AMERGINT WANFEC
Ground Technology and Info to Meet Laser Communications Requirements

POCs

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Company Overview
AMERGINT products play a key role in many of our nation’s space systems

**softFEP Front Ends** process the International Space Station’s Voice, Data, Video, Telemetry, and Commands

**satTRAC Modems** handle the TT&C links for the GPS Constellation

**softFEP Data Recorders** capture image data from DigitalGlobe’s WorldView satellites

**softFEP** and **satTRAC** products are integral to several DoD and other Gov’t programs

**softFEP Data Acquisition** systems support launch control of the Atlas and Delta launch vehicles
We are employee-owned, stocked with creative engineers.

Our technology focus is signal and data processing for space, satellite, range, and launch systems.

We enjoy playing an important role in each customer’s success.

AMERGINT has made $75M in product deliveries over eight years.
**satTRAC** is the product name for our modem/baseband units, including RF conversion

**softFEP** is the product name for our front ends, recorders, and data acquisition systems

**AMERGINT** has a suite of interchangeable applications used from the antenna to the network
**SwDs** is short for software devices, and each SwD performs an “atomic” function.

Code Generators guarantee tightly-controller interfaces and have round-trip protection.

We have more than 700 SwDs in our **SwD Libraries**.

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<tr>
<th>Ternary</th>
<th>Command</th>
<th>Telemetry</th>
<th>SLE</th>
<th>CCSDS</th>
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</thead>
<tbody>
<tr>
<td>ADC Transfer</td>
<td>Frame Receiver</td>
<td>Space Packet Transmitter</td>
<td>AOS MPDU Receiver</td>
<td>Reset Subnet / Exchange Encoder</td>
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<tr>
<td>ADC Transfer</td>
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<td>Space Packet Filter</td>
<td>AOS MPDU Receiver</td>
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**Bit Error Rate Test**

**Error Detection/Correction**

**Digital Signal Processing**

**AFSCN**

**IRIG/Time**

**COMSEC**

**M&C/Logging**

**Binary RS 422**

**Network/Files**

**Data Recording**

- *SwD Libraries*
Processing Chains link and order the SwDs using Python scripts, forming the App

GUI Editing uses drag-and-drop widgets and can be done while the system is live

Dataflow Diagrams, ICDs, and other Documentation are auto-generated from the source code
What it Means to Have True Software

Run One or More Apps

Iterative Development is fully supported with our SOFTLINK Product Architecture

Product Tailoring specific to what you need

Application Switching rather than monolithic software

Customer Configurability after we deliver

Scalable Server Platforms reduce cost

Technology Refresh Program for long term support
softFEP Heritage

• US Government
  – NRO
  – SMC
  – AFSPC
  – NASA
  – NOAA

• NRO Comm WANFEC System

• Millennium Space

• Crypto Depot Test systems

• Other AF, NASA and Commercial Systems

• Raytheon
  – M2C2
  – Apex
  – Lynx
  – Shiloh
  – Sterling
  – SkyFox

• Lockheed Martin
  – FEP14
  – MSP
  – GPS

• Northrop Grumman
  – NOPS Test System
  – COMSEC Converter
  – JWST Systems

• Boeing
  – Broncos DCSTE
  – WGS

• Ball
  – Apex
  – Magnus
  – SkyFox

• US Government
  – NRO
  – SMC
  – AFSPC
  – NASA
  – NOAA
High Rate Processing

Payload Processors
- Multi-Gbps Downlink Data Streams
- Image, Instruments, Other

WAN Forward Error Correction
- 10Gbps Throughput
- Recover Lost Packets without Retransmission

Optional CCSDS Processing
- Reed Solomon Decoding
- Virtual Channels, APID, Space Packets, AOS processing

Data Recorders
- DVR-like Recording and Playback
- Data Quality Monitoring
- Import/Export, Preserve

RAID-1 and RAID-5 Storage
- Multi-Terabyte Capacity (Internal or External)

Full Duplex Channels
- Single, Dual, Quad or More
- Ethernet and Serial
WANFEC
Most ”Private” WAN service today is via MPLS VPN
- MPLS = Multi Protocol Label Switching. An IP only service for creating a virtual private network over WAN provider’s backbone (e.g., Verizon, AT&T, Level 3, etc)

When purchasing WAN service, the provider signs up to a Service Level Agreement (SLA)

Typical SLA Performance Metrics are:
- Availability. Typical Class A service (highest) is 99.999%
- Latency. Class A: 10msec
- Packet Loss. Class A: <= 0.005%
  (measured as # packets lost / # packets sent over a period of 1 month)
- Jitter. Class A: 4msec
- All metrics are measured per month
Several WAN protocol options are available within AMERGINT’s solution

- TCP/IP
- NORM (NACK-Oriented Reliable Multicast)
- WANFEC (Wide Area Network Forward Error Correction)

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>TCP/IP (TCP Layer 4)</td>
<td>- Guaranteed Delivery of packets at the transport layer (Layer 4)</td>
<td>- Potential high data latency with retransmission</td>
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<tr>
<td></td>
<td>- Simple implementation</td>
<td>- Reduced overall transmission rate when retransmission is required</td>
</tr>
<tr>
<td>NORM (UDP Layer 4)</td>
<td>- Built in support for one to many data distribution (Multicast)</td>
<td>- Not 100% guaranteed delivery (configurable transmit buffer)</td>
</tr>
<tr>
<td></td>
<td>- Efficient use of WAN for long haul communications</td>
<td>- Potential high data latency with retransmission</td>
</tr>
<tr>
<td>WANFEC (UDP Layer 4)</td>
<td>- Efficient use of WAN for long haul communications</td>
<td>- Potentially large WAN bandwidth overhead based on WAN SLA and</td>
</tr>
<tr>
<td></td>
<td>- No retransmission is required</td>
<td>- data flow requirements (e.g., input bit rate, latency, data</td>
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<tr>
<td></td>
<td>- Best option for WAN over a satellite link</td>
<td>- reliability)</td>
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<tr>
<td></td>
<td></td>
<td>- Not 100% guarantee delivery. If the WAN outage is long enough,</td>
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<td></td>
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<td>- data will be dropped</td>
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Satellite WAN Issues

- Very long pipeline delay
- Exaggerates the data latency, especially when retransmission is required (TCP/IP or NORM)
- Packet loss rate is much worse than the terrestrial link
- Expensive bandwidth
AMERGINT’s WANFEC Capability

- Designed for high data rate (> 1Gbps) data transport
  - System delivered running 10Gbps at the smallest packets size (e.g., 64 Byte)
- Collects UDP or raw IP traffic and encapsulate into WANFEC data block
- WANFEC data block consists of the user data packets and correction packets
  - Number of correction packets generated is configurable
- Multiple WANFEC data blocks are interleave to provide better burst correction capability
- WANFEC data block packets are transmitted to multiple receivers using standard UDP/IP protocol
- WANFEC receiver corrects out of order packets and recreates missing packets
  - Running in real time at up to 10 Gbps data rate
  - Corrects up to 10% missing packets at 10 Gbps
- Optional Retransmission capability to provide guaranteed delivery
WANFEC Retransmission
WANFEC Retransmission Design

- Retransmission at the FEC block level, not the individual packets like NORM or PGM

- Each WANFEC RX reports to transmitting WANFEC TX over point-to-point retry link (independent session over the mission WAN)
  - Use UDP transport for heartbeat and retry requests
  - Bi-Directional heartbeat on each retry link

- WANFEC TX stores the transmitted FEC blocks in a circular buffer until the buffer overflows
  - Current WANFEC TX system has sufficient memory for ~40 seconds of storage at 10Gbps in the circular buffer
  - Using additional RAM or SSD storage (e.g., PCIe based NVMe), the circular buffer retention time can be increased

- WANFEC RX corrects all FEC blocks that are correctable, and only request retransmission of uncorrectable FEC blocks
  - Data stream output is paused until the missing data is received

- Upon receipt of the retransmission request, the WANFEC TX transmits the entire FEC block

- FEC block Interleave is mutually-exclusive with the retransmission function
  - Select one or the other in the system configuration
Design Benefits and Issues

• Benefits
  – Using the heartbeat process, measure true WAN roundtrip latency continuously
    • Both the TX→RX(s) path and RX→TX path
    • Measurement is available via standard GEMS interface and via the AMERGINT’s analytics package
  – Short burst of packet loss (i.e., <32 packets within a FEC block) is corrected by the WANFEC algorithm without a need for retransmission
  – Recover from longer WAN outage without missing mission data

• Issues
  – When retransmission occurs, end-to-end latency increases
AMERGINT’s WANFEC Future Roadmap

- **100Gig**
  - Incrementally increase the error correction capability as the compute resource improves
  - ~20Gbps by Summer of 2018
  - ~40Gbps by end of 2018
  - Full 100Gig by Summer of 2019

- **UDP to TCP Conversion to support mission processing and the crypto interface (end of 2017)**

- **High Availability Architecture for the transmit system (Spring of 2018)**

- **Adaptive error correction capability (Summer of 2018)**
  - Increase or decrease the error correction capability based on the measured WAN correction on the receive systems
AMERGINT’s WANFEC Advantage

• Initially designed and prototyped over 3 years ago and delivered on several programs
• Software-oriented design means capabilities can evolve
  – Inherent risk in the fragility of legacy firmware-based solutions
  – Future AMERGINT capabilities can become integrated into the product
  – Your technological investment is protected and obsolescence is mitigated because a capability update is delivered via DVD
• AMERGINT’s commitment to test and validation is built into everything we do
• Built upon the same proven AMERGINT architecture your ground stations are founded upon
• Security can evolve as needs change
  – Built on COTS Linux platforms (RHEL)
  – DISA/STIG-hardening updates are available
• AMERGINT’s support is unparalleled in the industry
  – Customers and Users talk directly to the engineers who designed and built the solution
Summary

- AMERGINT WANFEC is currently operating at 10 Gbps wire rate
- AMERGINT has an architecture and design that will evolve to 100 Gbps and beyond
- AMERGINT has a proven track record of providing reliable software-based solutions that can evolve over numerous years in a fielded operational environment
- AMERGINT has an impeccable reputation for supporting their products and the customers that use them