GLOBAL NAVIGATION SYSTEM

SENSOR APPROACH

(GNSSA) MODULE

OVERVIEW

BAE SYSTEMS

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NovAtel: Who are we?

- Canadian Corporation, located in Calgary, Alberta, Canada
- Established 1983 - initially Telecommunications now 100% high-end GPS
- Initial public offering in 1997 (NASDAQ: NGPS)
- 1999 revenues $24.2 m Cdn, 100 people, 46,000 sq. ft HQ
- BAE SYSTEMS Canada majority shareholder (58%)

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NovAtel: Our Organization

- OEM
- Aviation
- Custom Products Group
- Research and Development
- Marketing and Sales
- Customer Service and Support

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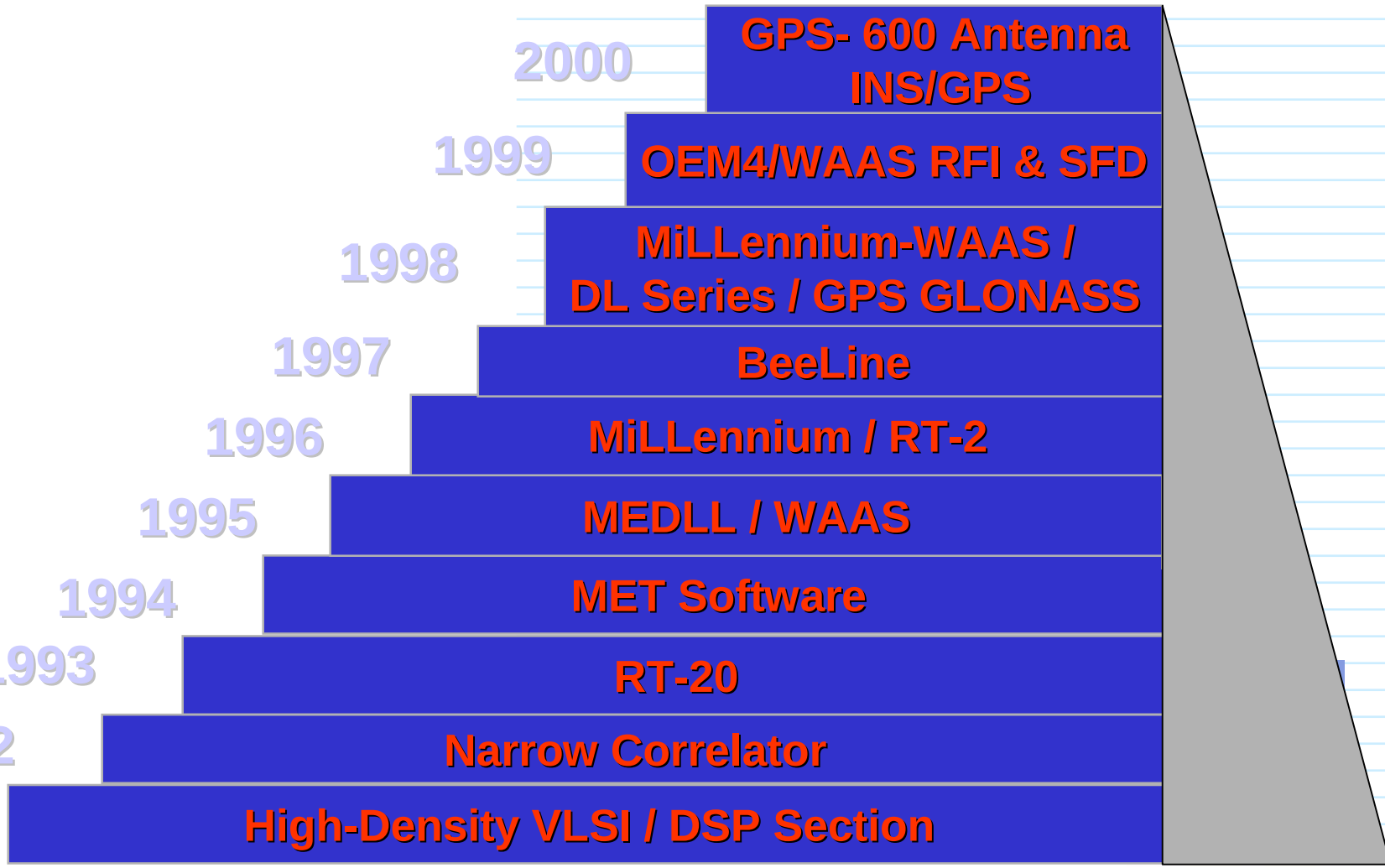
NovAtel GPS Technologies

Innovative, Proprietary Technology



GNSSA Program

- Global Navigation System Sensor Approach (GNSSA) module
- Joint Program between BAE Systems Canada (BSC) & NovAtel
- High integrity GPS landing receiver, designed to meet latest DO-229B MOPS & TSO C-145, LAAS CAT I/II/IIIb
- Integrated in Honeywell airborne FMS products
- Designed for integration into all Local Area Augmentation System (LAAS) ground stations

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GNSSA Program

- NovAtel - L1/L1 dual RF front-end & MINOS4 DSP ASIC qualification
- BSC - Receiver integration, Digital, Interface ASIC, DO-178B Level A Software
- Beta receivers scheduled for Spring 2000
- Certification scheduled for September 2000
- Market split: NovAtel address ground
  BSC address air & Honeywell ground

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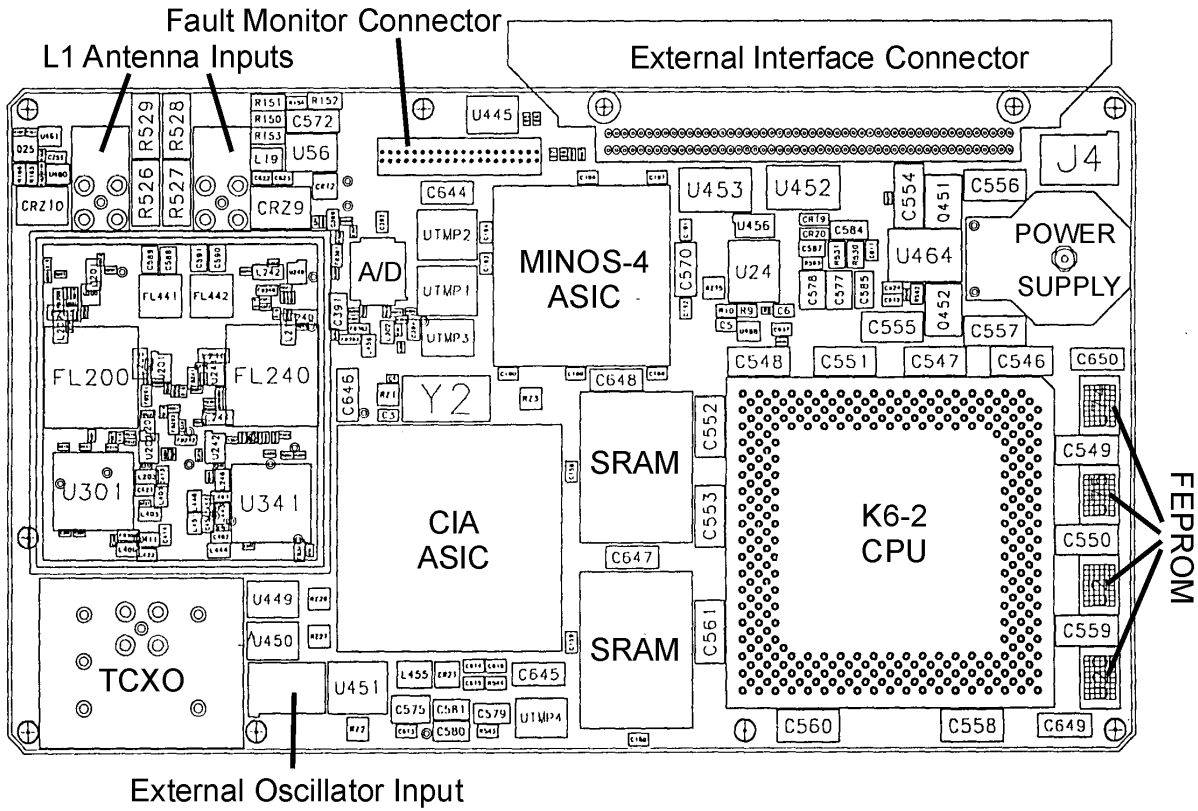
CMA 4024 GNSSA Module



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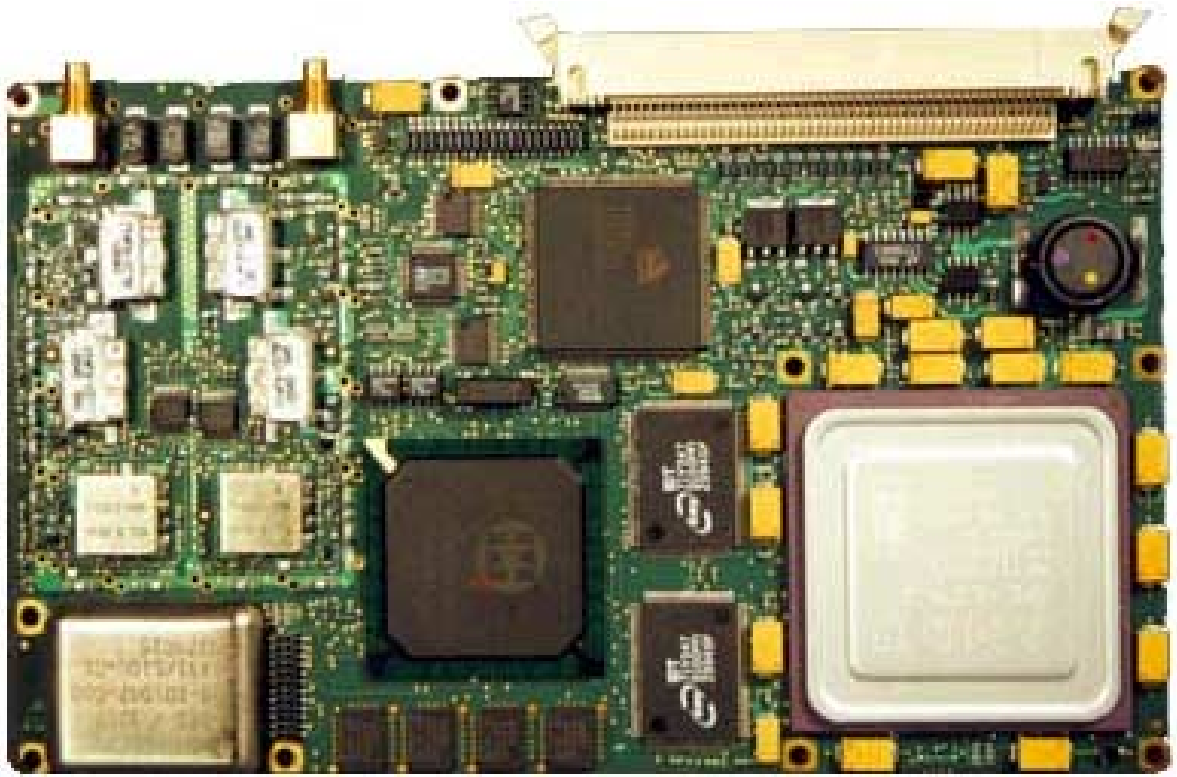
GNSSA Pre-production Model



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GNSSA Program
CMA 4024 GNSSA Module - Specifications

ACCURACY (Without Selective Availability)

Horizontal Position	22.5 meters, 95% S/A off
Altitude	30 meters, 95% S/A off
Velocity	0.05 knot. 95% S/A off
Track Angle	0.5° (V > 120)
Vertical Velocity	200 feet per minute
Time	2 microseconds
GPS Measurement Accuracy	0.15 meters

ACQUISITION TIMES

Initialized First Fix	105 sec. Max; 95% confidence
No Initialization	10 min. worst case; 3 min. nominal
Power Drop-out < 10 seconds	5 sec. typical
Satellite Re-acquisition	5 sec. typical

PHYSICAL / ENVIRONMENTAL

Size	6.5” x 4.5” x .6”
Weight	< .7 lbs
Temperature Range	-55 to + 85 ° C
Altitude Range	Between 15,000 and 60,000 ft

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GNSSA Program
CMA 4024 GNSSA Module - Specs (continued)

ELECTRICAL POWER

Operating Power	12.5 Watts max.		
Input Power	+3.3 ± .25 VDC	2000 mA	6.6W
	+5 ± .25 VDC	300 mA	1.5W
	+14 + 1.5 - 0.5 VDC	200 mA	2.8W
	-14 + 1.5 - 0.5 VDC	80 mA	1.1W
		TOTAL	12.0W

RELIABILITY

Operational Hours MTBF 72,000 hours

SENSITIVITY

Acquisition Sensitivity -134.5 dBm 100K Sky Noise

Tracking Sensitivity 3 dB less C/No than acquisition

INTERFERENCE

In-band CW Rejection RTCA/DO-229B Appendix C

Out-of-band Rejection RTCA/DO-229B Appendix C

+30 dB min band

Burn-out Protection +20 dBm out of band

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GNSSA Program
CMA 4024 GNSSA Module - Specs (continued)

INTERFACES

Inputs 9 ARINC 429, 2 RS-232, 2 RS-422

Outputs 5 ARINC 429, 2 RS-232, 2 RS-422
2 28V valid discrete
3 1-Hz time marks

SOFTWARE

Language Ada

Level DO-178B level A development
level B certification

Processor 64-bit K6-2

BITE

Continuous coverage > 95% fault decision

CONFORMITY

ARINC 429-12, ARINC 743A, DO-160D,
DO-217 (optional), DO-178B, DO-229,
DO-245, TSO-C129A, TSO-C145

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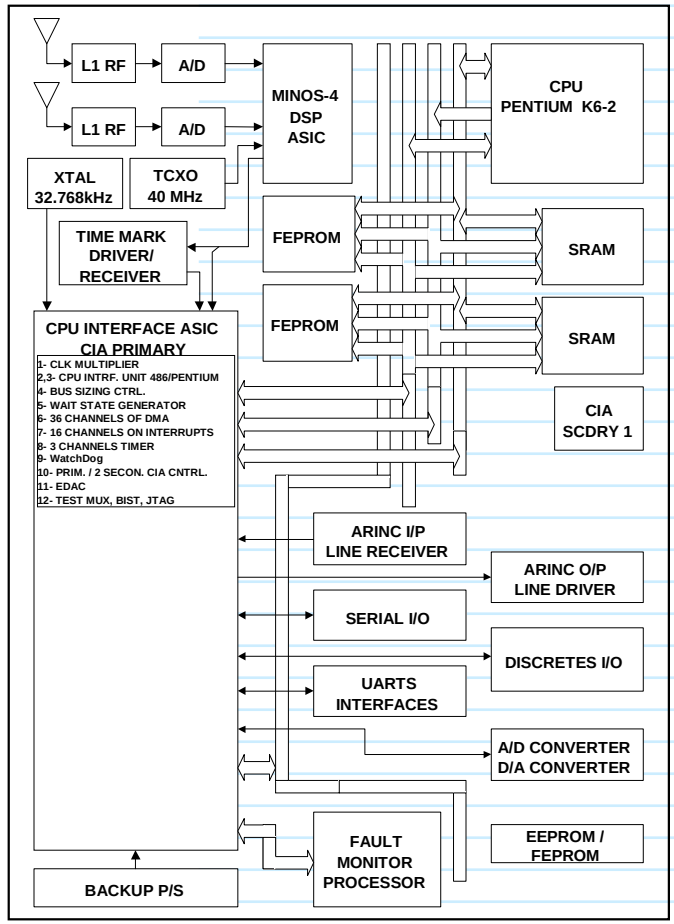
GNSSA Block Diagram



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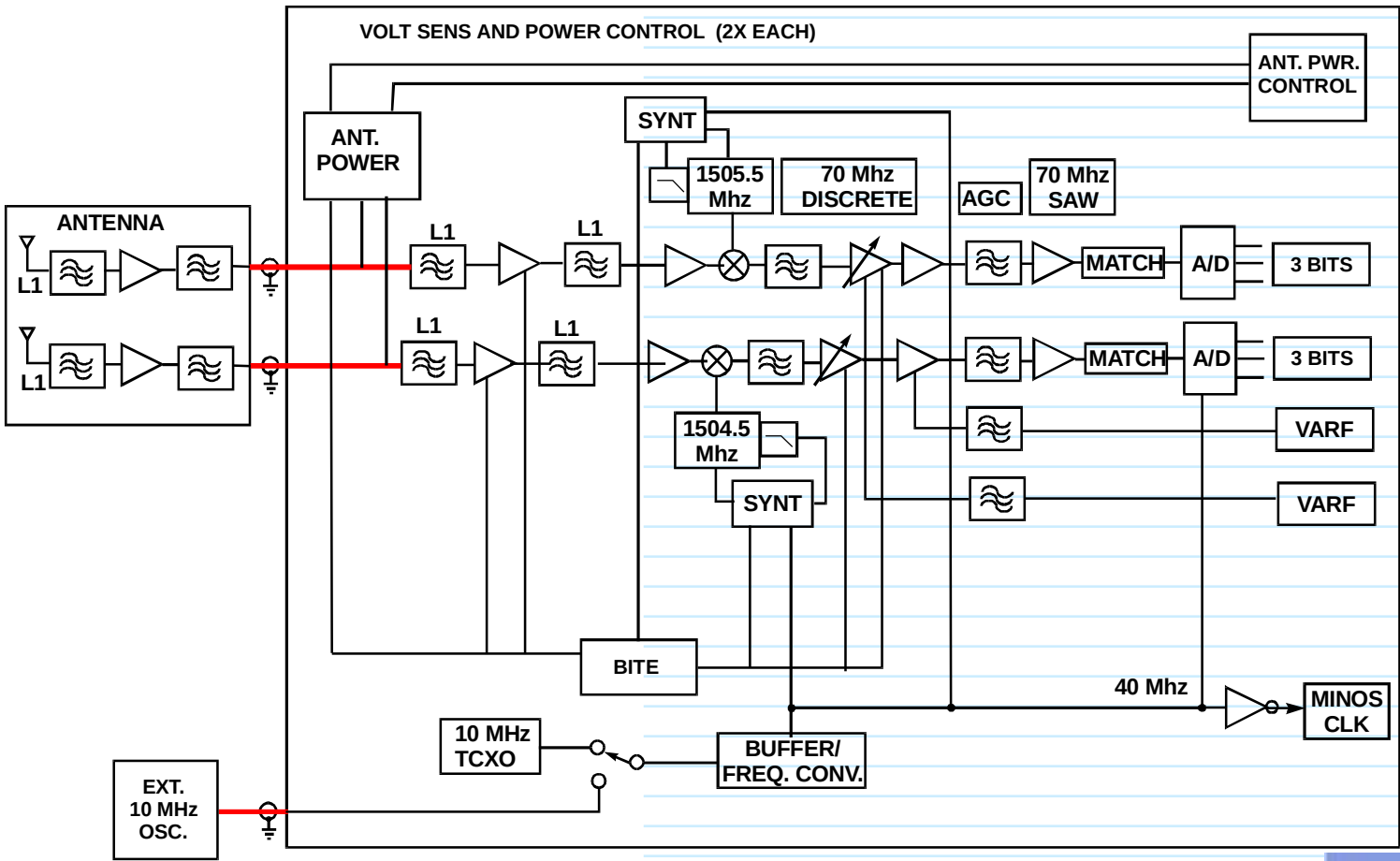
Dual L1 / L1 RF-Deck

- Two independent RF-channels
  - independent antenna feeds
  - independent digital outputs
- Single stage down conversion to 70MHz
  - minimizes in-band intermodulation & interference

Dual L1 / L1 RF-Deck

- IF amplification stage has 45dB AGC range
  - covers full GPS signal strength variation
  - accommodates DO-229B RF interference
- 3-bit sampling at 40 MHz
  - practical optimum for RFI resistance
  - superior RFI resistance

Dual L1 / L1 RF-Deck



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MINOS-4 DSP ASIC

- 24 correlator channels, each correlator channel comprises:
  - Early-Late I and Q channels
  - Prompt I and Q channels
  - Large DCO range accommodates GLONASS spectrum
- GPS C/A and P codes (not P(Y))
- GLONASS C/A and P codes
- Narrow Correlation to 1/20th chip spacing

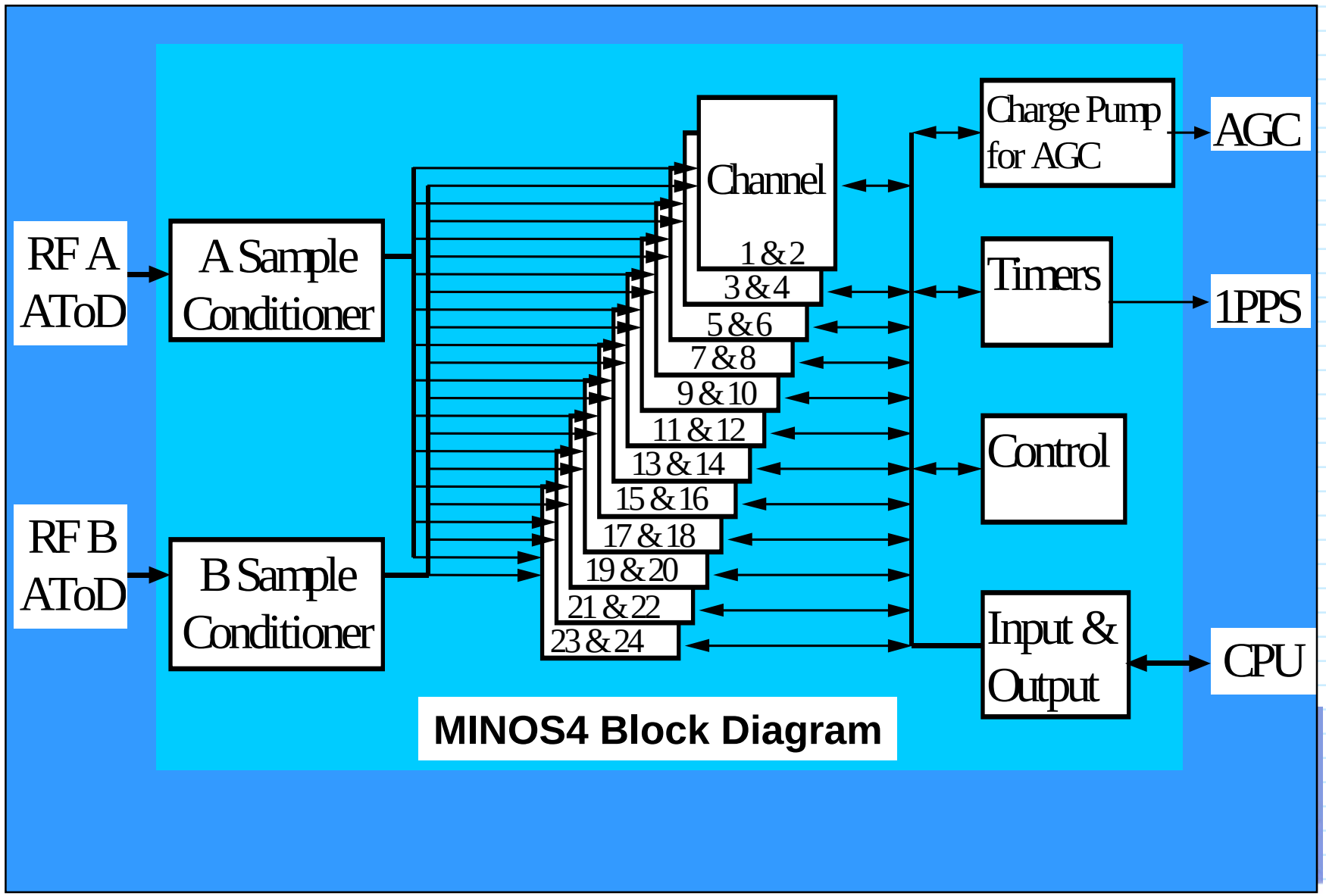
cont'd

MINOS-4 DSP ASIC

- Two independent data inputs
- On-the-fly configuration of correlator channels
  - selectable input channel
  - selectable GPS/GLONASS C/A or P code
- Hardware sky search
- Hardware bit histogram

cont'd

L1/L1 GPS Receiver



ARINC 429 Transmitters

- Five independently buffered outputs (out of a maximum of 8 available)
- Each output can be driven at either high speed (100 kHz bit rate) or low speed (12.5 kHz bit rate)
- Each outputs is fully monitored with an independent receiver read-back
- Same proven design as GNSSU

ARINC 429 Receivers

- Nine ARINC 429 input buses
- Each input has the capability to receive data @ either high speed (100 kHz bit rate) or low speed (12.5 kHz bit rate)
- Data rate automatically detected by software
- Same proven design as GNSSU

Time Mark Driver / Read-back

- Three independently buffered outputs
- Outputs meet EIA Standard RS-422 for voltage levels & impedance
- Each output is fully monitored with an independent receiver read-back

Discrete Inputs

- Eleven Discrete Inputs
- Standard Open/Ground with diode isolatition
- Proven design
- Power Down Interrupt (PDI) discrete for advance warning of power failure, uses TTL level inputs

Discrete Outputs

- Two Discrete Outputs are available
- Each output has the capability to sink 280 mA through a resistive load
- Each output is short circuits protected
- Each output is fully monitored

RS-232 input/output

- Two independent RS-232 output and input ports
  - Each output meets the EIA Standard RS-232 for voltage levels and impedance requirements.
  - Baud rate is programmable from 9600 to 115200 bits per seconds
  - Parity = none
  - Start bits = one
  - Stop bits = one
  - Data bits = eight
- Same proven design as GNSS Module

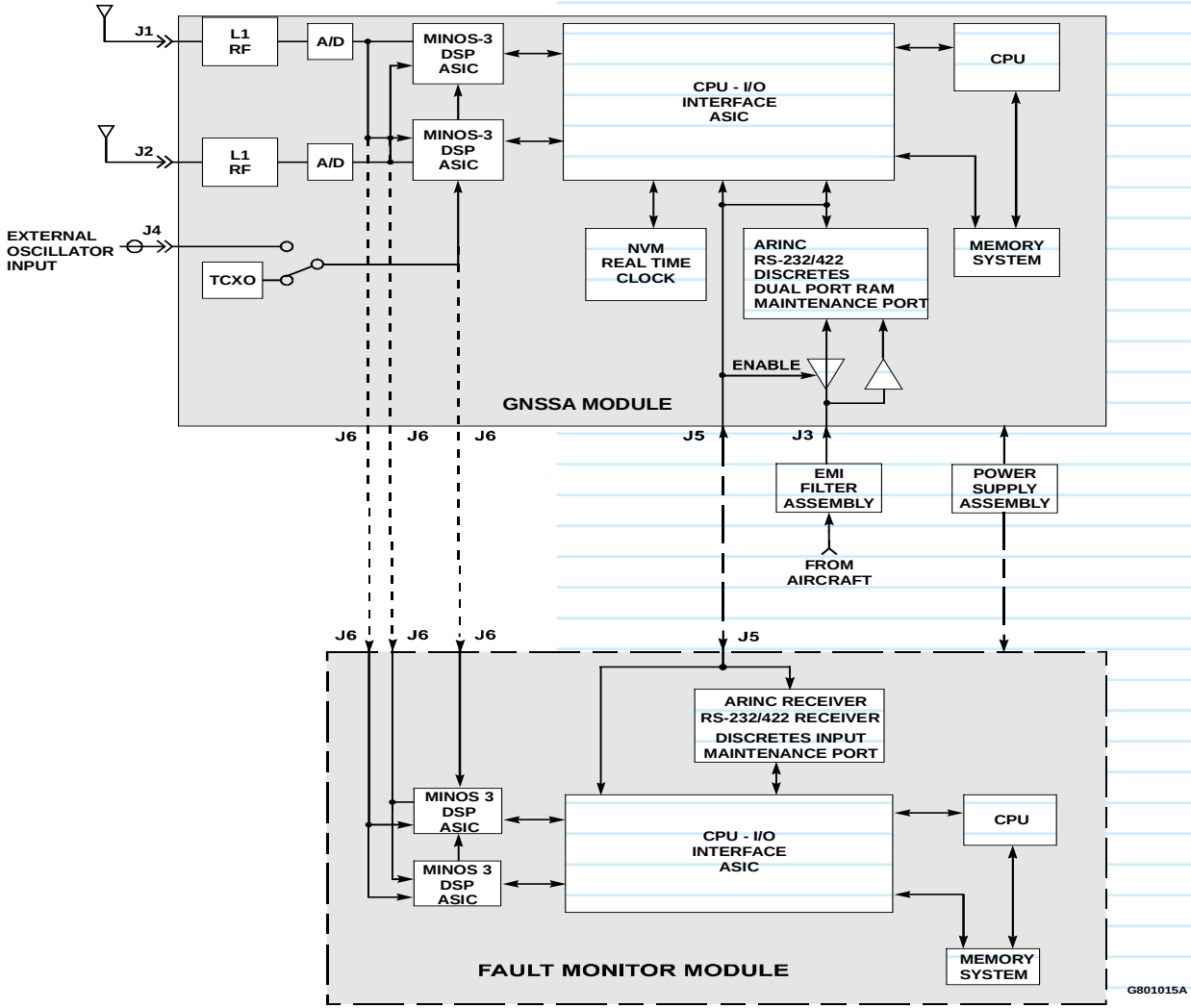
RS-422 input/output

- Two independent RS-422 output and input ports
  - Each output meets the EIA Standard RS-422 for voltage levels and impedance requirements.
  - Baud rate is programmable from 4800 to 1.2M bits per seconds
  - Parity = none
  - Start bits = one
  - Stop bits = one
  - Data bits = eight
- Same proven design as GNSS Module

Fault Monitor Processor

- Similar hardware to that of the GNSSA
- Inputs:
  - A/D samples from GNSSA and 40MHz clock signal
  - ARINC and RS-232/422 outputs from GNSSA
  - Power
- 2 lines send health status between the two processors. Lines are frequency modulated to prevent stuck HI or LOW. In case of discrepancies between GNSSA and Fault Monitor, Fault Monitor prevents data output.
- Designed for future plug-in update

GNSSA and Fault Monitor Processor Architecture



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Reliability

- GNSSA MTBF = 72,000 operating hours
- Reliability prediction based on MIL-HDBK-217F:
  - using adjustment factors for:
    - field experience (GNSSU)
    - engineering judgment
    - test data
    - manufacturer data
  - environmental conditions:
    - Aircraft uninhabited Cargo (AUC) @ 40° C
  - Component Stress Analysis for high temperature

LAAS Receiver

- US FAA LAAS Ground Facility (LGF) specification requires:
  - Signal Quality Monitor (SQM) - RTCA SC-159 WG 4A
  - Tracking 18 satellites, including up to 4 GEOs, pseudolites also possible
  - Antenna performance implies two element Multipath Limiting Antenna (MLA)
  - MLA requires dual L1 RF receiver inputs

LAAS Receiver

- **Signal Quality Monitor (SQM) requires:**
  - **Narrow Correlator ® tracking technology**
  - **Multiple correlators, at least 7 per channel**
- **Multipath Limiting Antenna (MLA) requires:**
  - **Dual RF inputs**
  - **Spare tracking channels for transition of mid-elevation satellites between 2 elements**

LAAS Receiver

- **NovAtel/BSC LAAS Receiver:**
  - **Meets LGF specification requirements**
  - **SQM function uses dual MINOS4 DSP – up to 10 correlators per channel**
  - **Tracks 18 GPS/GEOs with 6 dedicated transition & BITE channels**
  - **Dual RF for MLA antenna inputs**

LAAS Receiver Partner

- NovAtel/BSC would like to establish partnership
- To work with LAAS system supplier:
  - To verify LAAS receiver requirements
  - Each supplier may need custom solutions
  - To establish long-term business relationships

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Summary

- NovAtel/BSC GNSSA development underway
- High integrity airborne version available soon for evaluation
- LAAS receiver requirements still evolving
- Significant receiver engineering required
- Risk-sharing partnerships needed to address LAAS market opportunity