a last mile solutions provider

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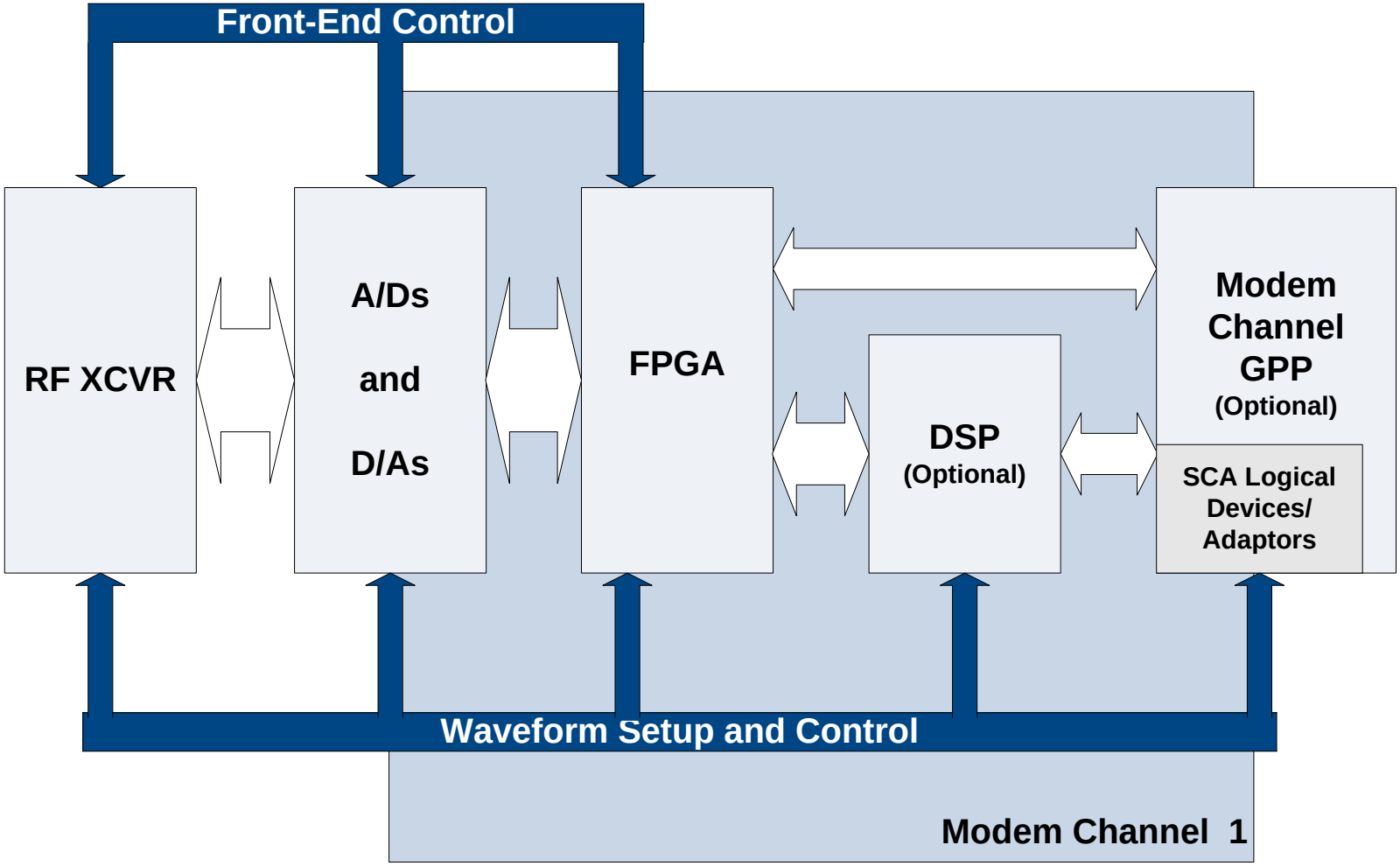
Software Defined Radio Hardware Platform: Requirements

- For Terminal or Radio Manufacturer
  - Provide economies of scale
  - Simplify bug fixes and software updates
  - Reduce time to market
  - Support both legacy and advanced waveforms
- For a Network Operator or Systems Integrator
  - Maximize equipment longevity by allowing upgraded capabilities and enhancements as standards evolve
  - Deploy new services quickly
  - Flexible spectrum allocation

Software Defined Radio Hardware Architecture



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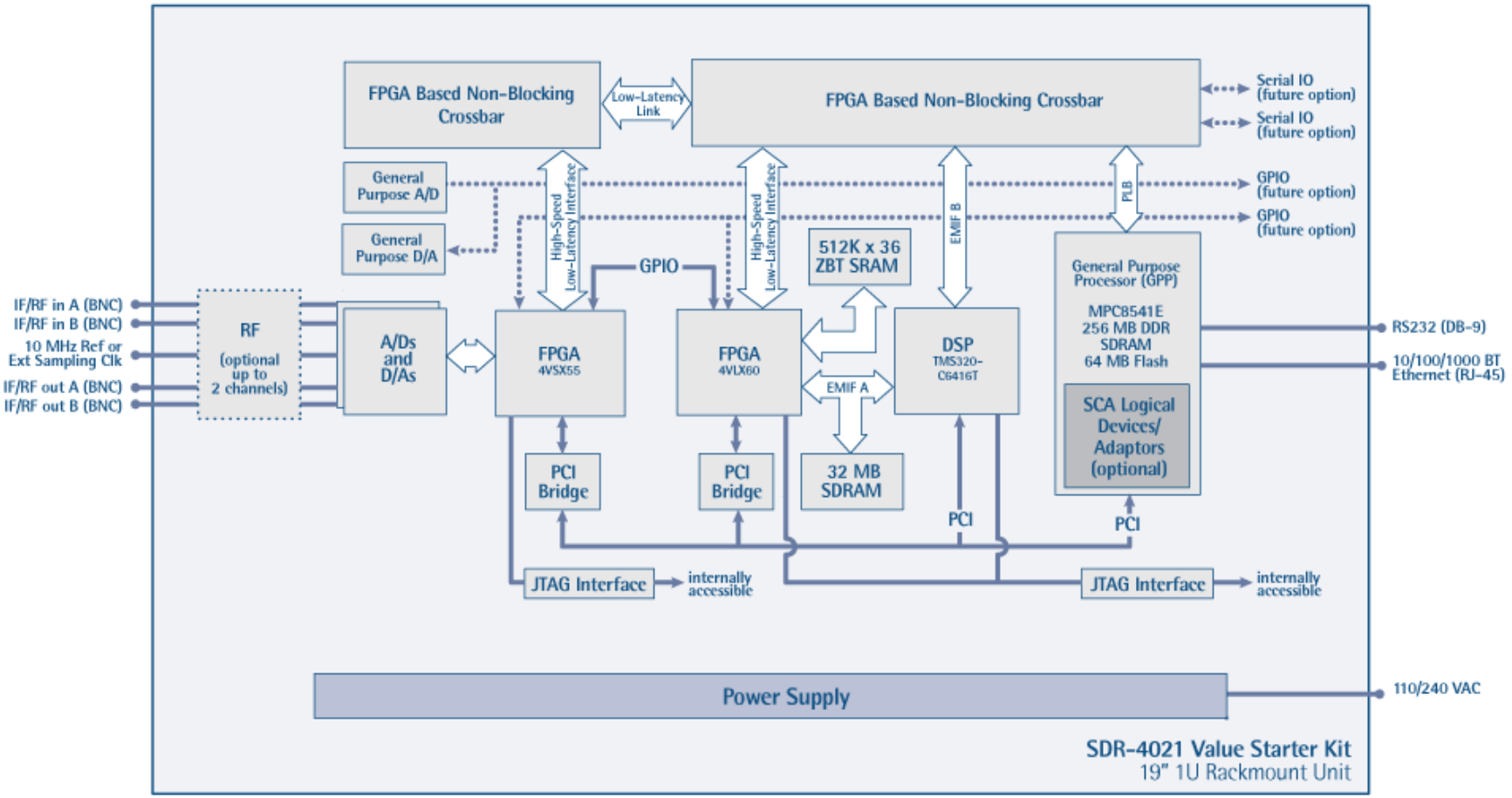
Software Defined Radio Hardware Platform: A COTS Platform

SDR-4021



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Software Defined Radio Hardware Architecture: A COTS Platform

SDR-4021		
General	FPGA	Xilinx Virtex-4 SX55 and LX60
	DSP	Texas Instruments 600 MHz TMS320C6416T processor with 16 MB SDRAM
	GPP	400 MHz Freescale MPC8541E with 256 MB of 667 MHz DDR SDRAM and 64 MB flash
Analog I/O	ADC	Two Analog Devices AD6645 14-bit @ 96.0 MSPS
	ADC Input	AC coupled, 50 ohm load
	DAC	Two Analog Devices AD9755 14-bit @ 192.0 MSPS
	DAC Output	AC coupled, 50 ohm load
	Coupling	AC – standard, DC – optional
	Low-Speed ADC	Quad 12-bit @ 100 KSPS
	Low-Speed DAC	Dual 12-bit @100 KSPS
External Interfaces	Ethernet	GigE (10/100/1000 BaseT) RJ -45 on the rear panel
	Low-Speed Serial	RS232 data, DB-9 Serial port
	Analog Input	2 channels, BNC connector, 50 ohms
	Analog Output	2 channels, BNC connector, 50 ohms

Consists of modular cards that can be used in other applications

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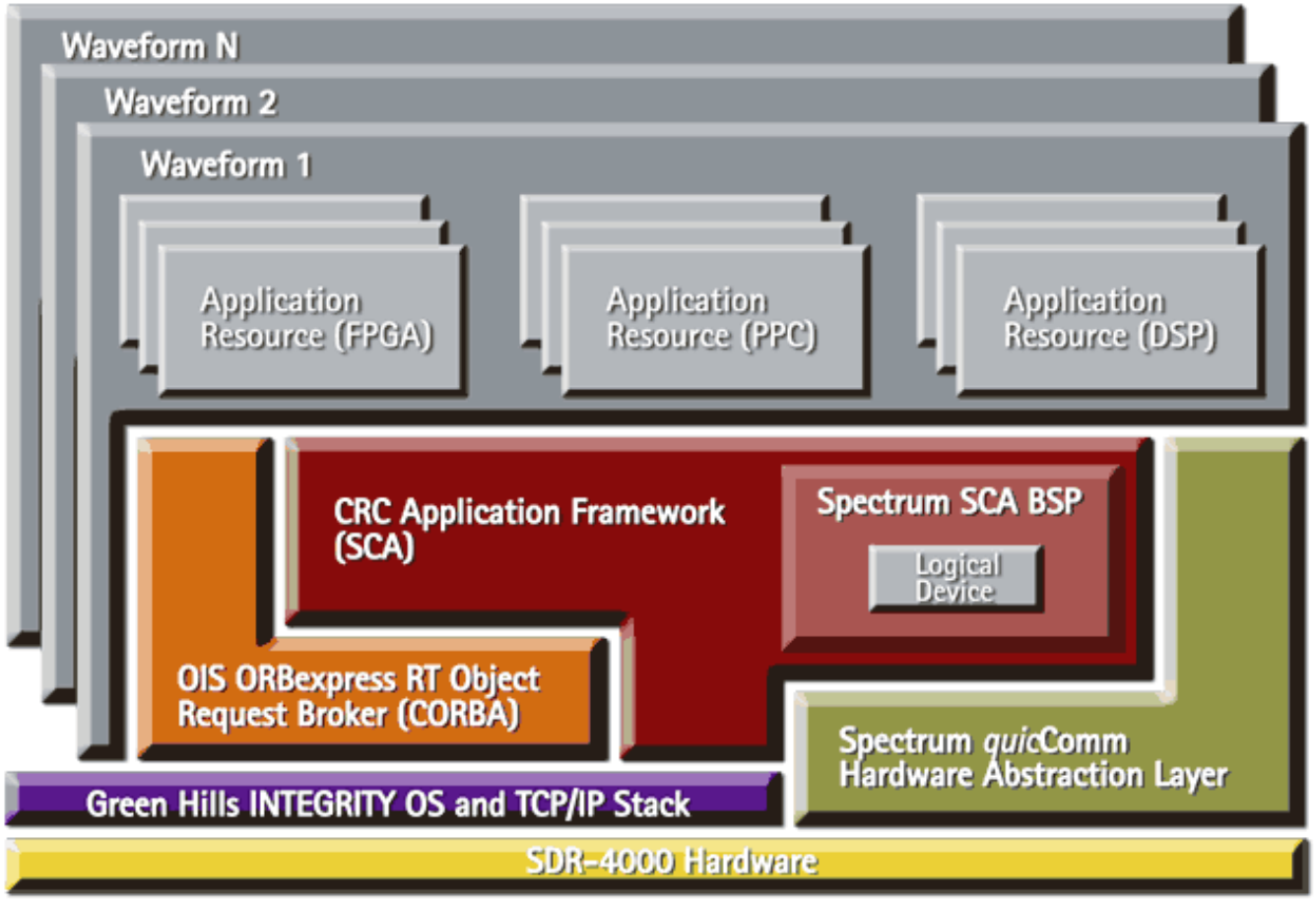
Software Operating Environment



SDR-4021 – One Modem, Multiple Waveforms

Military Waveforms

- MIL-STD-188-181B UHF SATCOM PHY
- WNW OFDM PHY – Wideband Networking Waveform – US only
- SRW EW PHY – Soldier Radio Waveform Electronic Warfare
- SINGCARS – Single Channel Ground and Airborne Radio System
- FM3TR – Future Multiband Multiwaveform Modular Tactical

Commercial Protocols or Standards

- INMARSAT BGAN – Broadband Global Area Network
- APCO P25 – Project 25 – Public Safety
- TETRA – Terrestrial Trunked Radio – Future
- DVB-S2 – Digital Video Broadcasting – Satellite Second Generation – Future
- DVB-RCS – Digital Video Broadcasting – Return Channel via Satellite – Future
- MPEG 2/4 Video Encode/Decode – Future

Prototype BGAN SDR Terminal

BGAN Class 10
Land Mobile
Tracking Antenna

Spectrum SDR-4021

L-Band Converters

RF Front-end
Antenna Control Unit
Power Supplies

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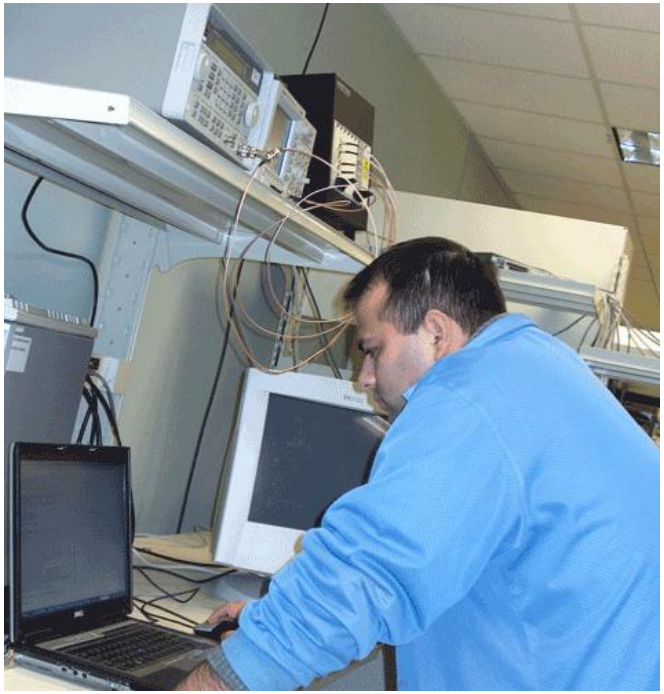
Current Status

- Porting and final waveform development accomplished in 8 months
- Compliant with Inmarsat Preliminary Conditional Case Approval (PCCA)
  - Allows for live demonstration on SDR Forum 2009
  - Physical layer and Protocol level test (on the bench)
  - On-air test on Inmarsat test network (I4-F2)
  - On-air test on Inmarsat operational network (I4-F2)
- Demonstration on SDR Forum 2009
  - Email (send an email to your PDA or laptop)
  - Streaming video
  - FTP transfers showing transfer data rates
  - WWW browsing

Use Scenario #1 – Waveform Development

Target Users

- Commercial Satellite Service Operators
- Commercial or Military SATCOM/Radio Manufacturers
- Research and universities



Advantages

- Develop specialized application or network layer enhancements to waveform
- Reduce hardware investment by re-using same platform for multiple waveform development efforts

Use Scenario #2 – Testing

Target Users

- Test Equipment Manufacturers
- Radio or Terminal Manufacturers
- Waveform Developers

Advantages

- Avoid expensive over-the-air testing by emulating Inmarsat BGAN network
- Invest in one reference SDR hardware platform that can be used to test other terminals
- Test equipment can be reconfigured at the factory or in the field

Use Scenario #3 – Field Terminal Development

Target Users

- Terminal and Radio Developers
- System Integrators

Advantages

- Develop and deploy using the same hardware
- Develop unique hybrid terminals or radio products that can support Inmarsat BGAN and other terrestrial waveforms

The Future is Software Defined…

End of presentation

Thank you!

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