In Search of Cybernautics

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Progress in Information Technology

Microprocessor performance has increased by factor of 25,000 since 1971 (Intel 4004 to Pentium 120).

Rate of increase has been 52% per year.

Rate has accelerated to 58% over past 5 years.

Performance multiplies by 10 every 5 years.

The Two Cultures

We Know All about These

$$\mathbf{f} = m\mathbf{a}$$

$$L = \rho U \Gamma$$

$$\rho \frac{\partial \mathbf{u}}{\partial t} + \rho \mathbf{u} \cdot \nabla \mathbf{u} + \nabla p = \mu \nabla^2 \mathbf{u}$$

But What about This One?

$$C = B\, log_2 \left[1 + \frac{S}{N} \right]$$

Data Rates

(bps = bits per second)

Device	Bandwidth	Bits	Data Rate
Modem			28.8 Kbps
CD-ROM			5.6 Mbps
Ethernet			10.0 Mbps
Cable TV	4.2 MHz	8	33.6 Mbps
Hard Disc			133.6 Mbps
Video Card	140 MHz	8	1.12 Gbps
P120 CPU	120 MHz	32	3.84 Gbps

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P120 CPU	120 MHz	32	3.84 Gbps
Human Eyes	400 MHz	10	4.00 Gbps

Aviation Now

Air

Expert pilots
Manual controls
Multiple navaids
Waypoint navigation
See and avoid under VFR
Voice communication with ATC
No communication with other aircraft

Ground

Expert controllers
Radar and Mode S sensors
Voice communication with aircraft

GPS Navigation and Control Tests

University of Arizona

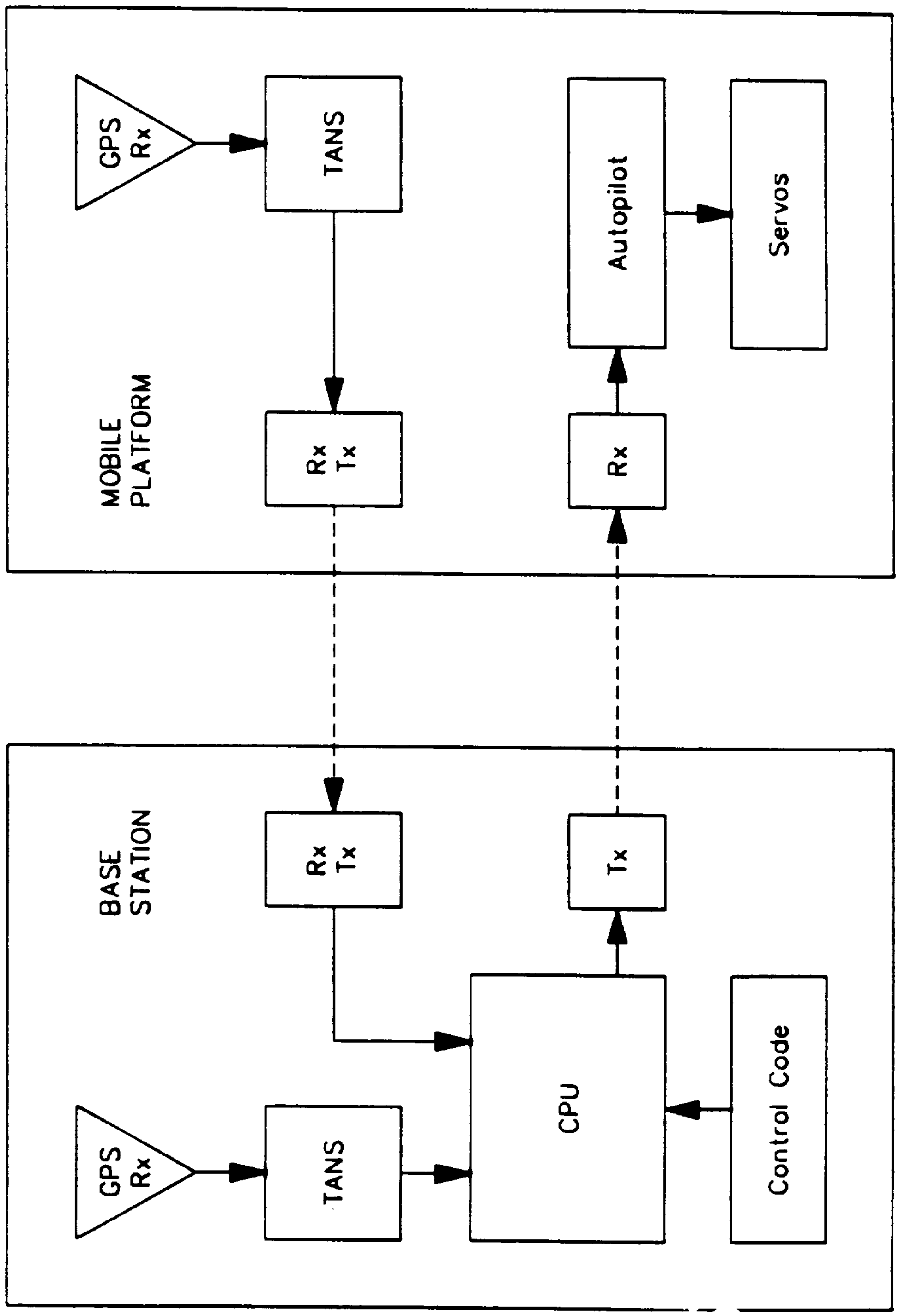
El Cuervo 2

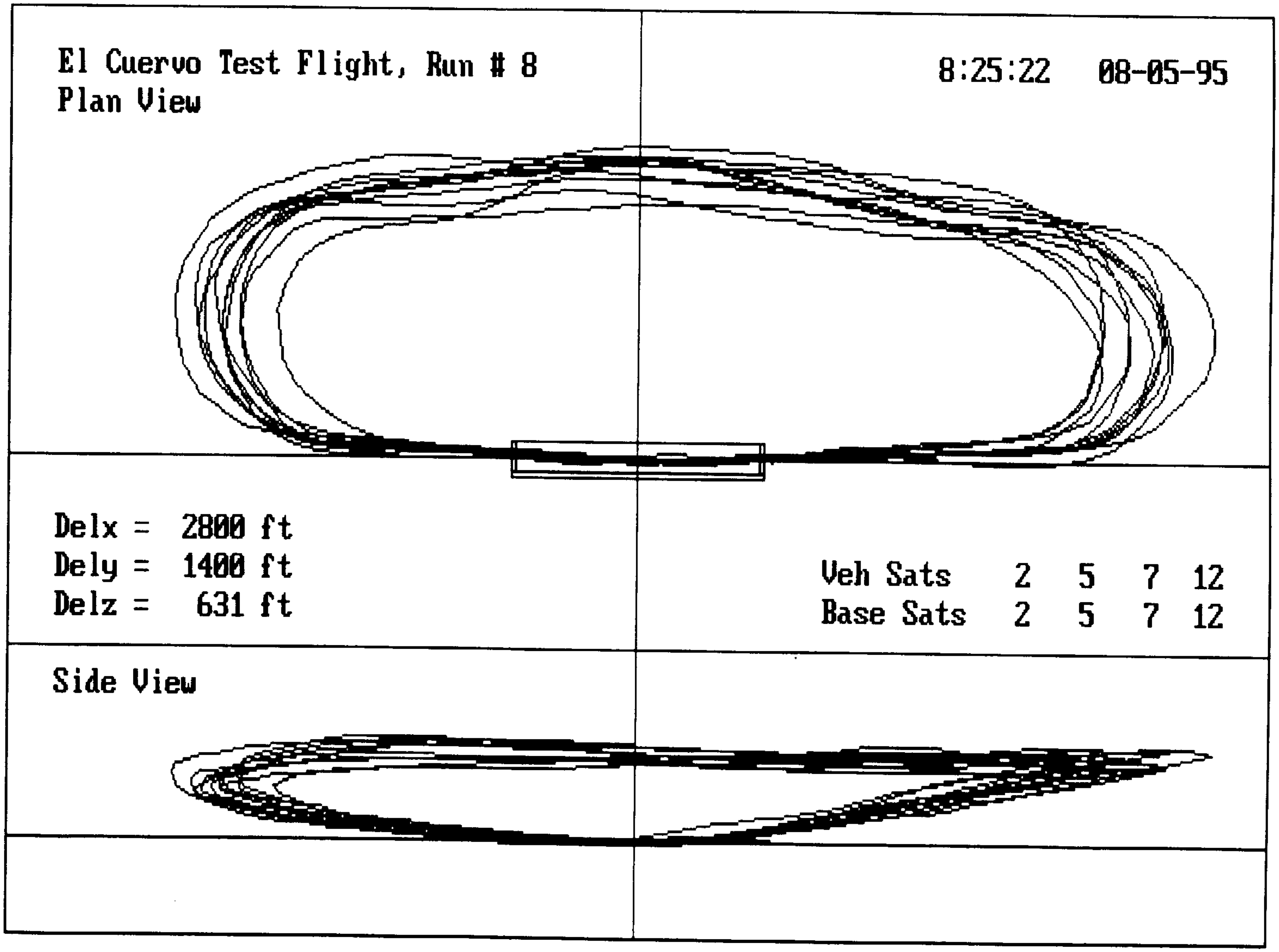
Stanford University

Paul Montgomery's Model Aircraft
Piper Dakota and Wide Area Augmentation System
Piper Dakota and Kinematic GNSS Landing System

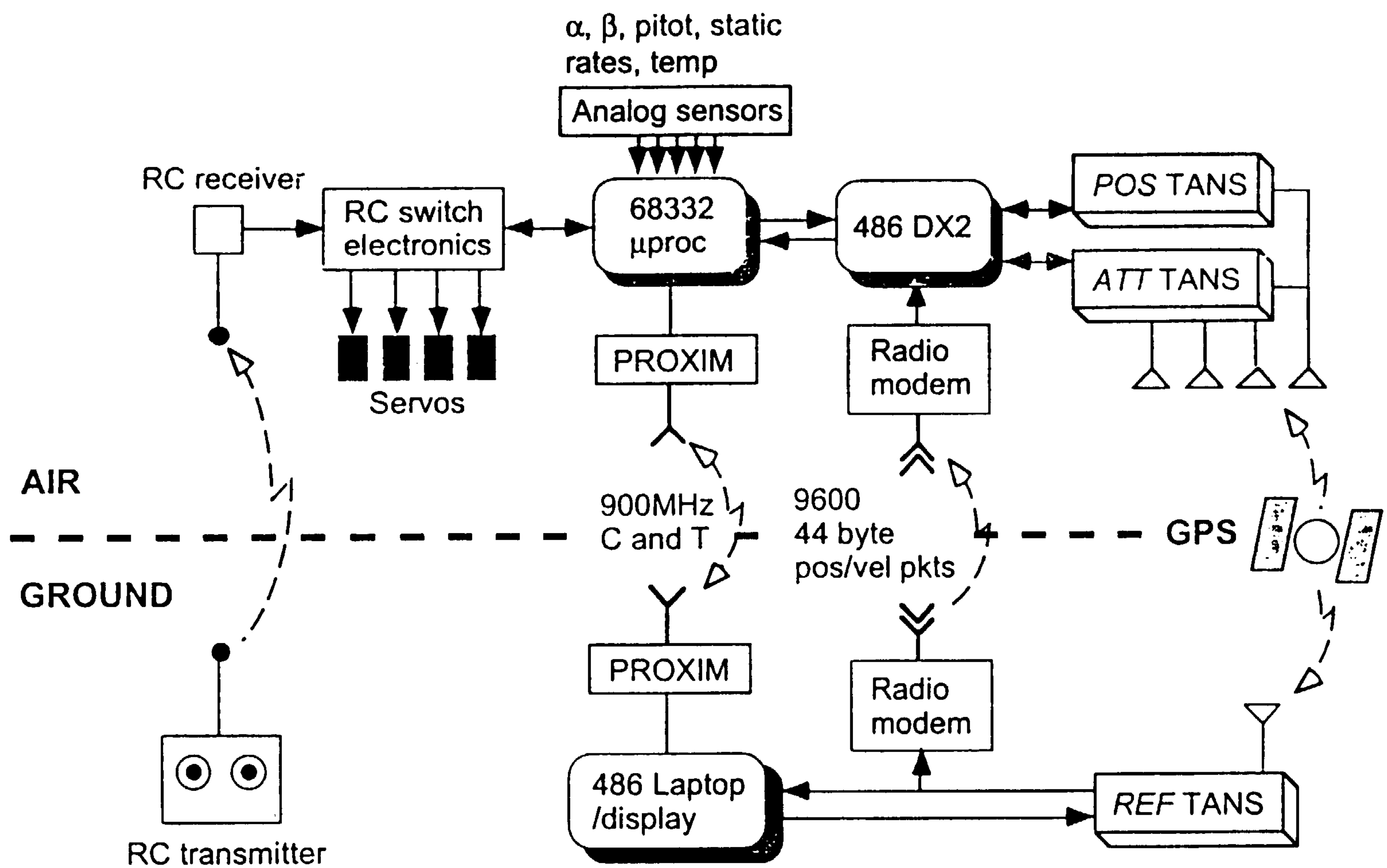
NASA Ames Research Center

King Air Precision Landings with DGPS/INS


MOBILE PLATFORM
GPS Rx
TANS
Rx Tx
Autopilot
Servos
Rx
BASE STATION
GPS Rx
TANS
Rx Tx
Tx
CPU
Control Code

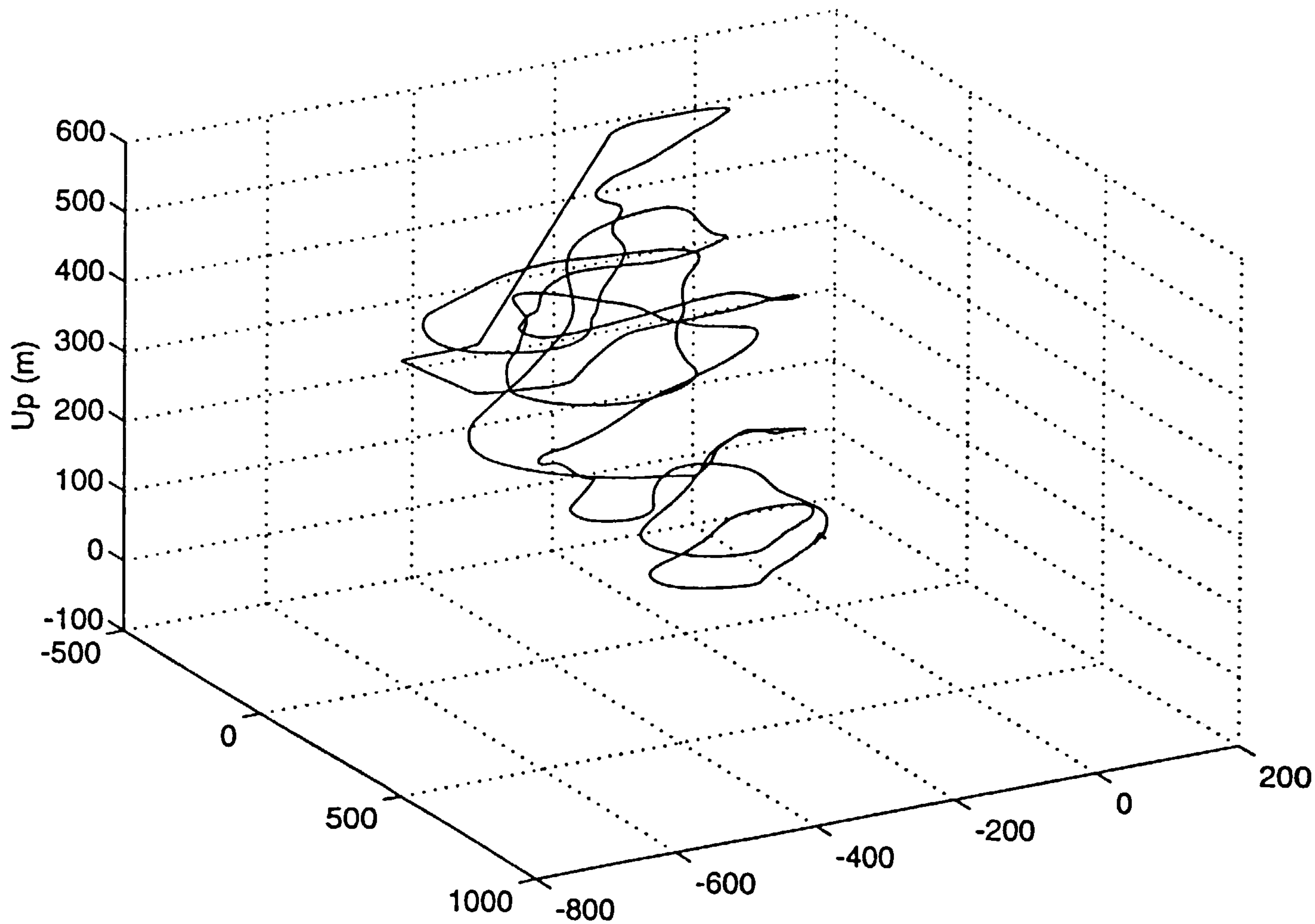

El Cuervo Test Flight, Run # 8
Plan View
8:25:22 08-05-95
Delx = 2800 ft
Dely = 1400 ft
Delz = 631 ft
Veh Sats 2 5 7 12
Base Sats 2 5 7 12
Side View

Stanford Model Aircraft Navigation and Control System

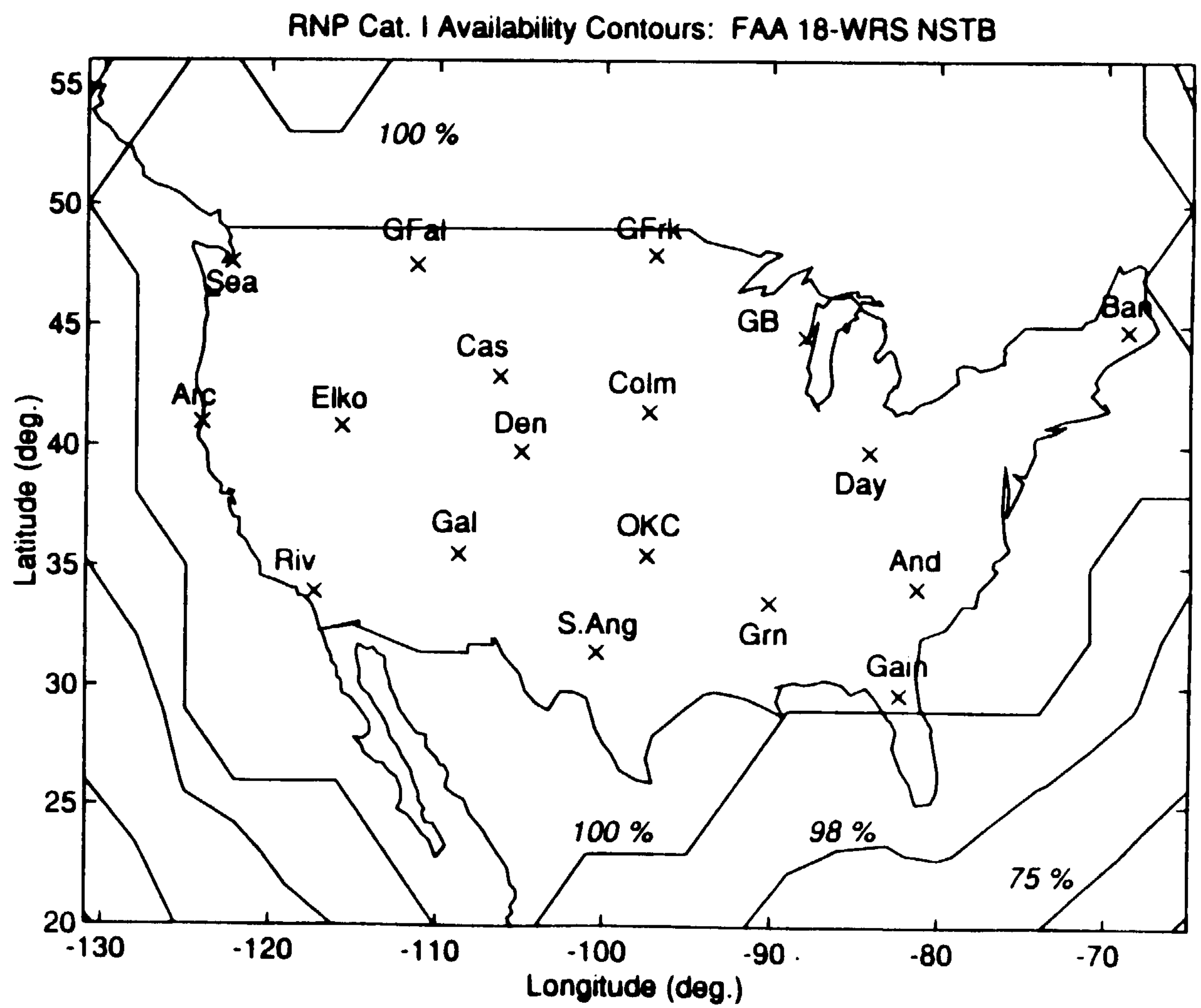


Model Aircraft Flight Path

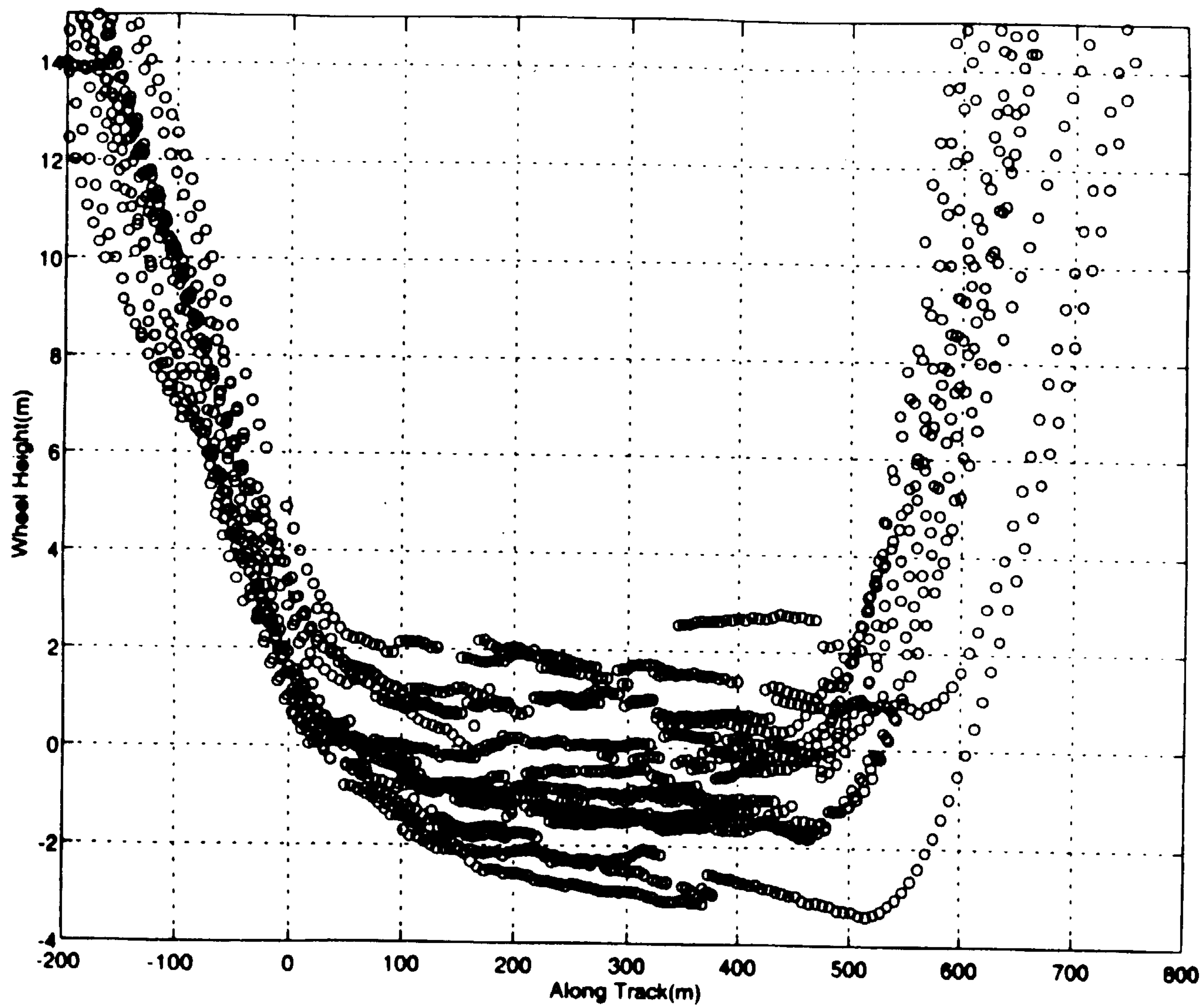
950417 : flight1



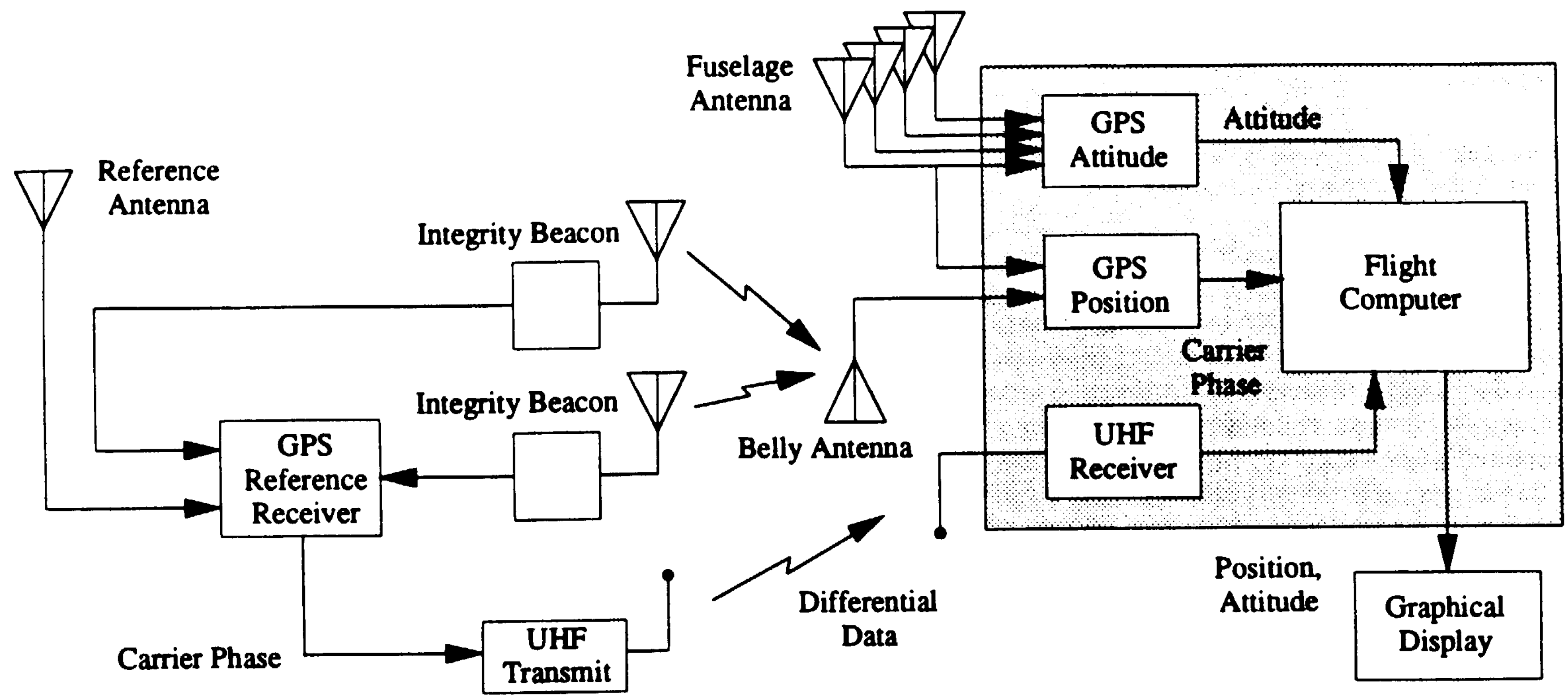
FAA Wide Area Augmentation System



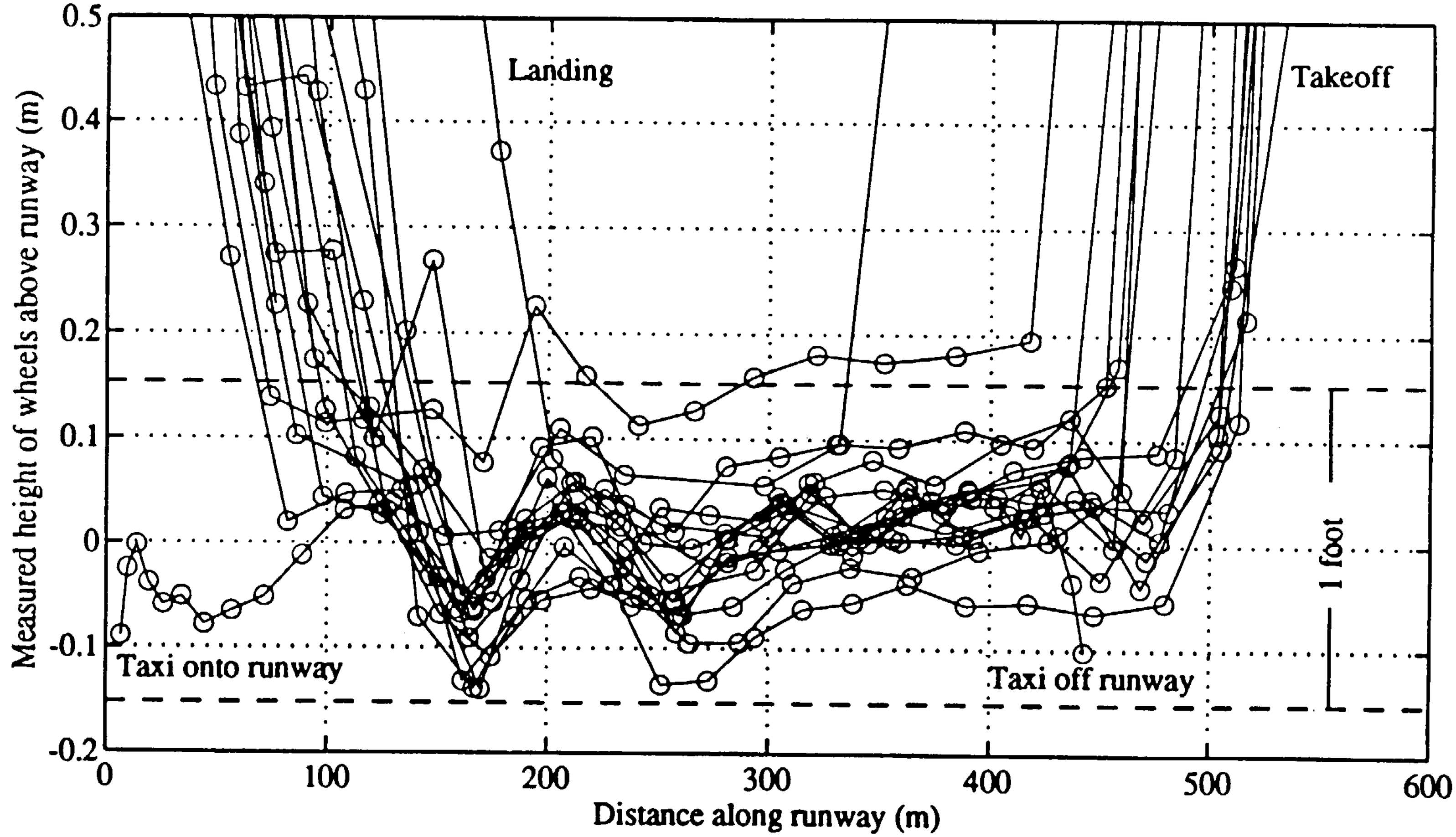
Touch and Go Landings with WAAS



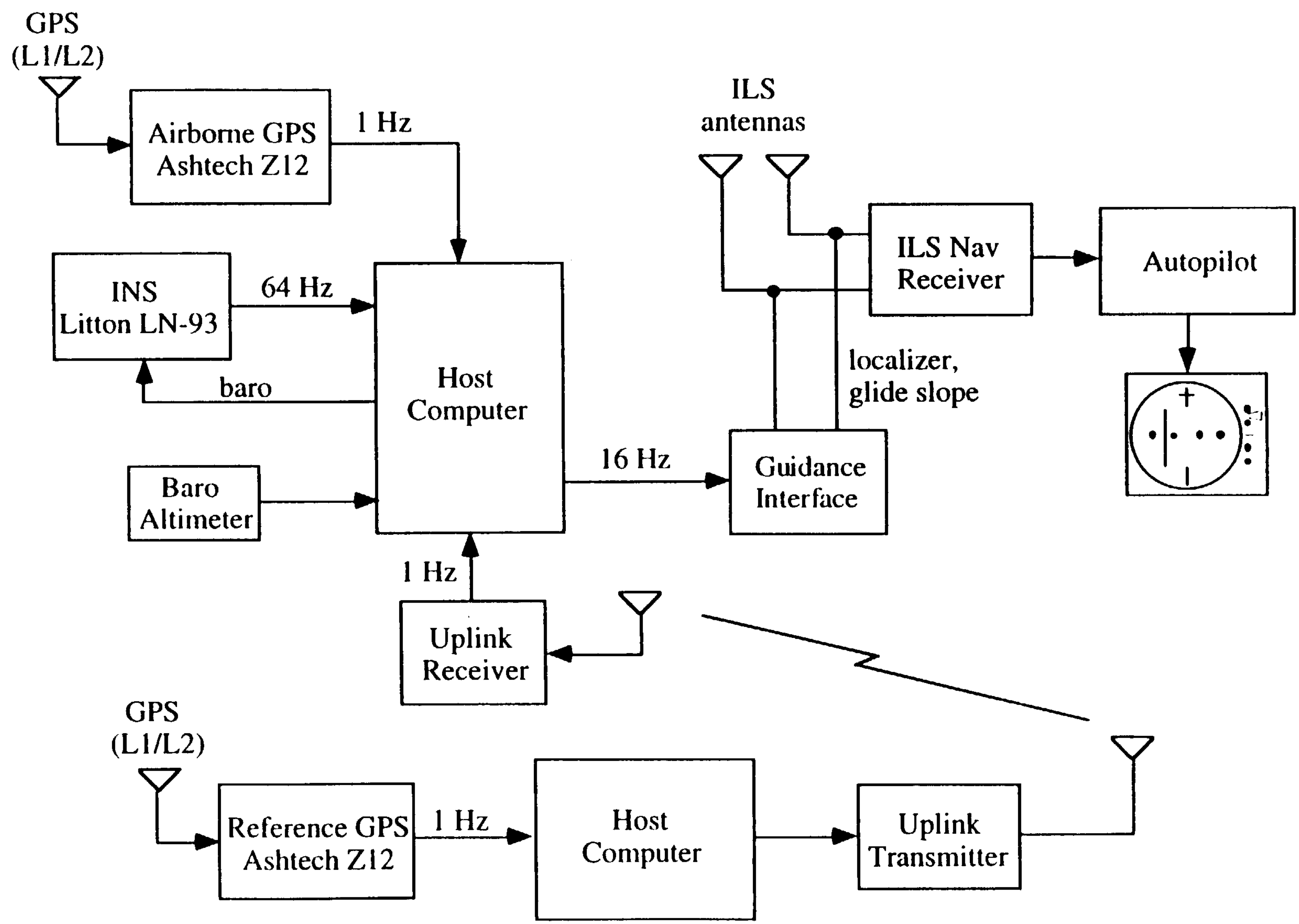
Stanford Kinematic GNSS Landing System



Touch and Go Landings with KLGS

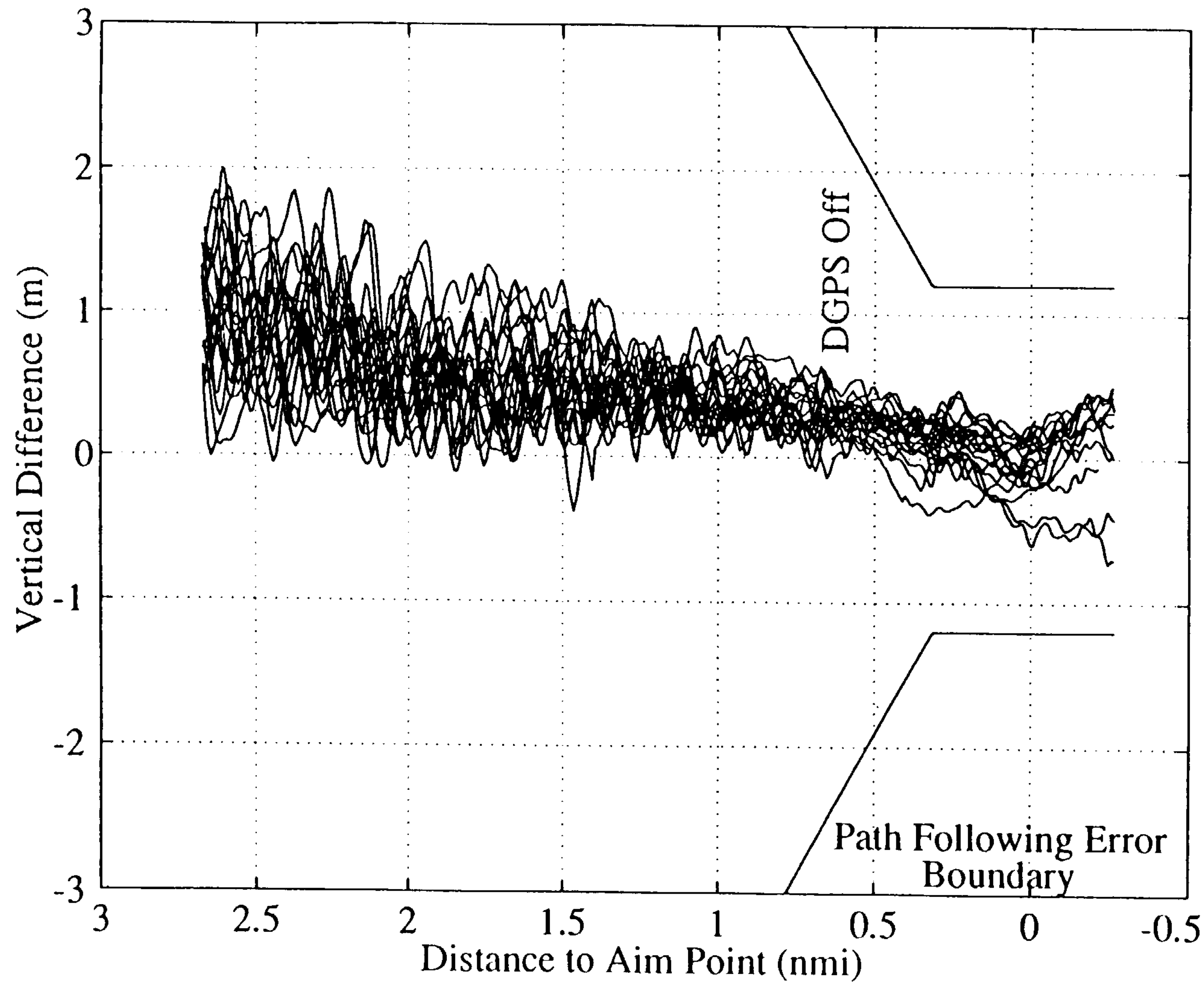


NASA Ames DGPS/INS System



Precision Approaches with DGPS Disabled at 200 ft

NASA King Air at Crows Landing, 22 Landings, 7/21/95



Aviation Future

Air

Automatic controls
GNSS/INS guidance
Free flight navigation
Inter-aircraft communication
Automatic collision and wake avoidance
Radio control reception for emergencies

Ground

GNS integrity assurance
Rules of the sky software
Expert pilots for emergencies

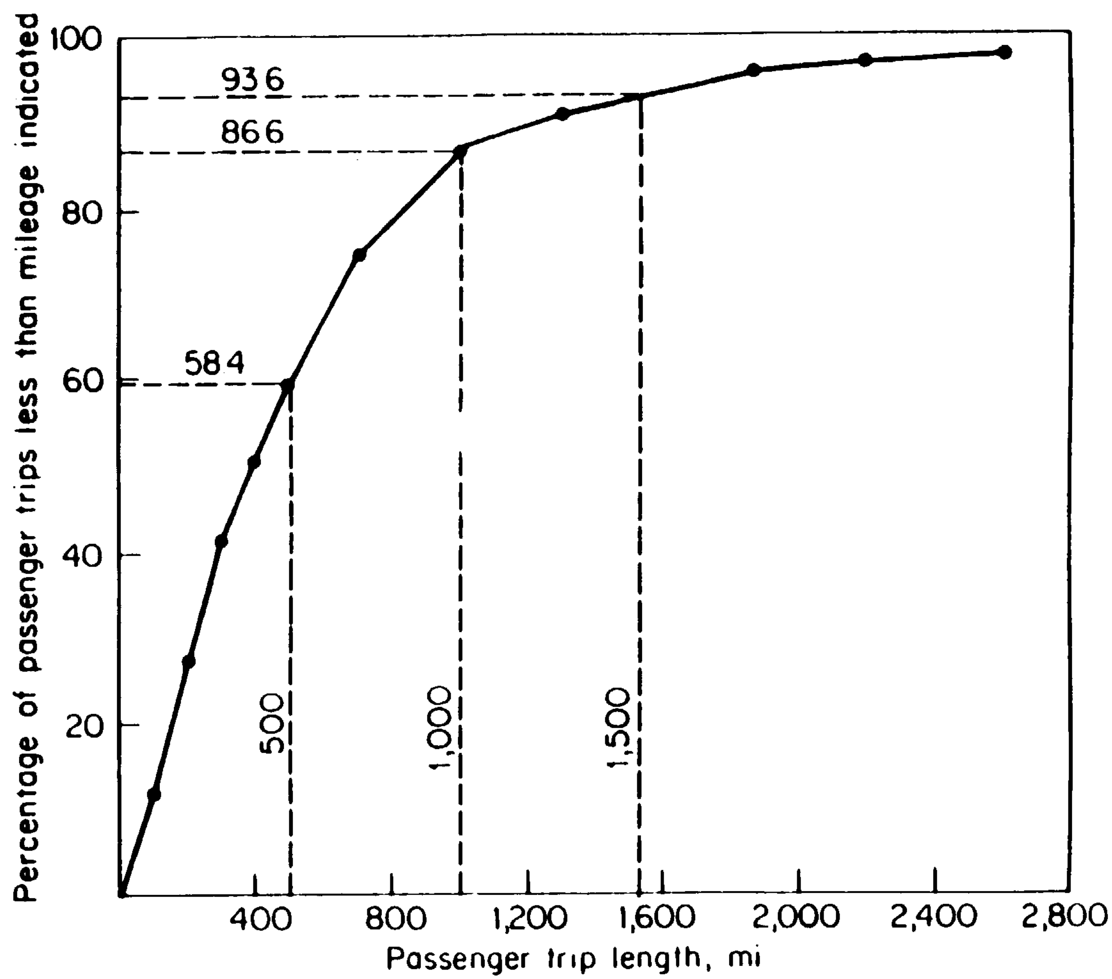
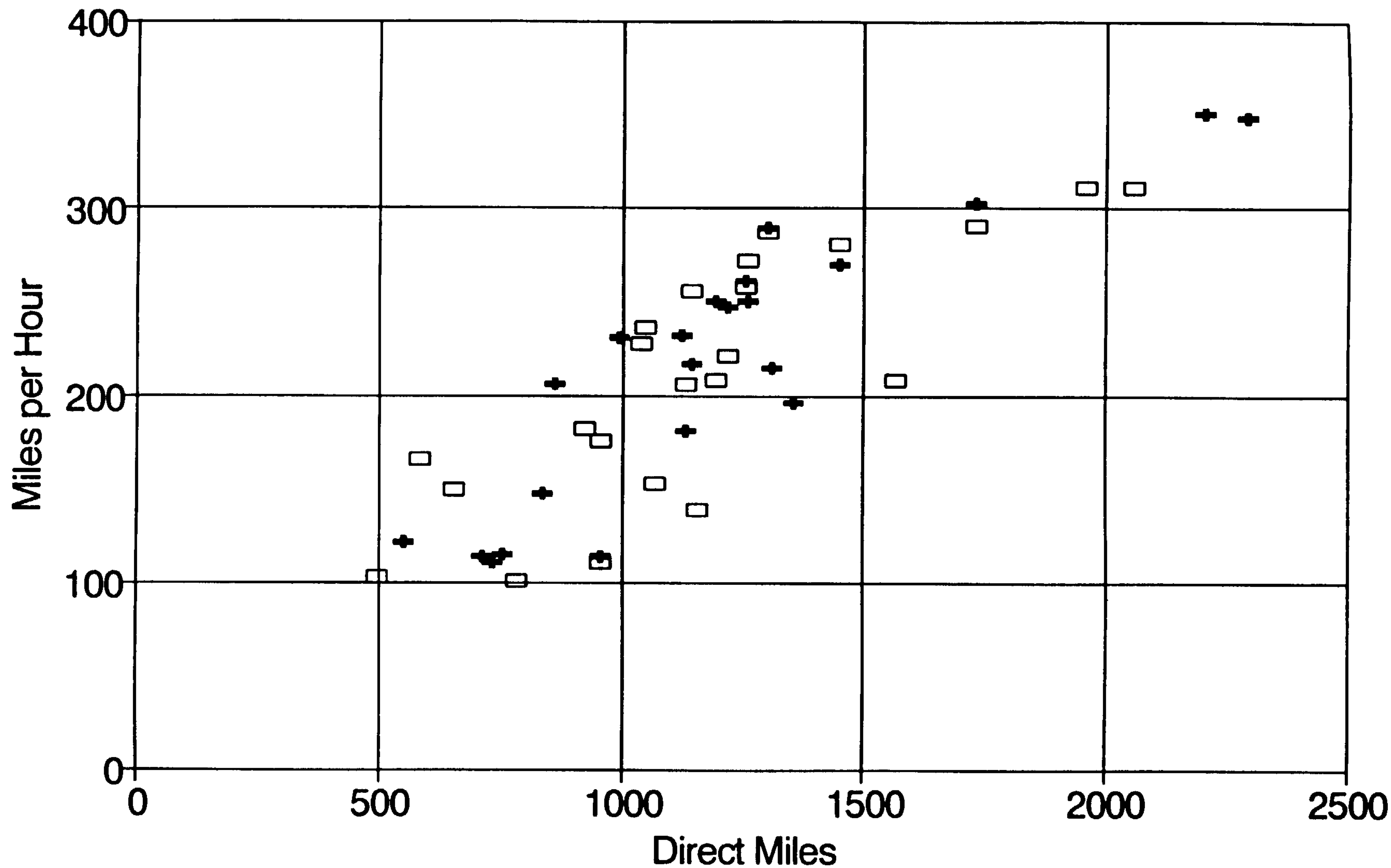
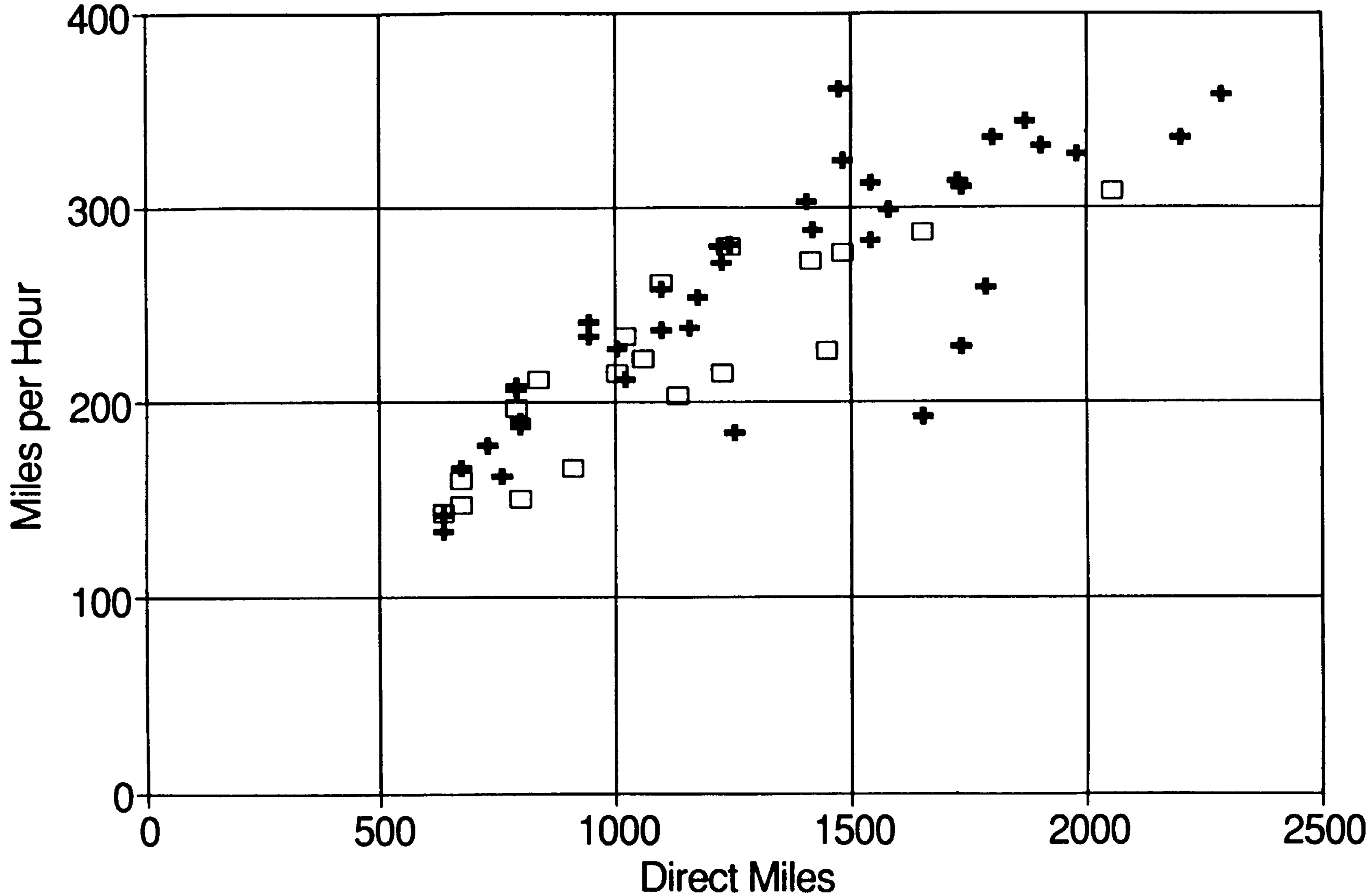


Fig. 1-1 Distribution of passenger trip lengths on scheduled domestic airline flights in the United States, November 1980. (*Civil Aeronautics Board [17]*.)

EFFECTIVE SPEED
Tucson through Denver Hub

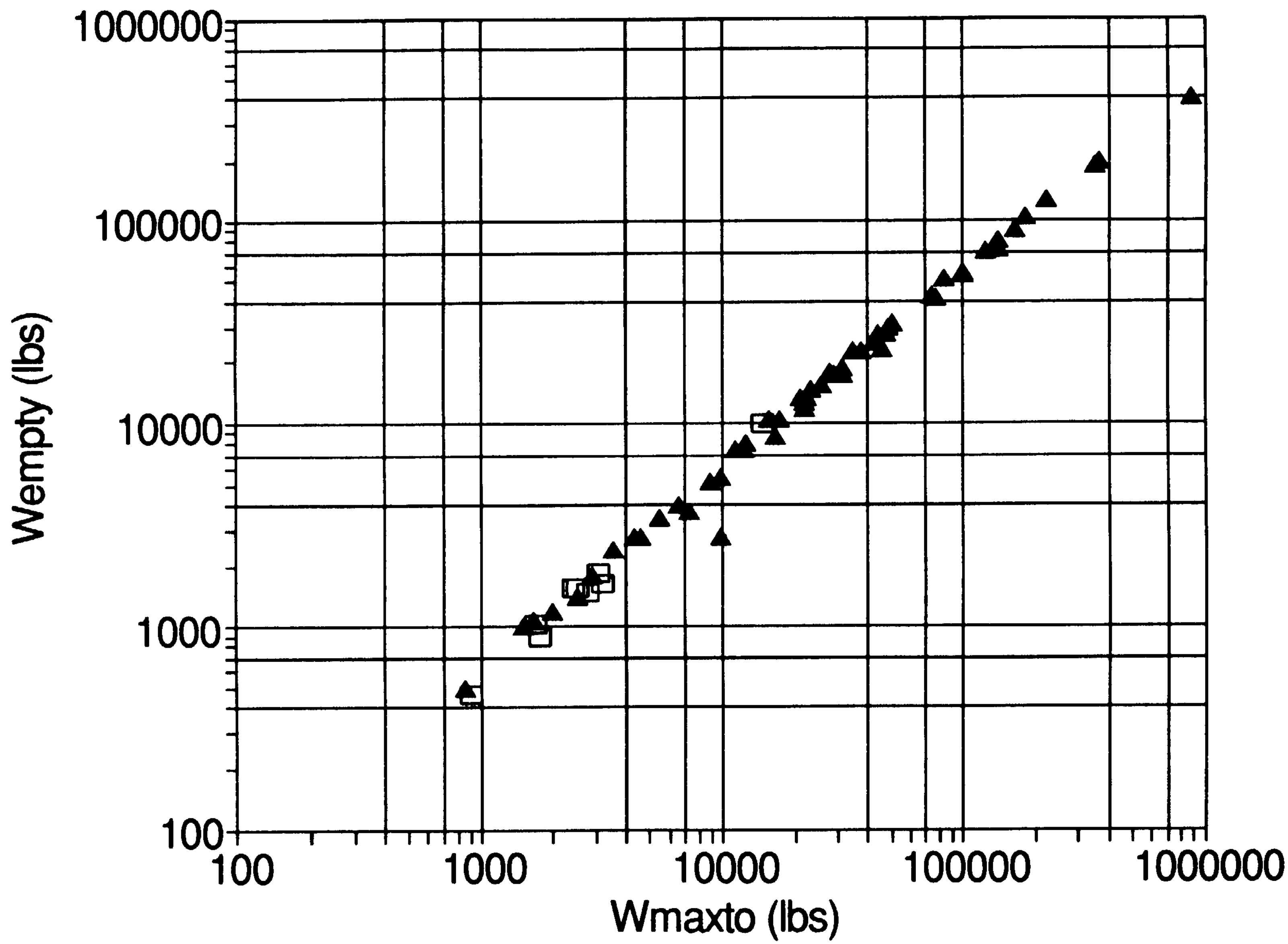


EFFECTIVE SPEED
Tucson through DFW Hub



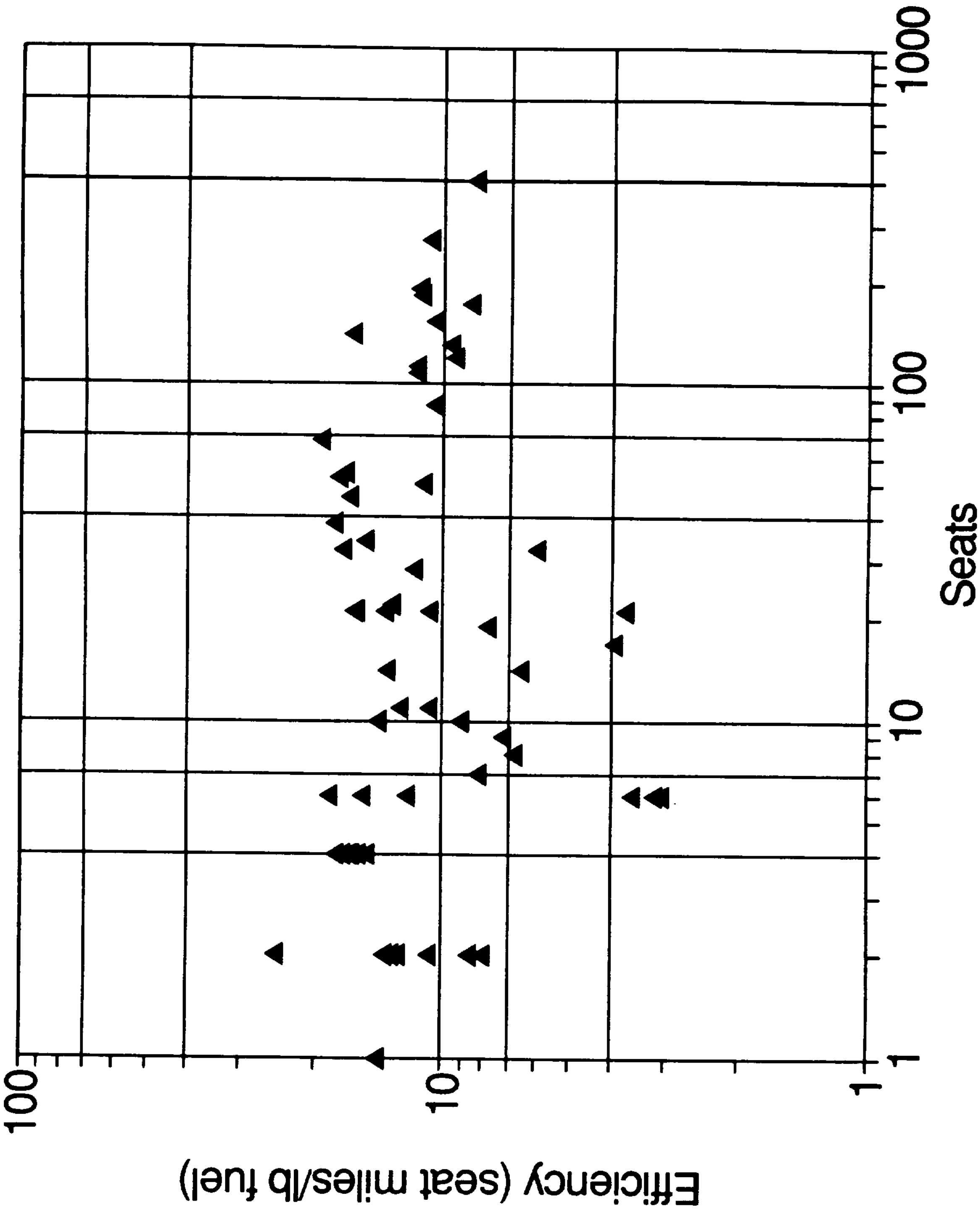
Empty Weight vs Max Takeoff Weight

Wempty = 0.656 * Wmaxto ^ 0.988



Fuel Efficiency vs Seats

Efficiency = 11.5 * Seats ^ -0.006



Conclusions

The information age is real and has produced machines able to process data as fast as humans and handle quantitative data much better.

The Global Positioning System allows vehicles to determine location, velocity, and attitude.

Digital telecommunications allow vehicles to communicate their states and plans among each other.

The rate gap between central processing and telecommunications will persist, so the brains of a transportation system will be aboard the vehicles.

Synthetic intelligence and telecommunications are cheap!

All this bodes well for personal aviation.