Rocketry Electronics – Beginning
Rocketry Electronics – Advanced

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NARCON 2003

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FLIGHT ELECTRONICS

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WHAT ARE FLIGHT ELECTRONICS?

- ELECTRONICS THAT ARE USED FOR RECORDING DATA, STAGING, AND CONTROLLING RECOVERY OF A MODEL OR HIGH POWER ROCKET.
  - TIMERS
  - ALTIMETERS
  - ACCELEROMETERS
  - PHYSICAL SENSORS
- NOT INCLUDED ARE CAMERAS OR VIDEO SYSTEMS

WHERE WE WERE

- Mercury Switches
- Timers
- Altimeters

MERCURY SWITCH STAGING

- Mercury switch with contacts toward nose.
- Depended on deceleration to trigger.
- Were not reliable.

EARLY TIMERS

- 555 timers
  - Uses RC network
  - Thermally sensitive
  - Requires changing resistors to set.
- Kitchen Timers
  - Tripped off the audio alarm.
  - Not very robust.

FLIGHT ELECTRONC CONSIDERATIONS

- Safety
- Batteries
- Testing
- KISS

SAFETY

- READ AND FOLLOW the manufacturers instructions.
- All electronics must be considered experimental devices and must not be used where failure could cause harm.
- All electronics must have a positive safe mechanism.
- Electronics must turn on “gracefully”, not in the ARMED or FIRE condition.
- Pyrotechnic devices must be shunted.

BATTERY

- READ AND FOLLOW the manufactures instructions.
- Batteries are cheap, rockets are not.
- Use fresh batteries.
- Check not only the voltage, but the current delivered.
- Batteries are temperature sensitive, too hot or too cold reduces their performance.

TESTING

- READ AND FOLLOW the manufacturers instructions.
- Understand what the electronics can do.
- Test the electronics configured as for flight.
- USE an e-match or other initiator, if you don't you won't know.

KISS

- READ AND FOLLOW the manufacturers instructions.
- Connectors and switches all DECREAS reliability.
  - If there are two components with 90% reliability, the total reliability is 81%.
- Keep wires intact, use no or few connectors.
- Switches should have a method for latching them in the ON or OFF condition.
- Plugs using audio connectors are not a good choice.

TIMERS

- Detect launch and count to a time set before launch.
- Most modern timers are digital, that is, they use a timebase and divide it to achieve the selected time.
- Timers are the best way to stage rockets.
- Timers are what the big boys use.

HOW A TIMER WORKS

- The timing must be selected using motor performance data or performance modeling.
  - Alticalc
  - RocSim
- The timer is typically set using DIP switches or software.
- At launch, an acceleration sensor or switch change starts the timer.
  - G-switch, a small weight trips a switch.
  - Accelerometer, measures the acceleration
  - Break wires, pull pins, roller switches have all been used.

ALTIMETERS

- Measuring barometric pressure change to determine altitude.
- Solid state sensor used to detect barometric pressure.
  - "Bare" sensors, require additional circuits to condition the signal for use.
  - Automotive sensors are conditioned
- All use a microprocessor and a method of converting the analog pressure sensor signal to a digital value.
- An altimeter will record the minimum pressure encountered, this can be converted to the altitude using the ICAO Standard Atmosphere.

ALTIMETER RECOVERY

- Establish the at rest altitude.
- Detect launch.
- During flight, the altimeter must not respond to trans-sonic effects.
- Stores peak altitude then, upon descent, triggers the Peak deployment.
- At a set value above the at-rest altitude, triggers the Main deployment.

ABSOLUTE ALTITUDE VS. PRECISION

- Absolute Altitude is the precise geographic altitude.
  - Measured typically with radar, precision optics or differential GPS.
  - Barometric altitude must be compensated for sensor linearity, sensor temperature compensation, local altitude, barometric pressure, temperature, local environmental conditions, seasons, upper wind conditions, day or night, etc.
- Altitude Precision depends on the digitization range of the microprocessor and how the compensation factors are used.
  - 8 bits, ± 100 feet/10 bits, ± 25 feet/12 bits, ± 6 feet
- The precision of the measurement cannot use more than 8 bits unless extraordinary efforts are taken.

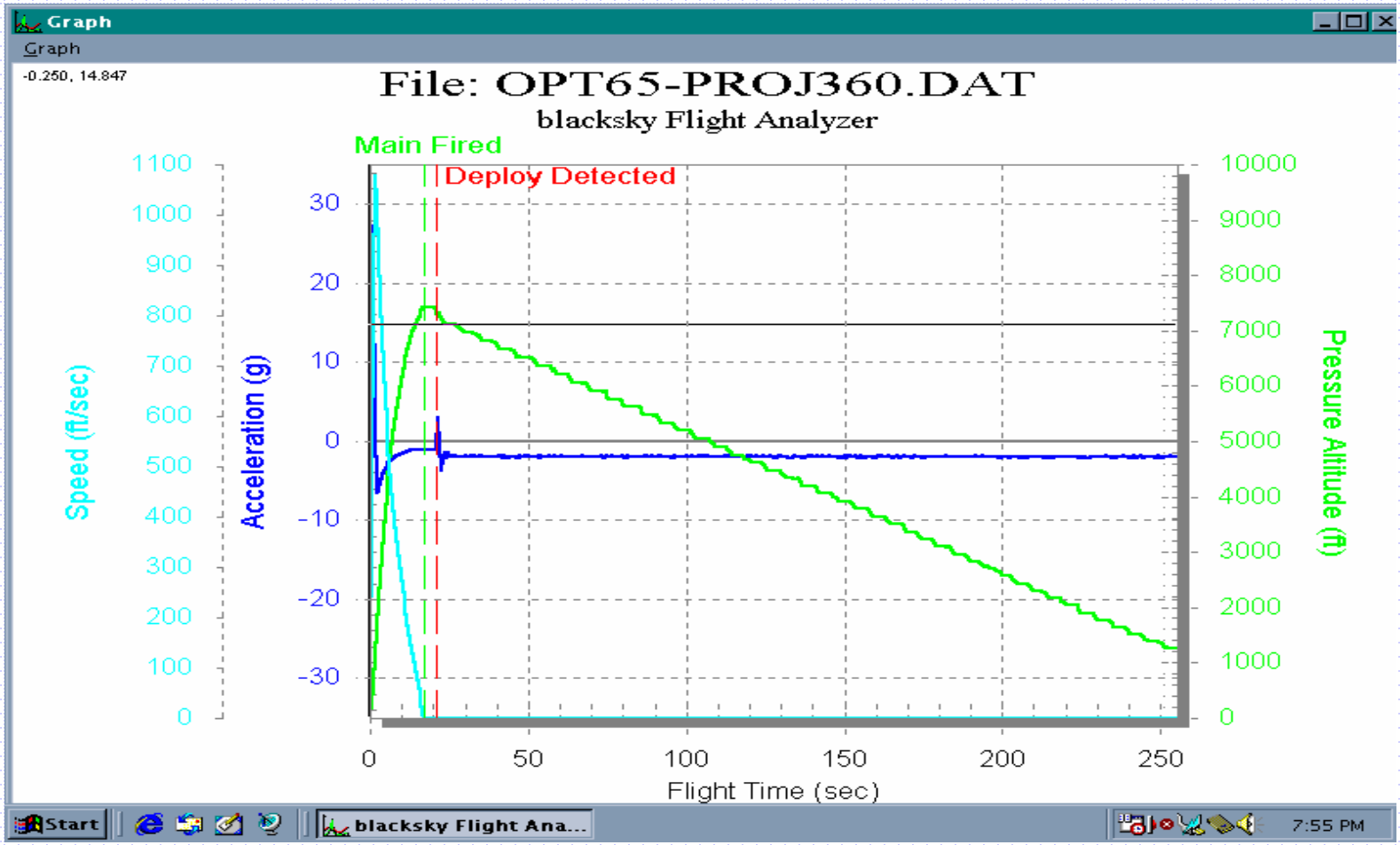
ACCELEROMETERS

- Measures the inertial acceleration of the rocket regardless of external effects (including gravity).
- Solid state sensor used for acceleration detection.
- Uses a microprocessor and a method of converting the analog acceleration signal to a digital value.
- The acceleration is integrated to determine the minimum velocity, which can be used for Peak deployment.

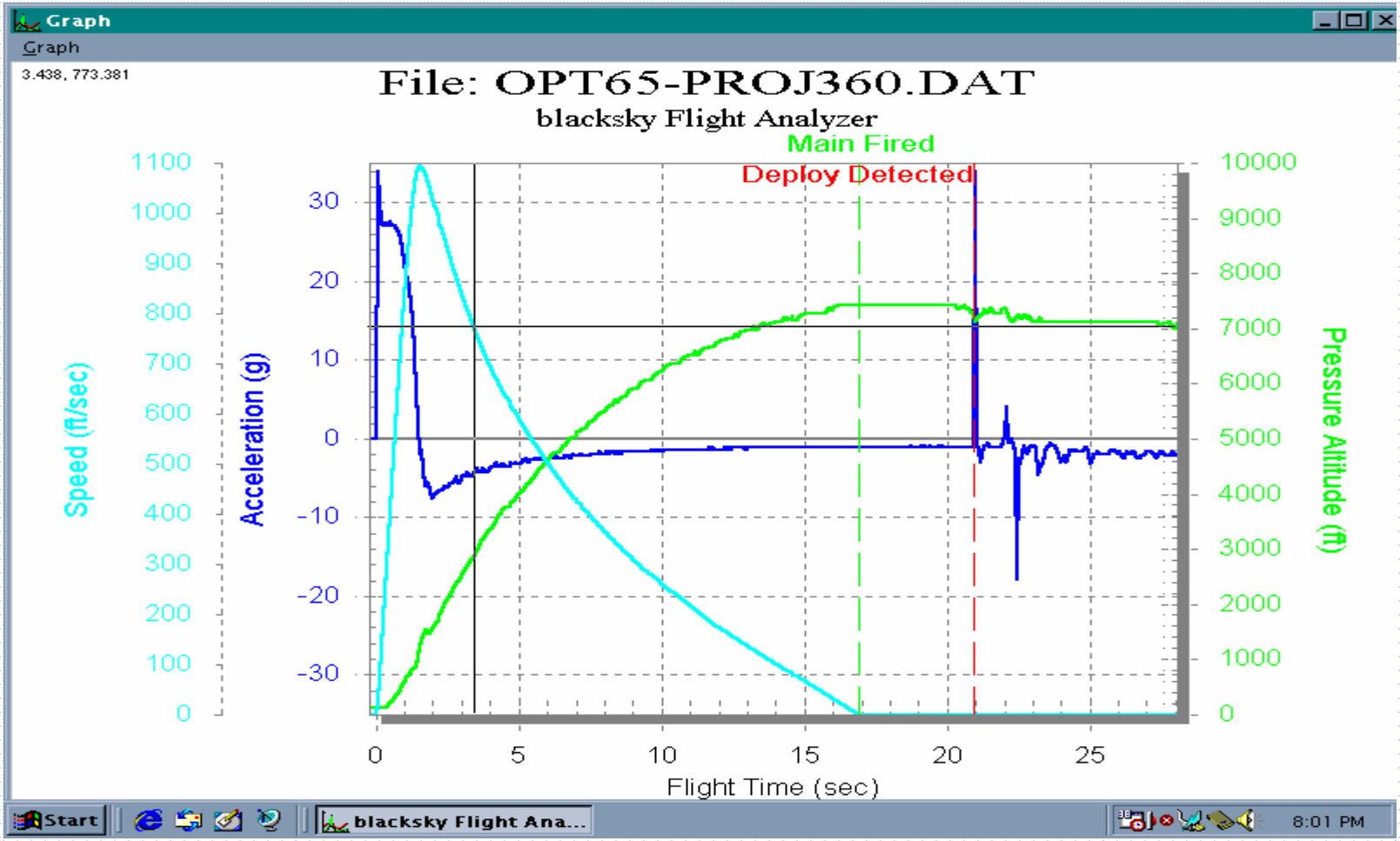
HOW ACCELEROMETERS WORK

- All accelerometers have a proof mass and signal processing to sense the change in velocity.
  - Strain gages.
  - Capacitive compensation drive.
  - Gas density.
- Acceleration values are
  - sampled at some rate and integrated (added) from the at rest acceleration (0 ft sec^2),
  - under acceleration, the values are positive,
  - at motor burn-out, the acceleration values become negative,
  - when the sum equals 0, mimimum velocity is achieved.

INTEGRATING ACCELERATION



INTEGRATING ACCELERATION



ACCELEROMETER ERRORS

- Accelerometers can be effected by non-vertical flights.
  - The accelerometer measures the flight length, not the absolute altitude.
  - Noise from motors can effect performance.
  - Deployment at minimum velocity in non-vertical flight will be aggressive (altimeter based systems deploy after peak altitude at higher velocities).

USING ACCELEROMETERS

- Acceleration based systems can be used to detect minimum velocity.
- For dual-deployment, a barometric sensor must be used to detect low altitude for Main deployment.
- Orientation and solid mounting are required for reliable operation.

OTHER SENSORS

- Magnetic sensors detect the earths magnetic field and depend on the rocket to tip to detect peak.
- GPS may be used, but has velocity limits.
- Rate-gyros detect the rate of rotation about an axis.
  - Good to detect roll and pitch rates of rockets.
  - Possibly used for vertical ascent control.