



# Flight Trials Comparing SatMate DSP Loran Receiver, GPS, and Legacy Loran Receivers

by

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**Locus, Inc.**

# FAATC Convair 580



# Flights and Data Collection

- Data collected by FAA Tech Center from August 20-28, 2001 during flight from Atlantic City, NJ to Anchorage, AK and back on Convair 580.
- Simultaneous data acquisition from GPS, SatMate and 2 legacy Loran receivers
- Velocities up to ~ 350 mph
- Receivers:
  - GPS NovAtel OEM 4 12-channel CA code WAAS enhanced
  - SatMate 1000 with E-field (Comant CI-121SP)
  - Apollo 618 with E-field
  - BF Goodrich (JET) 7201 with E-field

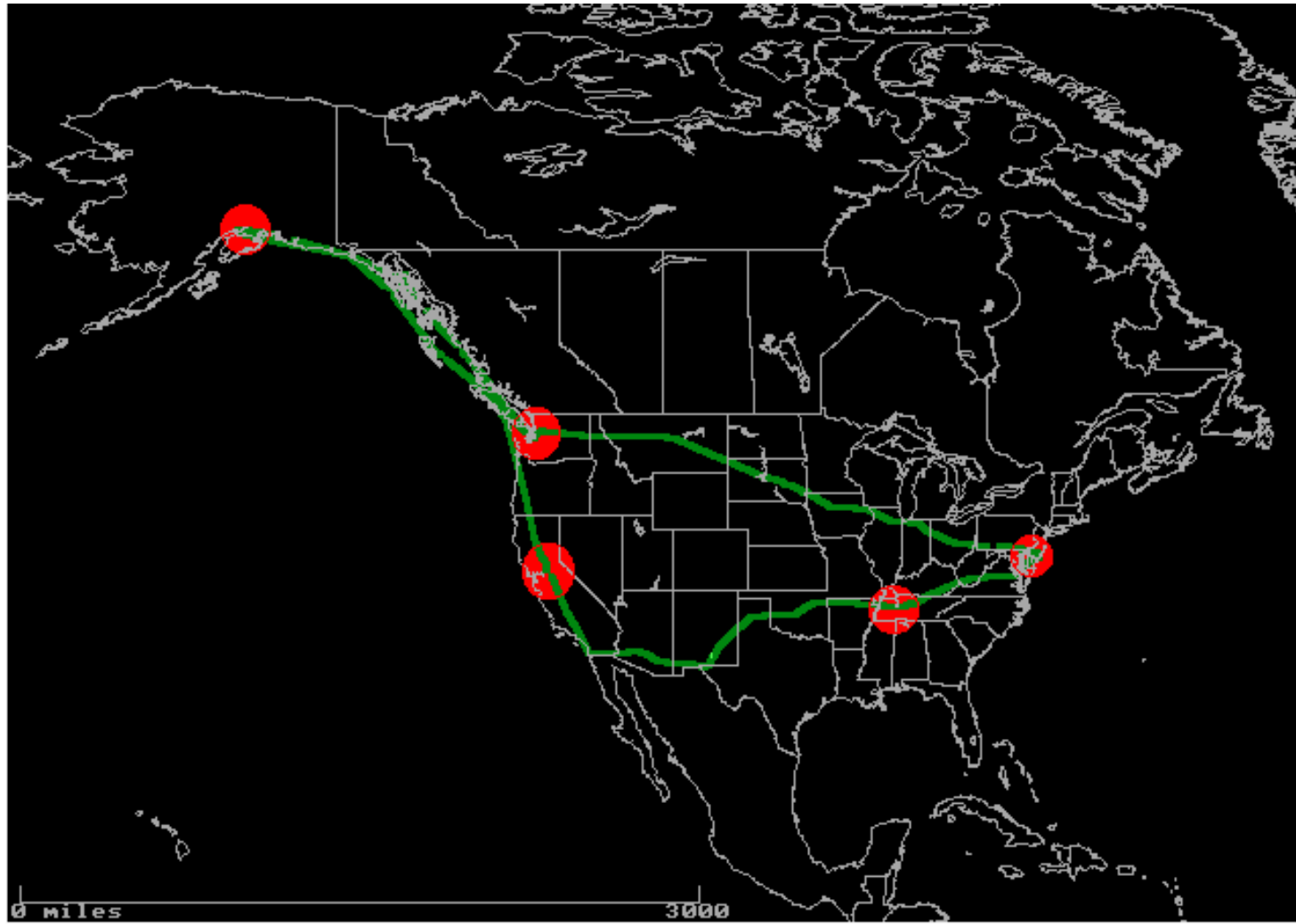
# Receiver Parameters

- Receiver update rate - 1 second unless noted
- Apollo 618 - no ASF model used; single-chain triad
- BF Goodrich 7201 - 8 station/3 chain receiver; ASF model used
- SatMate receiver - all-in-view receiver (40 stations) with multi-chain solution; no ASF map/model used, but applied general nav conductivity of 5 milli-Siemens; last sequence of plots around Atlantic City illustrate application of “quasi-ASFs” as detailed.

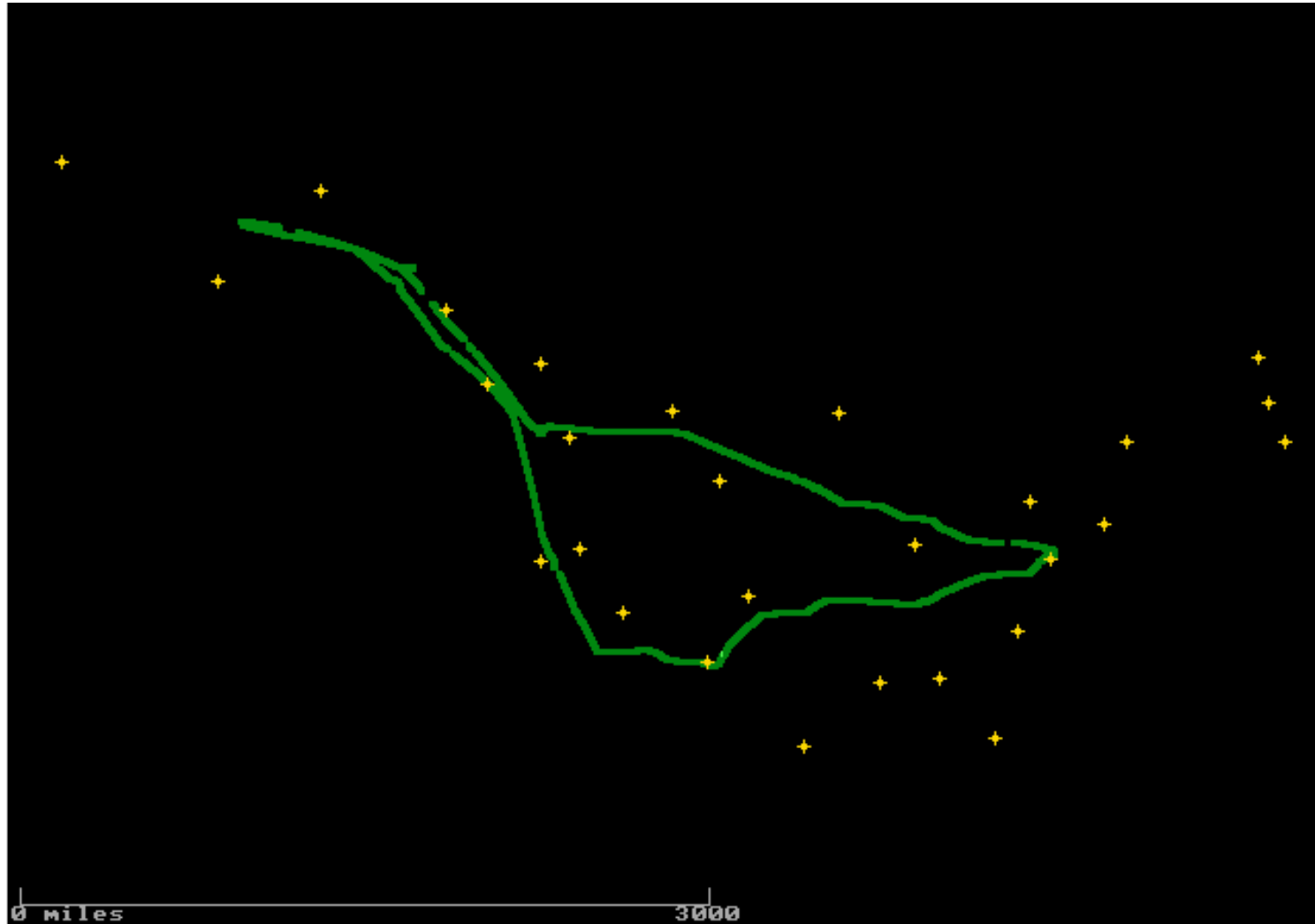
# Data Plots

- GPS - Green
- SatMate - White
- Legacy receivers - Yellow for both
- Legacy receiver data shown only in close-ups around airports to simplify display
- All plots in statute miles

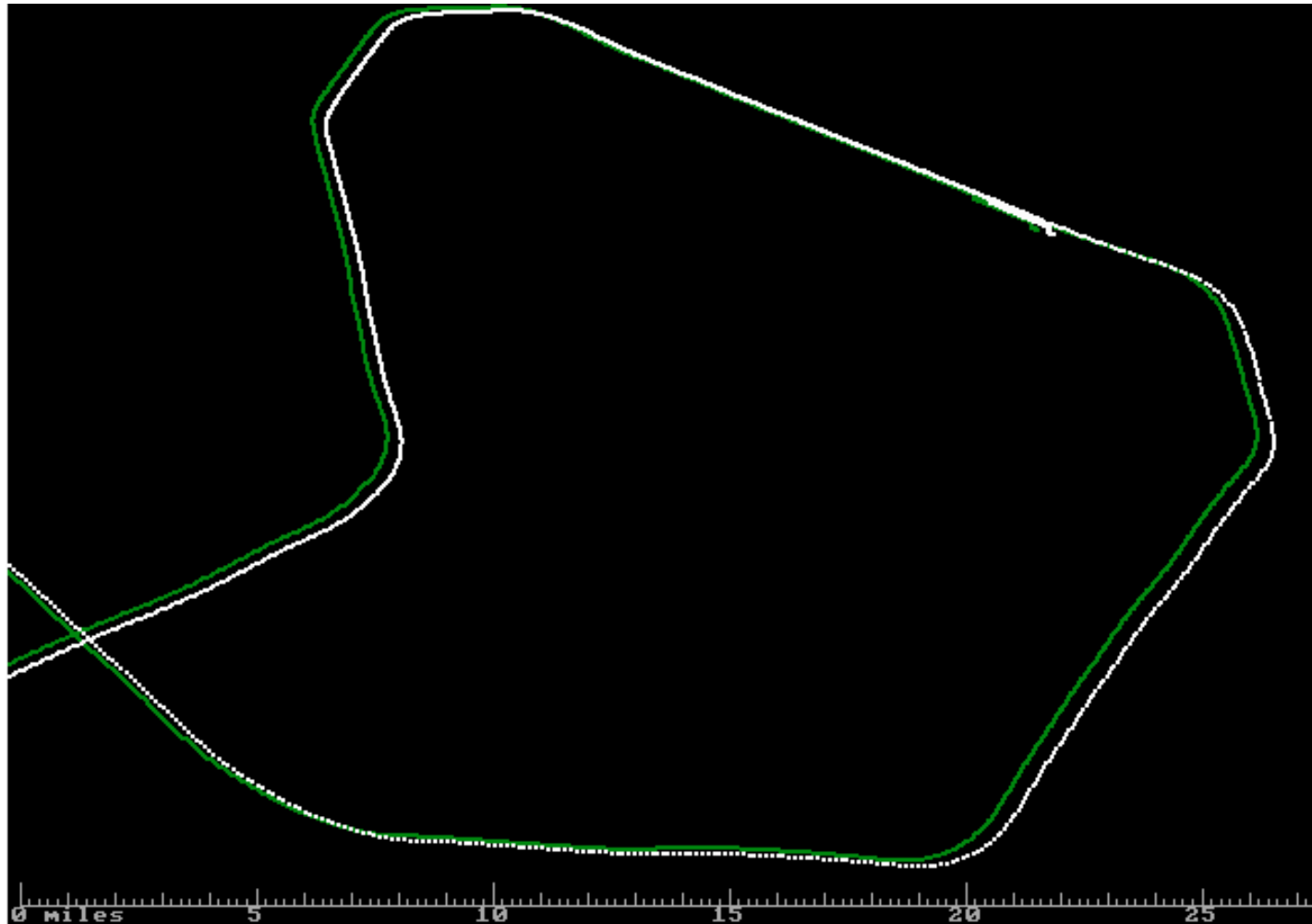
# Data Collection Areas for Sample Plots



# Flight Path with Loran-C Stations



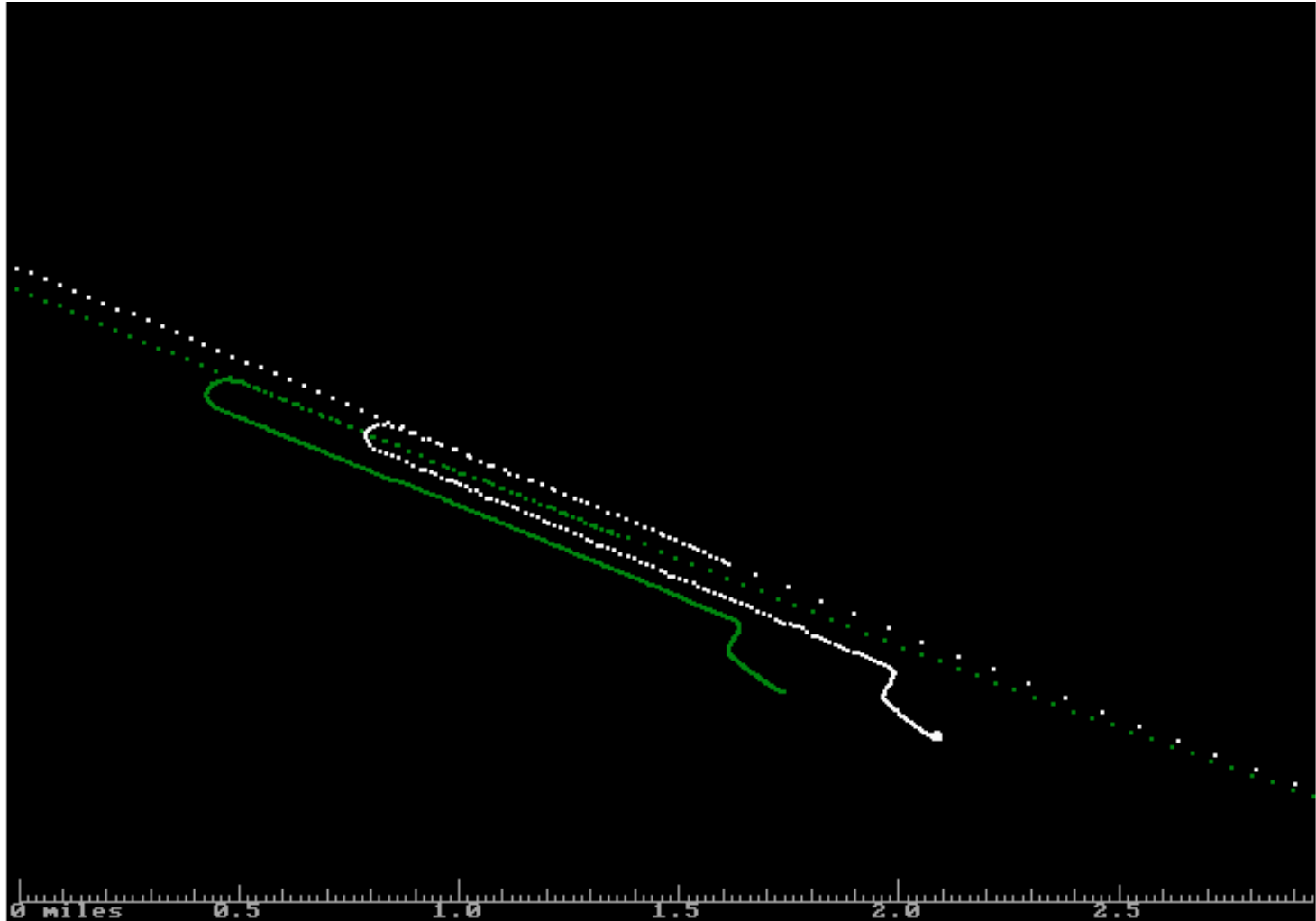
# Atlantic City, NJ Airport View of Approach, Takeoff, Landing



GPS and SatMate only; no SatMate ASF Corrections

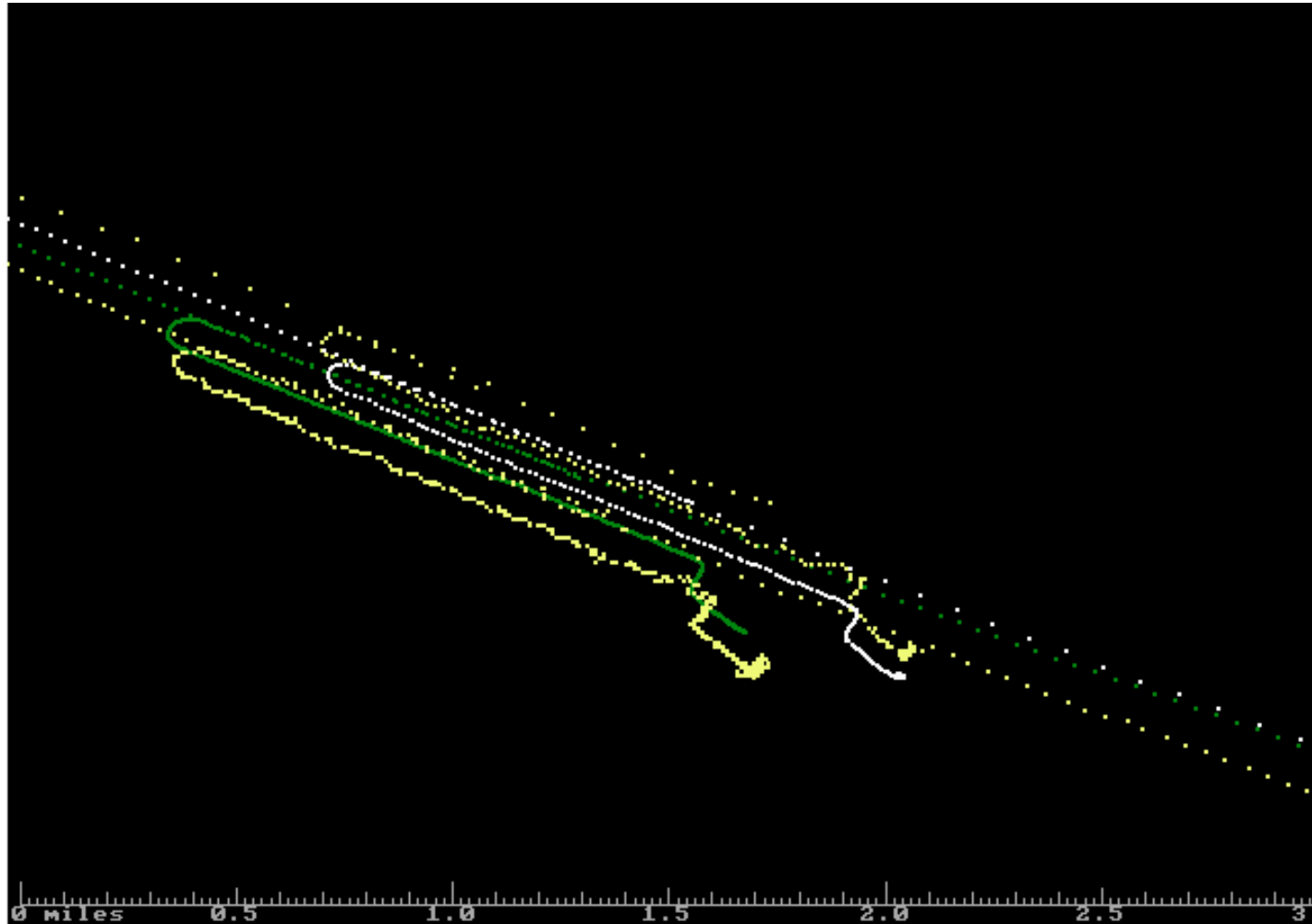
# Atlantic City, NJ Airport

## Close-up View of Aug. 20 Takeoff and August 28 Landing



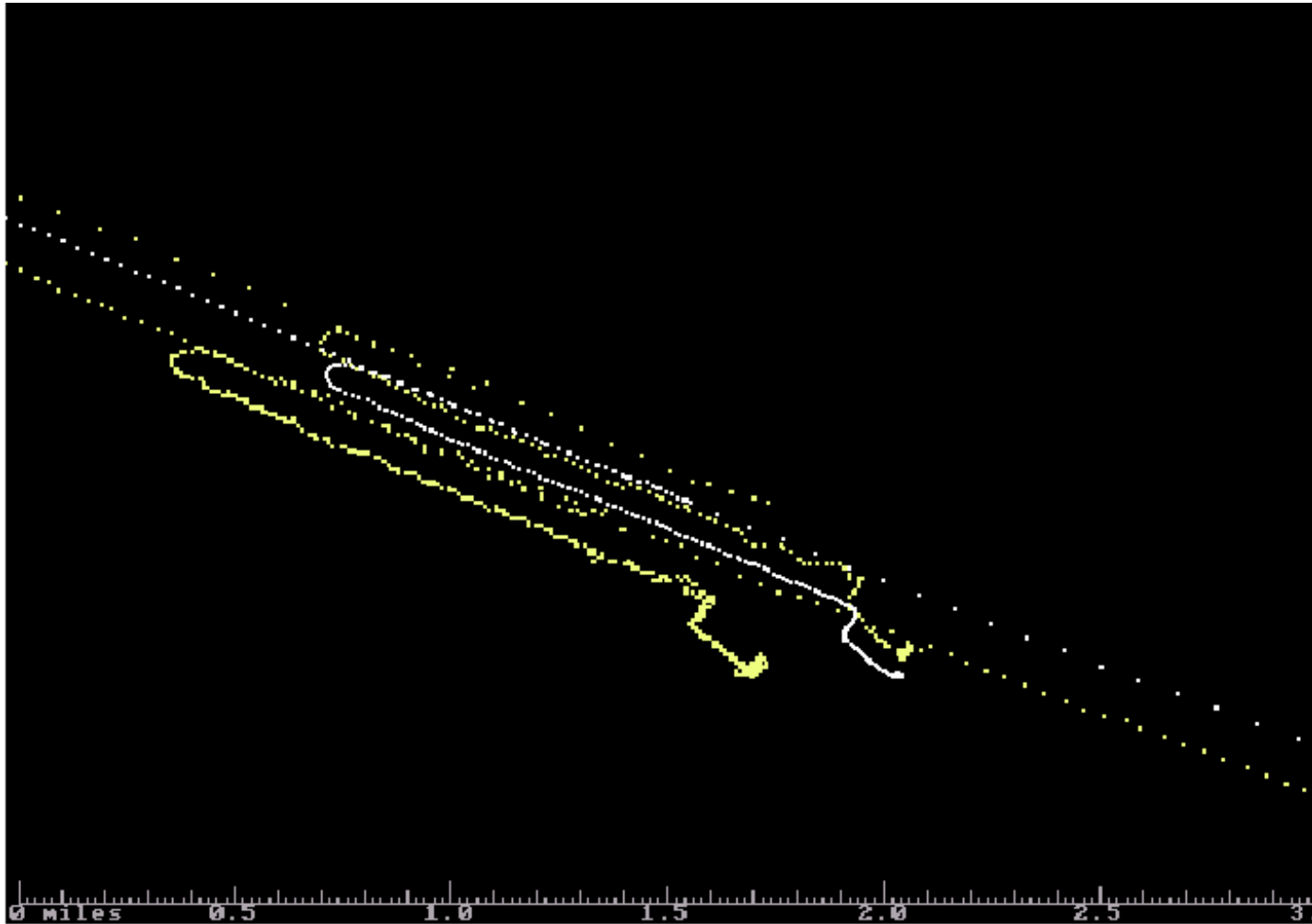
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# Atlantic City, NJ Airport Close-up View of Takeoff and Landing



GPS, SatMate and Legacy Receivers

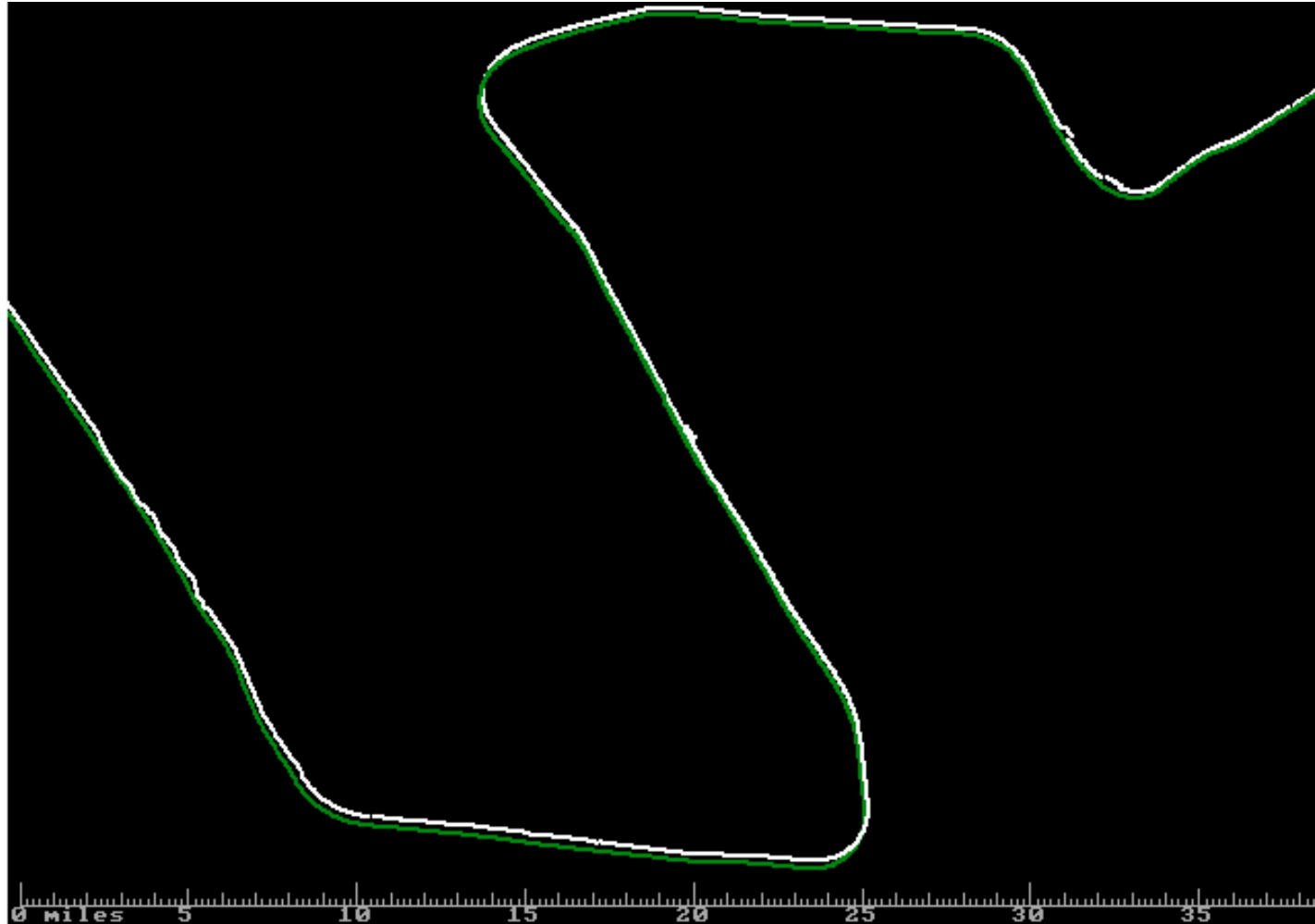
# Atlantic City, NJ Airport Close-up View of Takeoff and Landing



SatMate and Legacy Receivers

# Seattle Airport

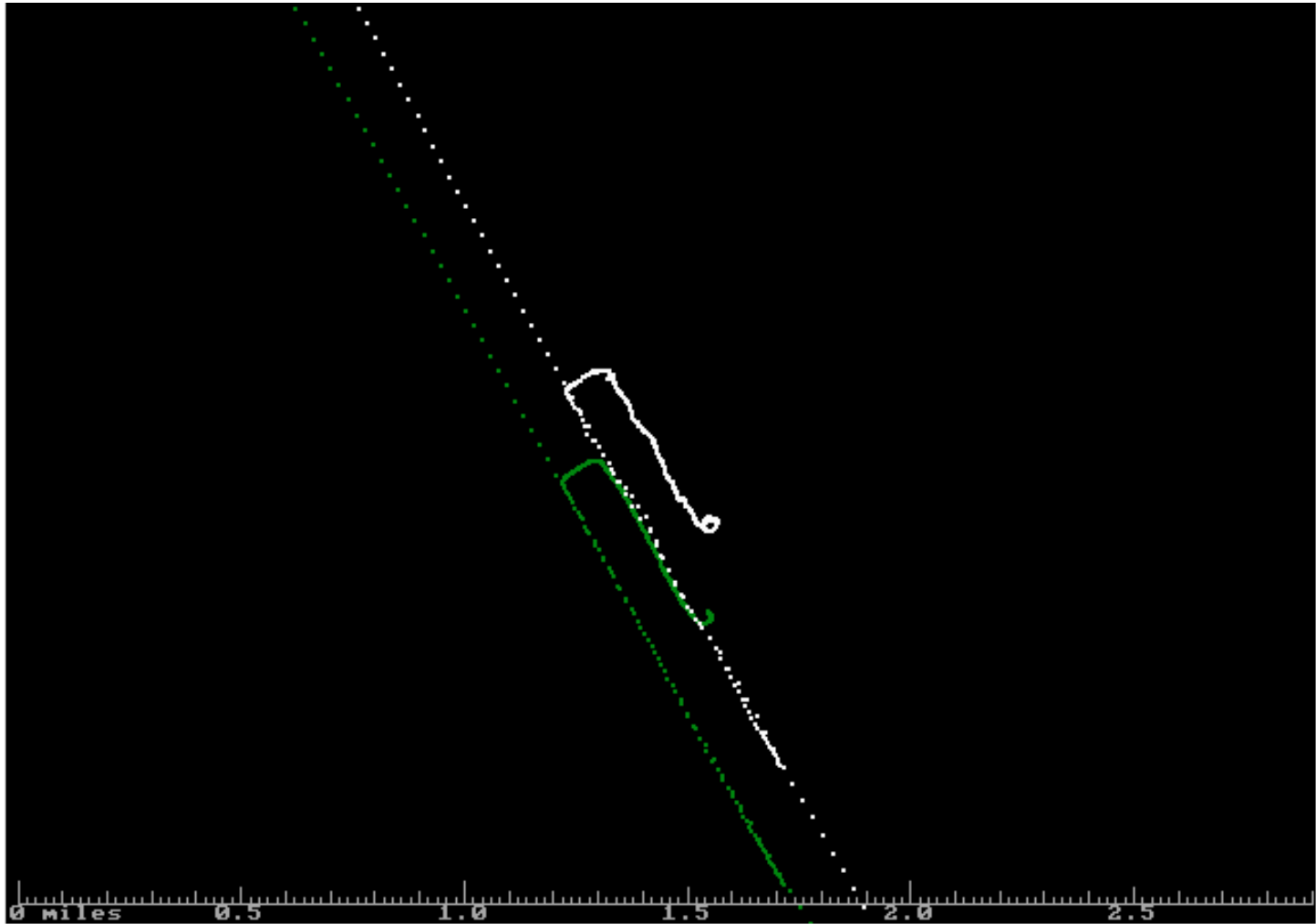
## View of Approach, Landing, Takeoff



GPS and SatMate only; no SatMate ASF Corrections

# Seattle Airport

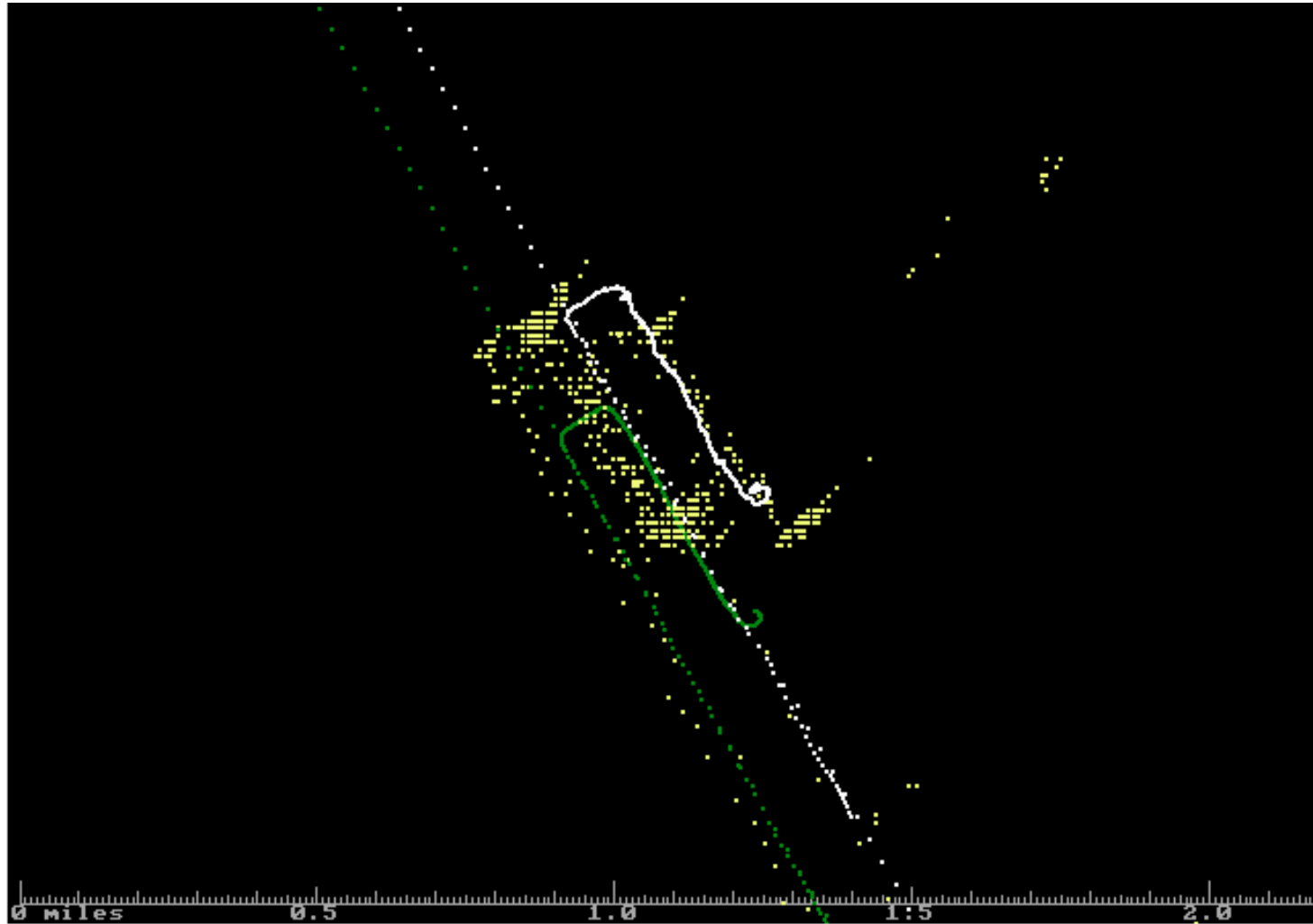
## Close-up View of Landing and Takeoff



GPS and SatMate only; no SatMate ASF Corrections

# Seattle Airport

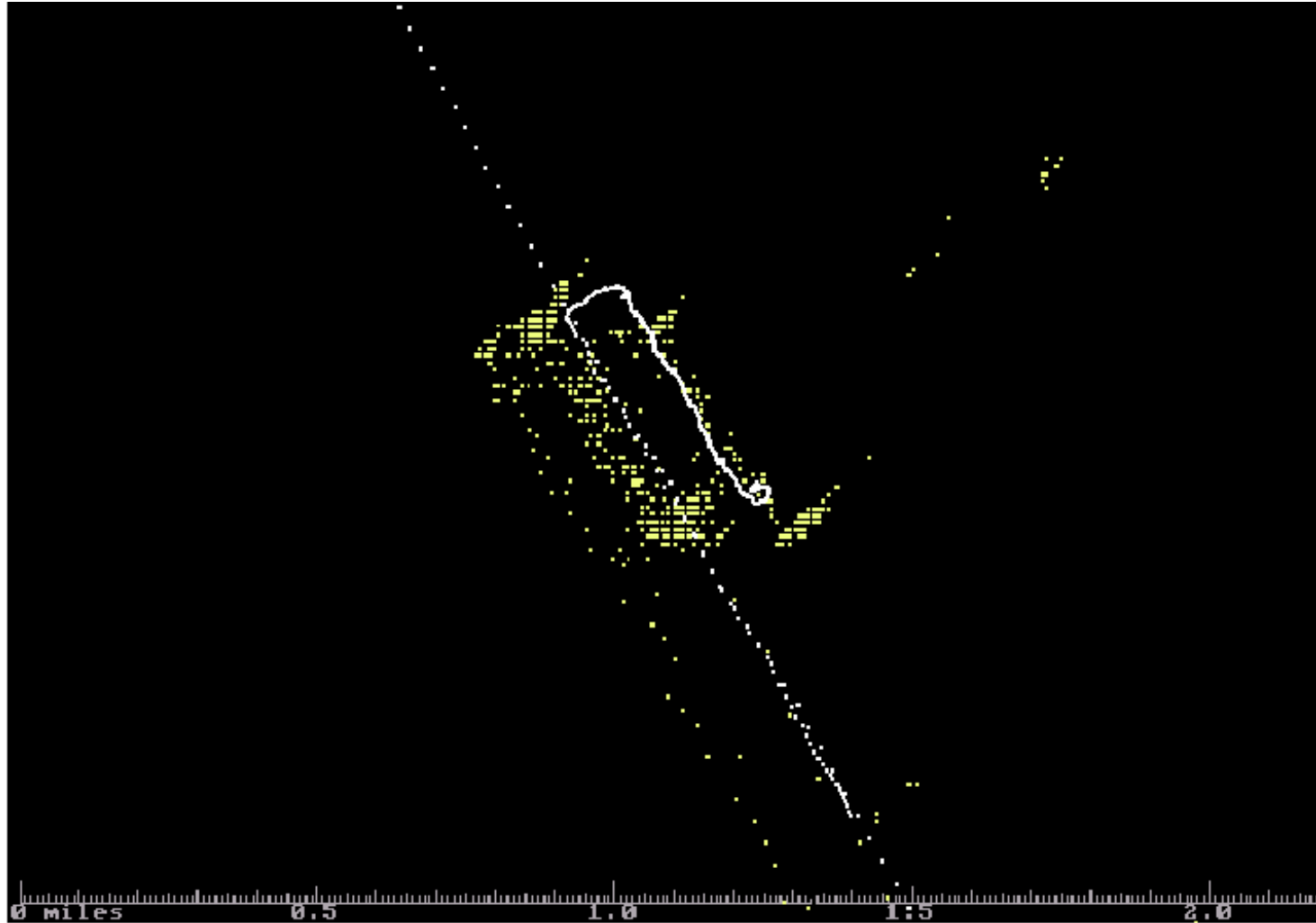
## Close-up View of Landing and Takeoff



GPS, SatMate, and Legacy Receivers

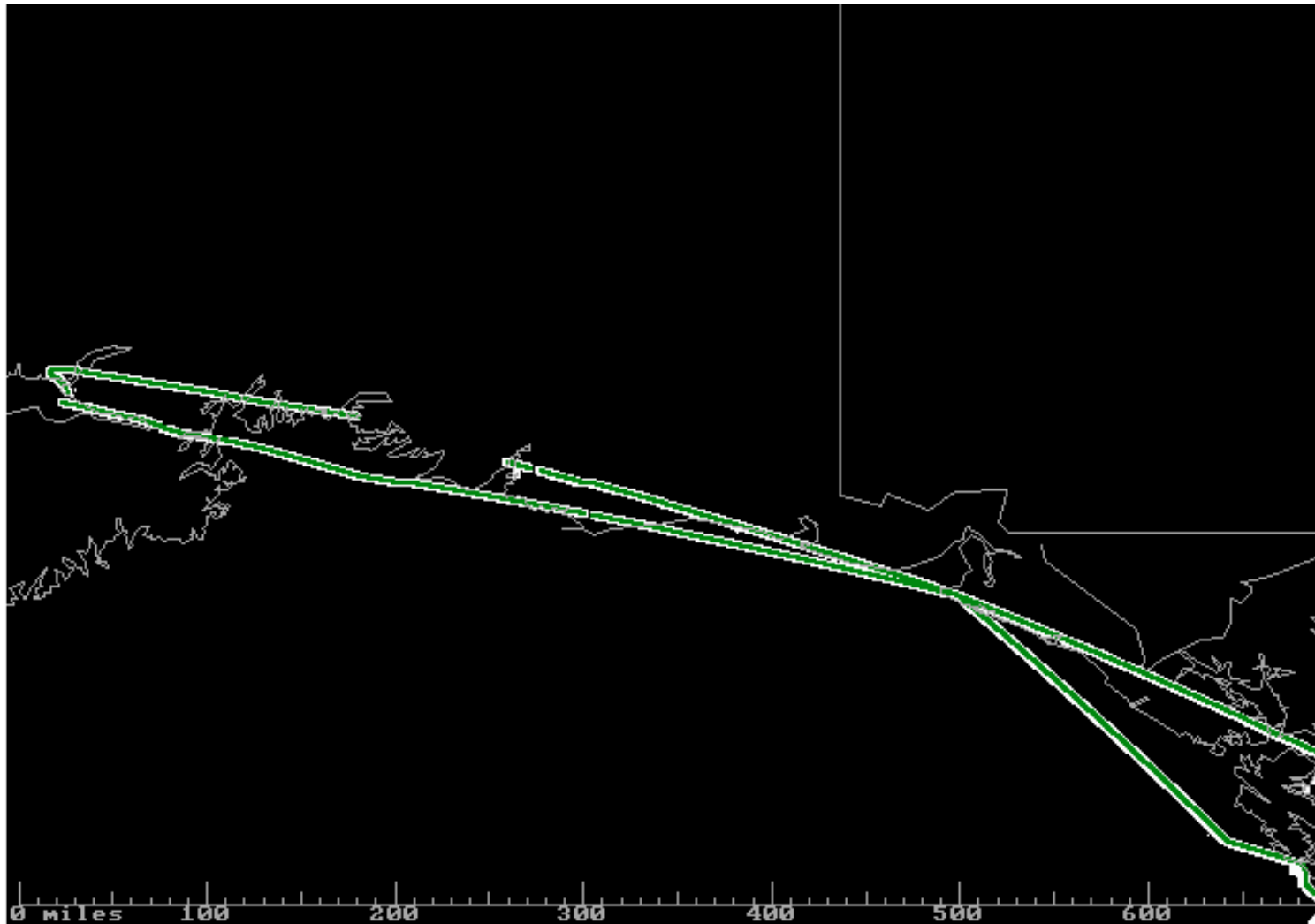
# Seattle Airport

## Close-up View of Landing and Takeoff



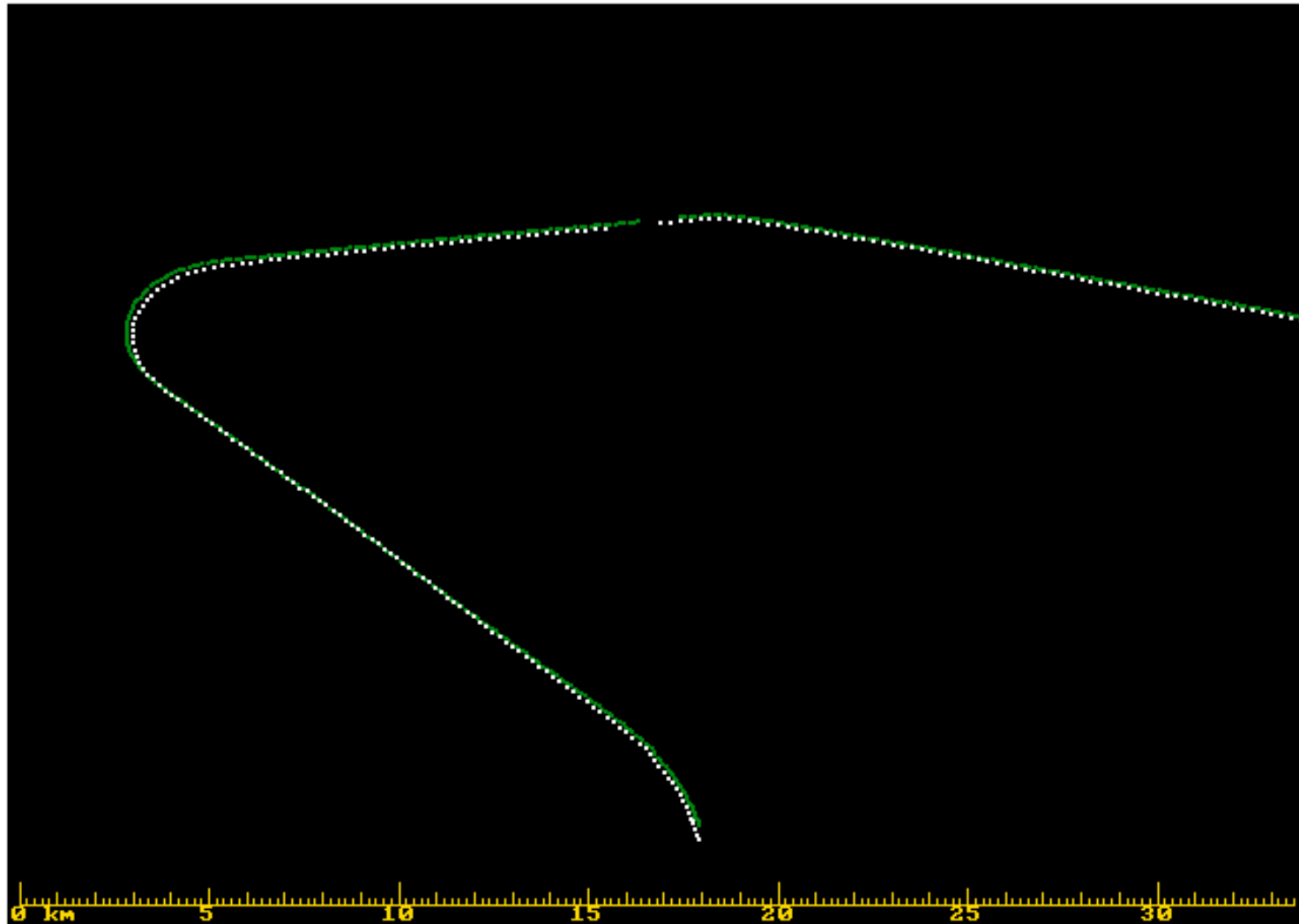
SatMate and Legacy Receivers

# Southern Coast of Alaska



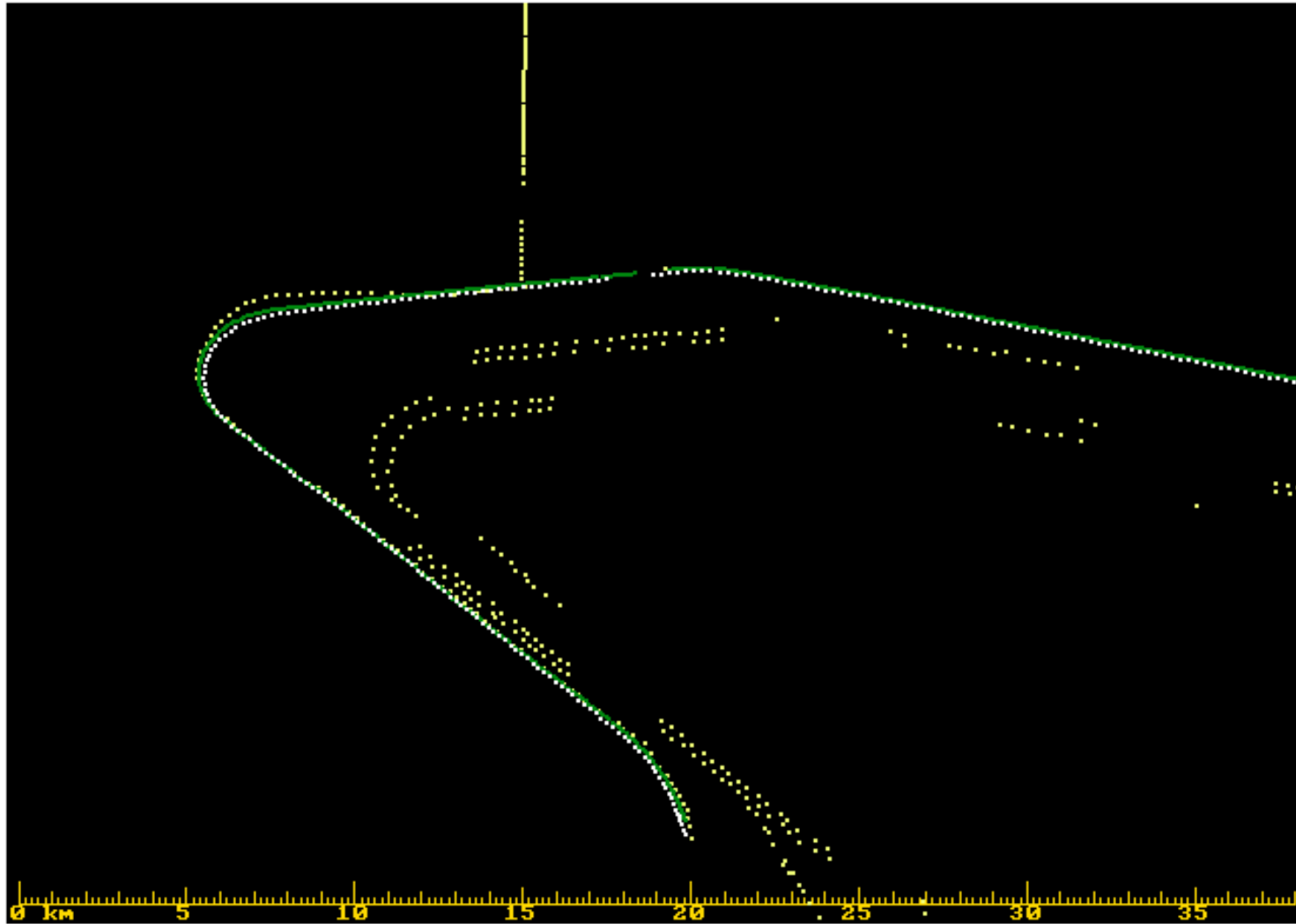
GPS and SatMate only; no SatMate ASF Corrections

# Anchorage Airport Close-up View of Takeoff



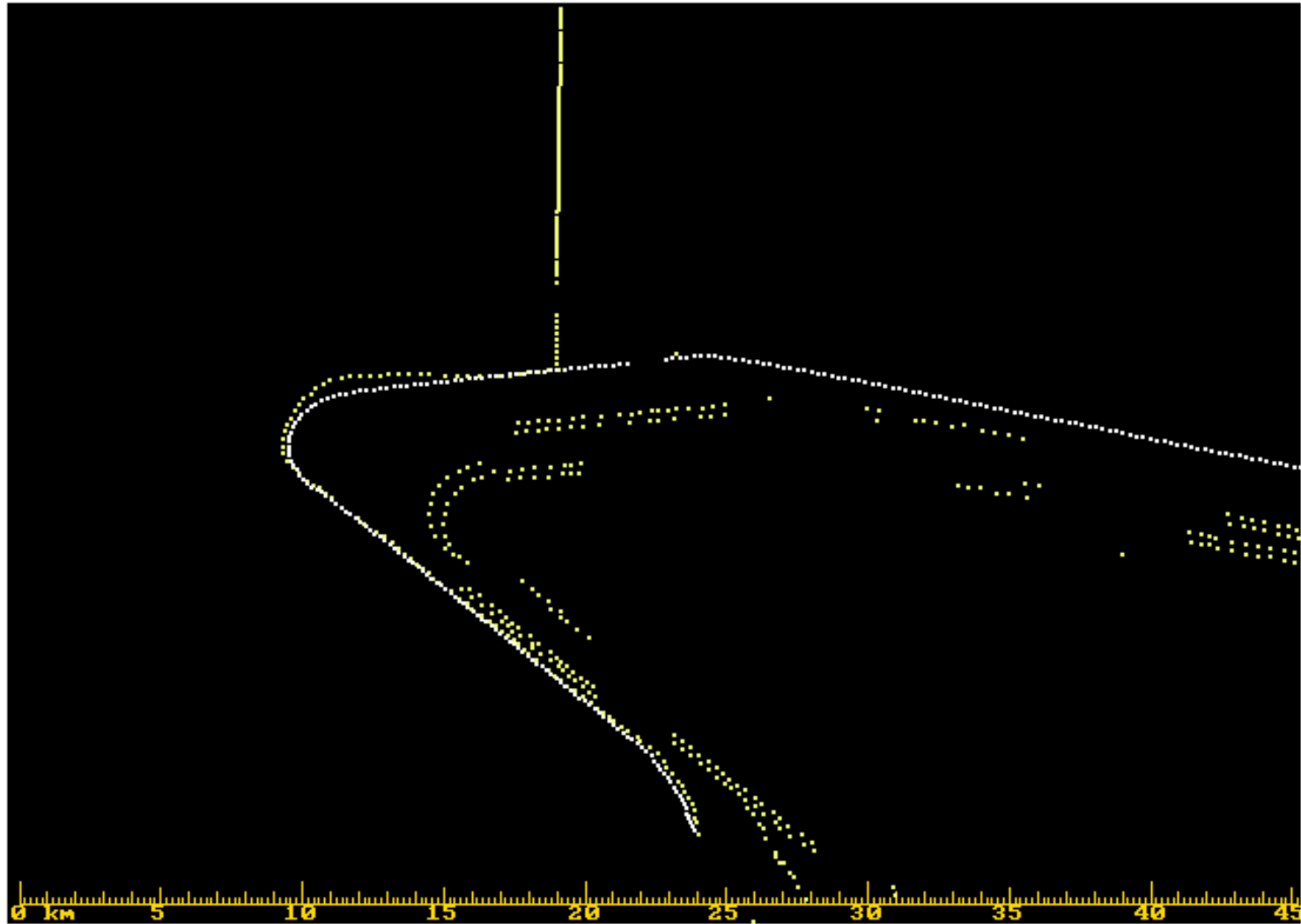
GPS and SatMate only; no SatMate ASF Corrections

# Anchorage Airport Close-up View of Takeoff



GPS, SatMate, and Legacy Receivers

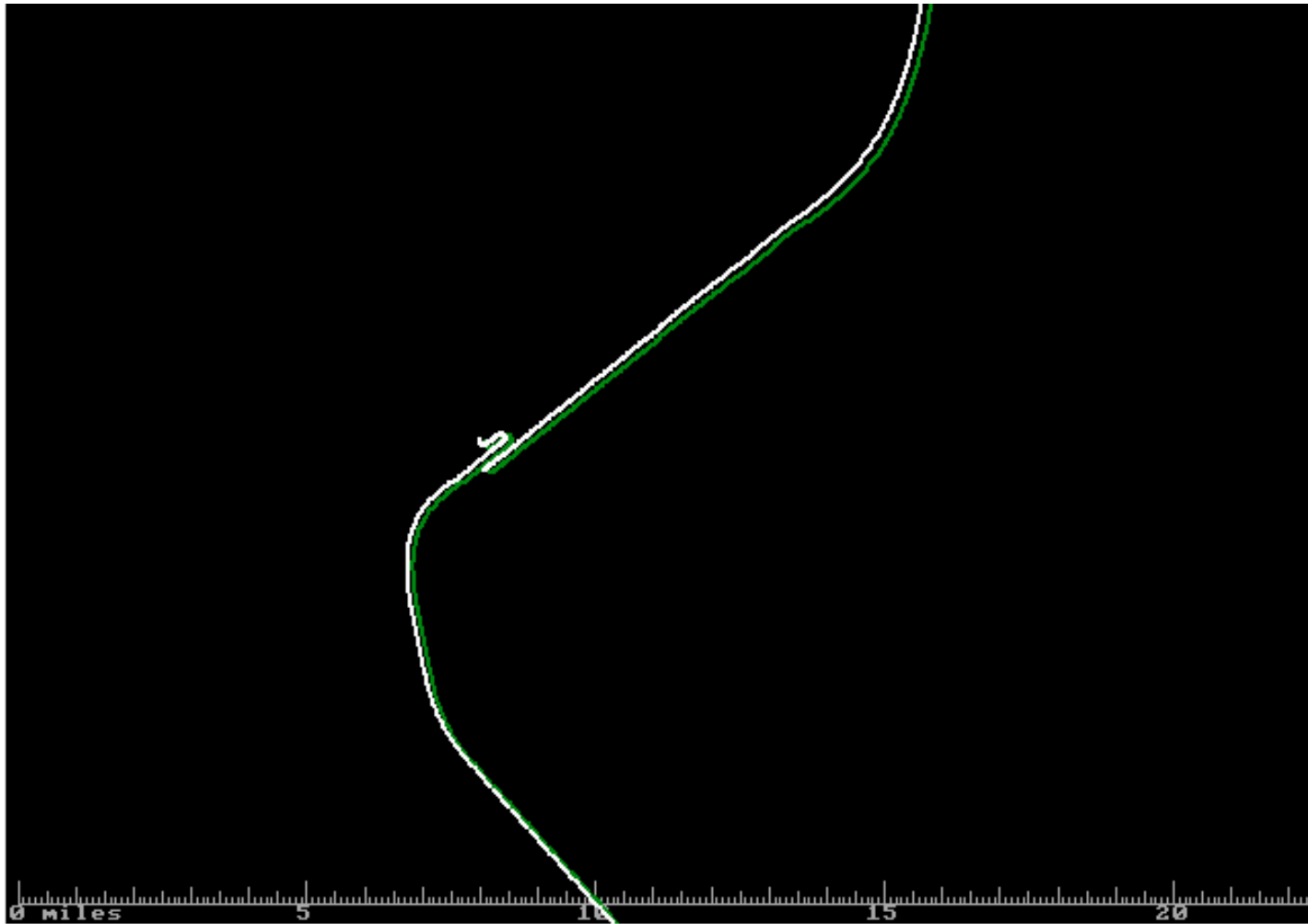
# Anchorage Airport Close-up View of Takeoff



SatMate and Legacy Receivers

# Sacramento Airport

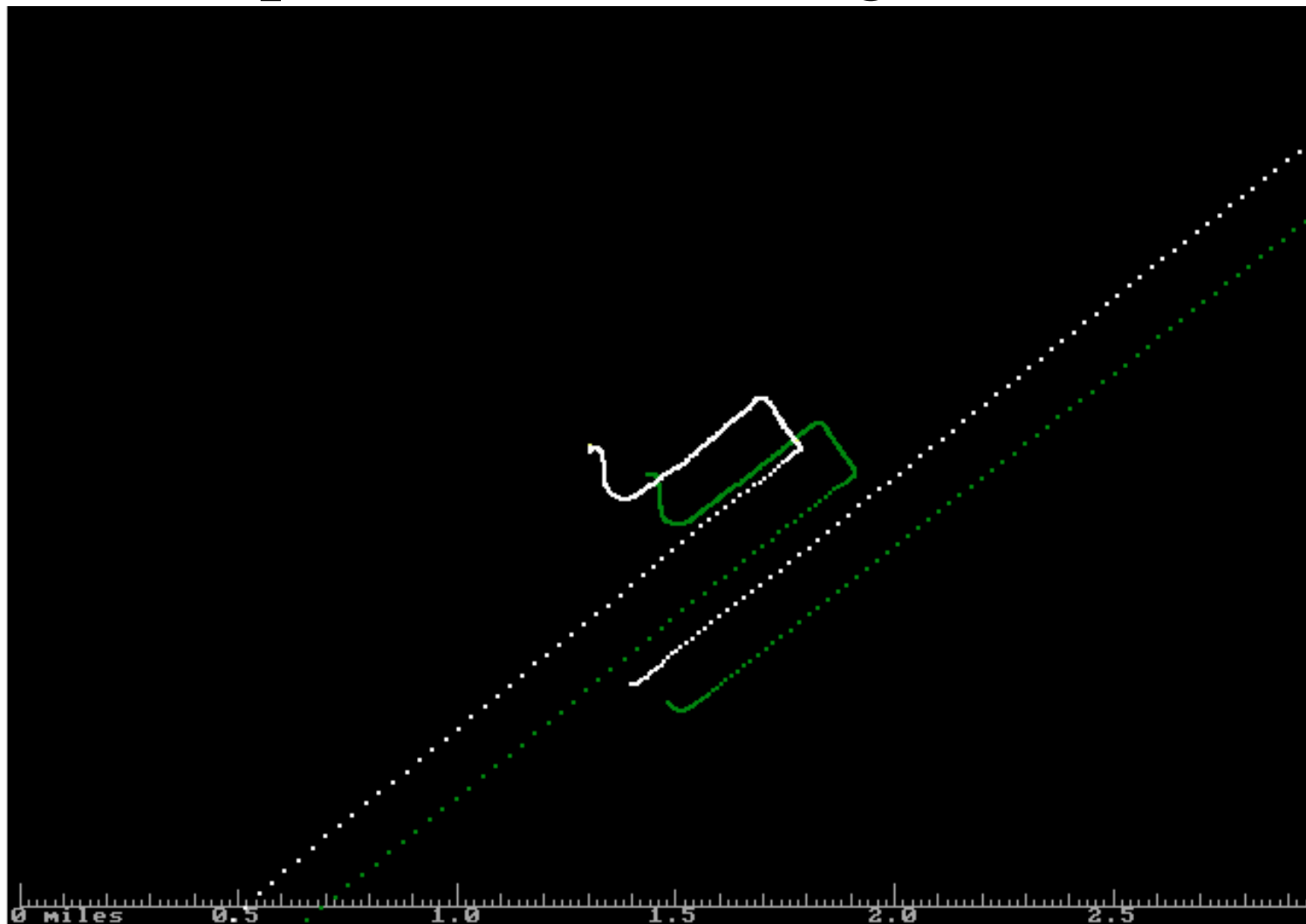
## View of Approach, Landing, Takeoff



GPS and SatMate only; no SatMate ASF Corrections

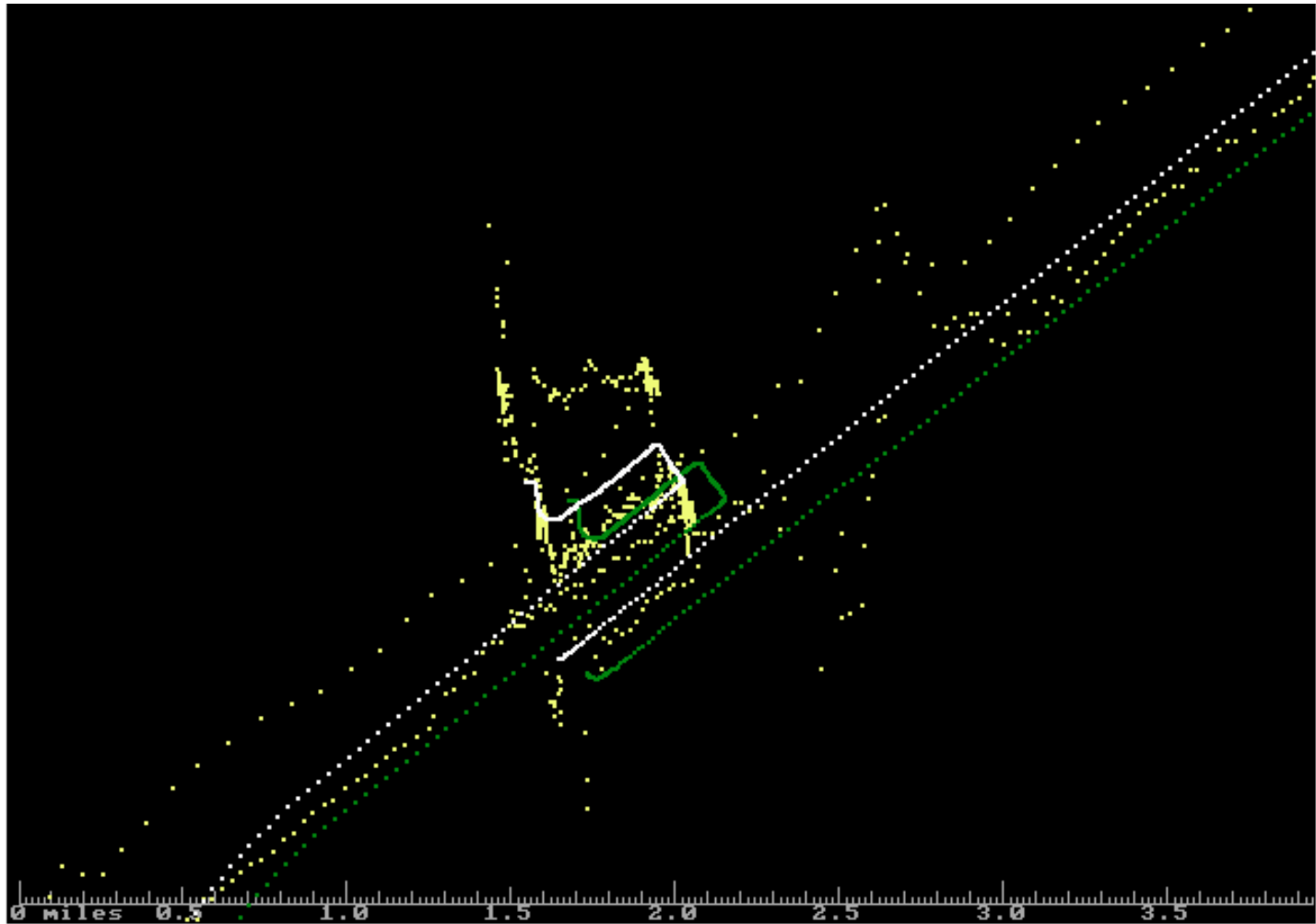
# Sacramento Airport

## Close-up View of Landing and Takeoff



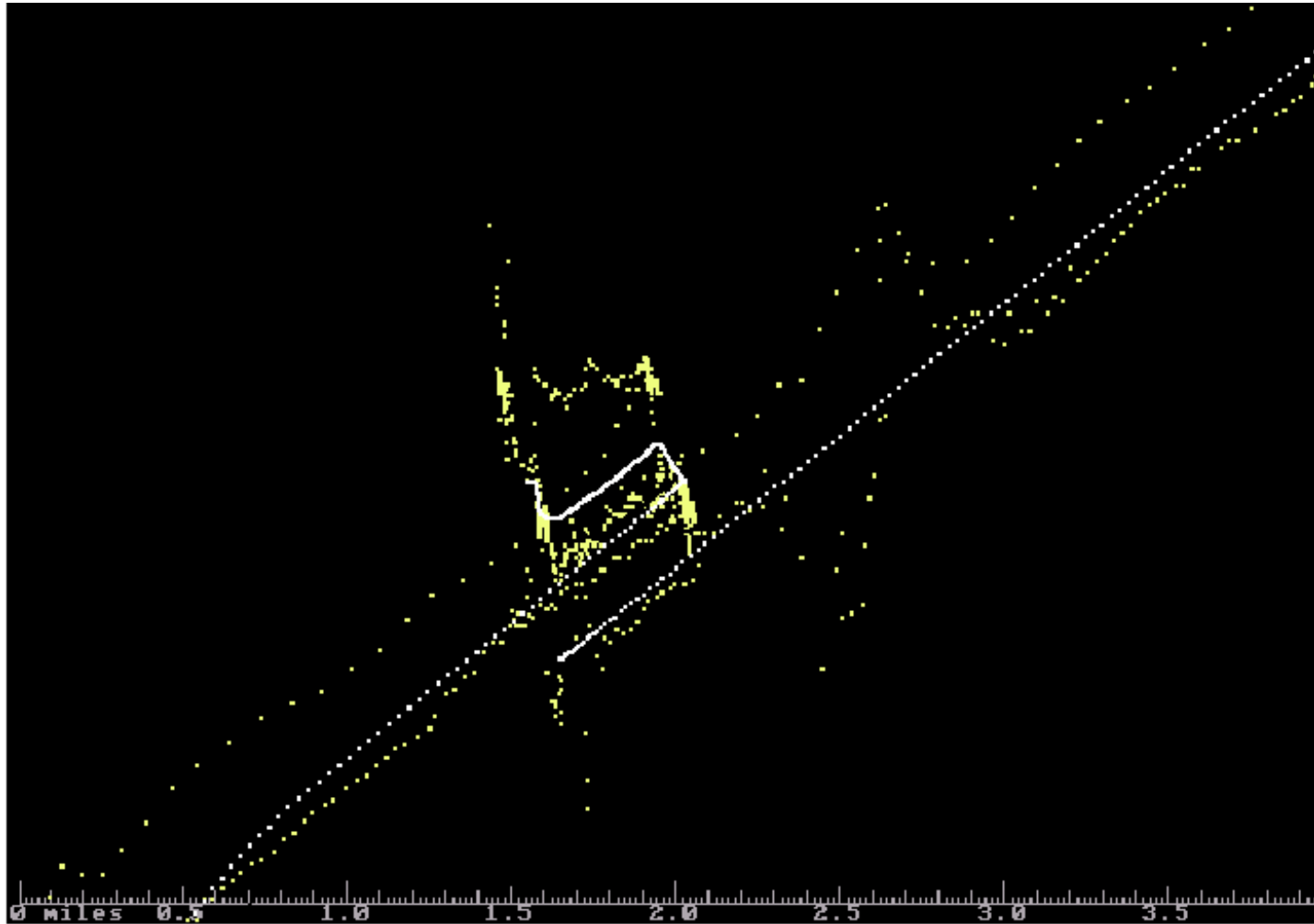
GPS and SatMate only; no SatMate ASF Corrections

# Sacramento Airport Close-up View of Landing and Takeoff



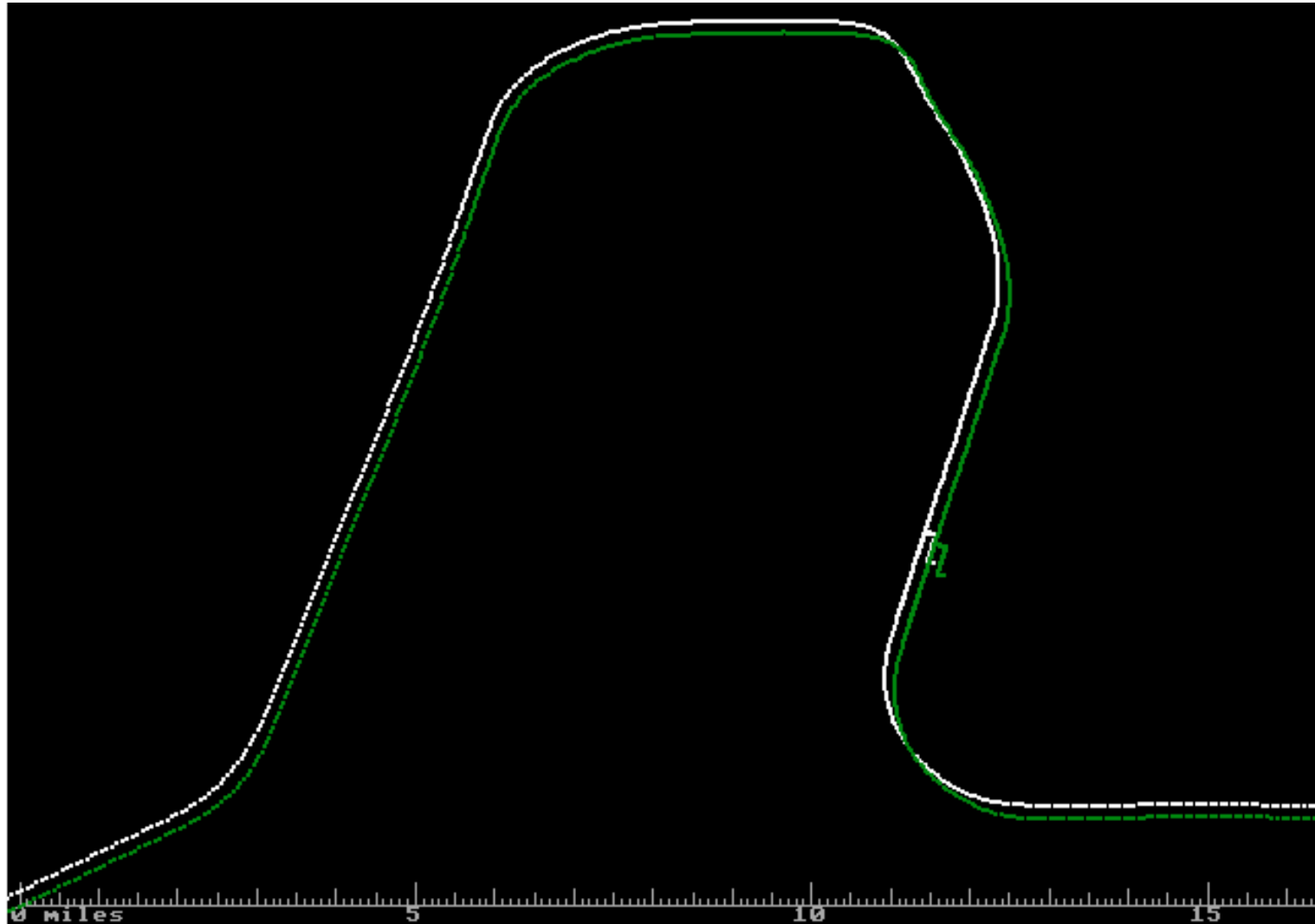
GPS, SatMate, and Legacy Receivers

# Sacramento Airport Close-up View of Landing and Takeoff



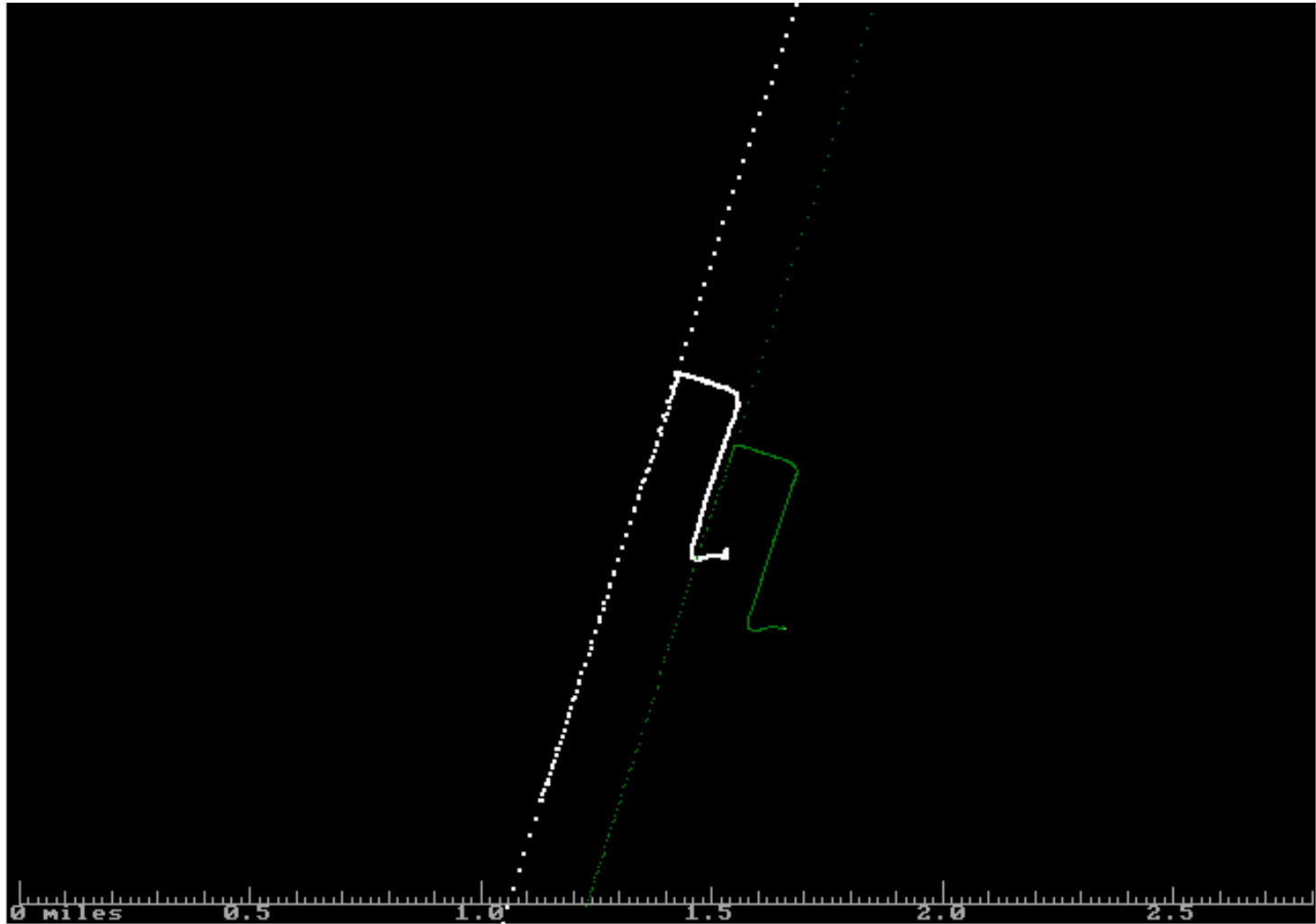
SatMate and Legacy Receivers

# Nashville, TN Airport View of Approach, Landing, Takeoff



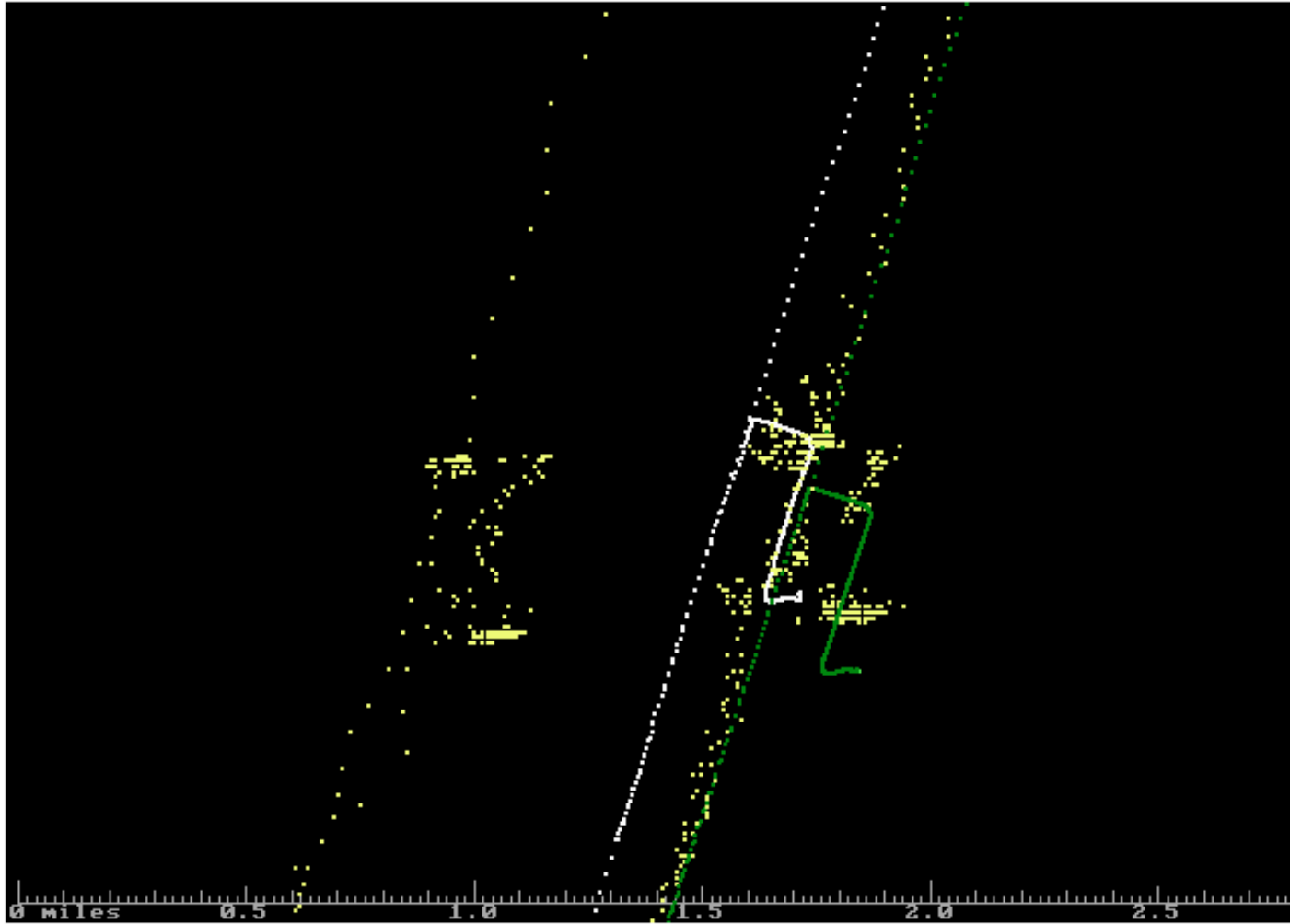
GPS and SatMate only; no SatMate ASF Corrections

# Nashville, TN Airport Close-up View of Landing and Takeoff



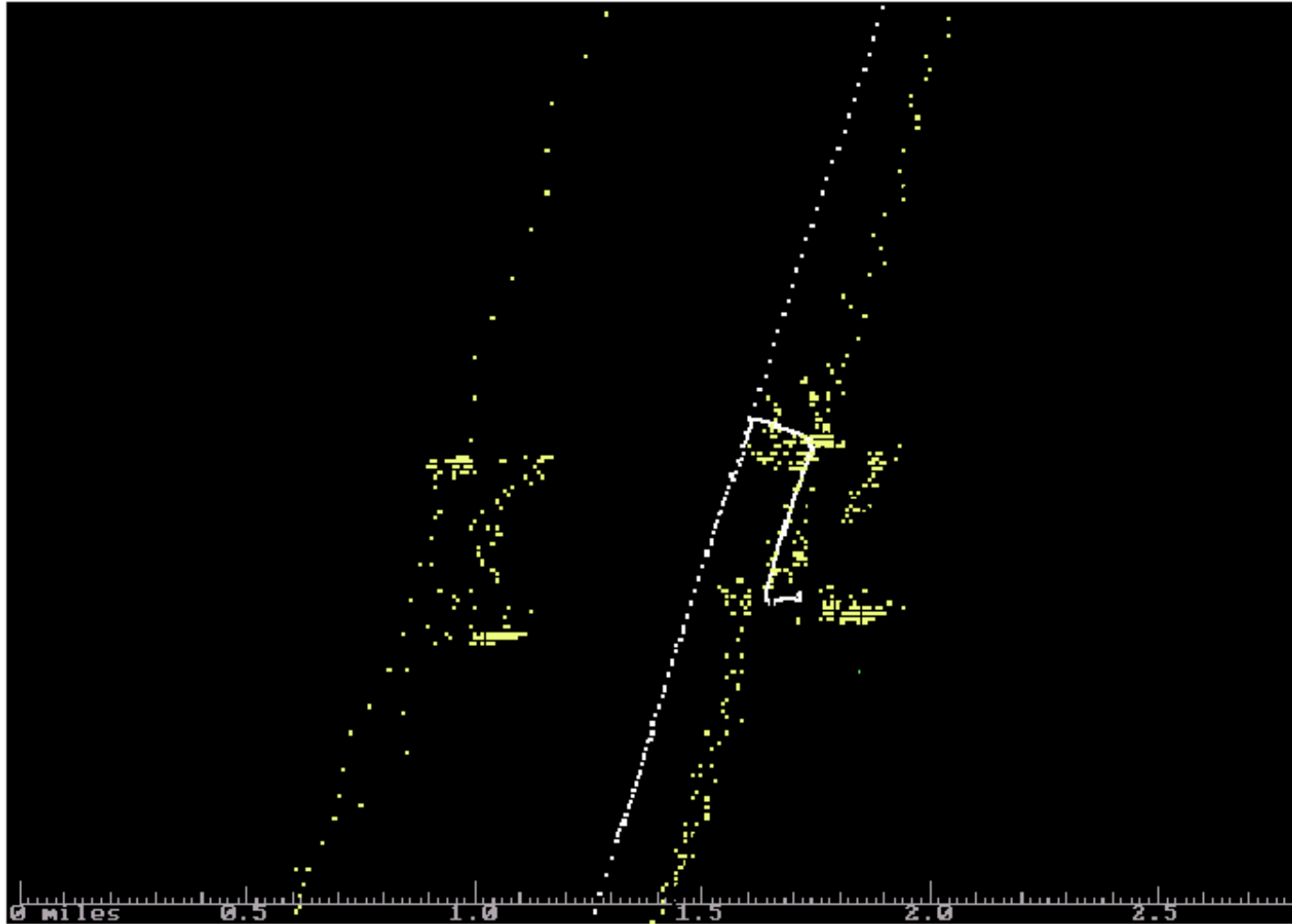
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# Nashville, TN Airport Close-up View of Landing and Takeoff



GPS, SatMate, and Legacy Receivers

# Nashville, TN Airport Close-up View of Landing and Takeoff

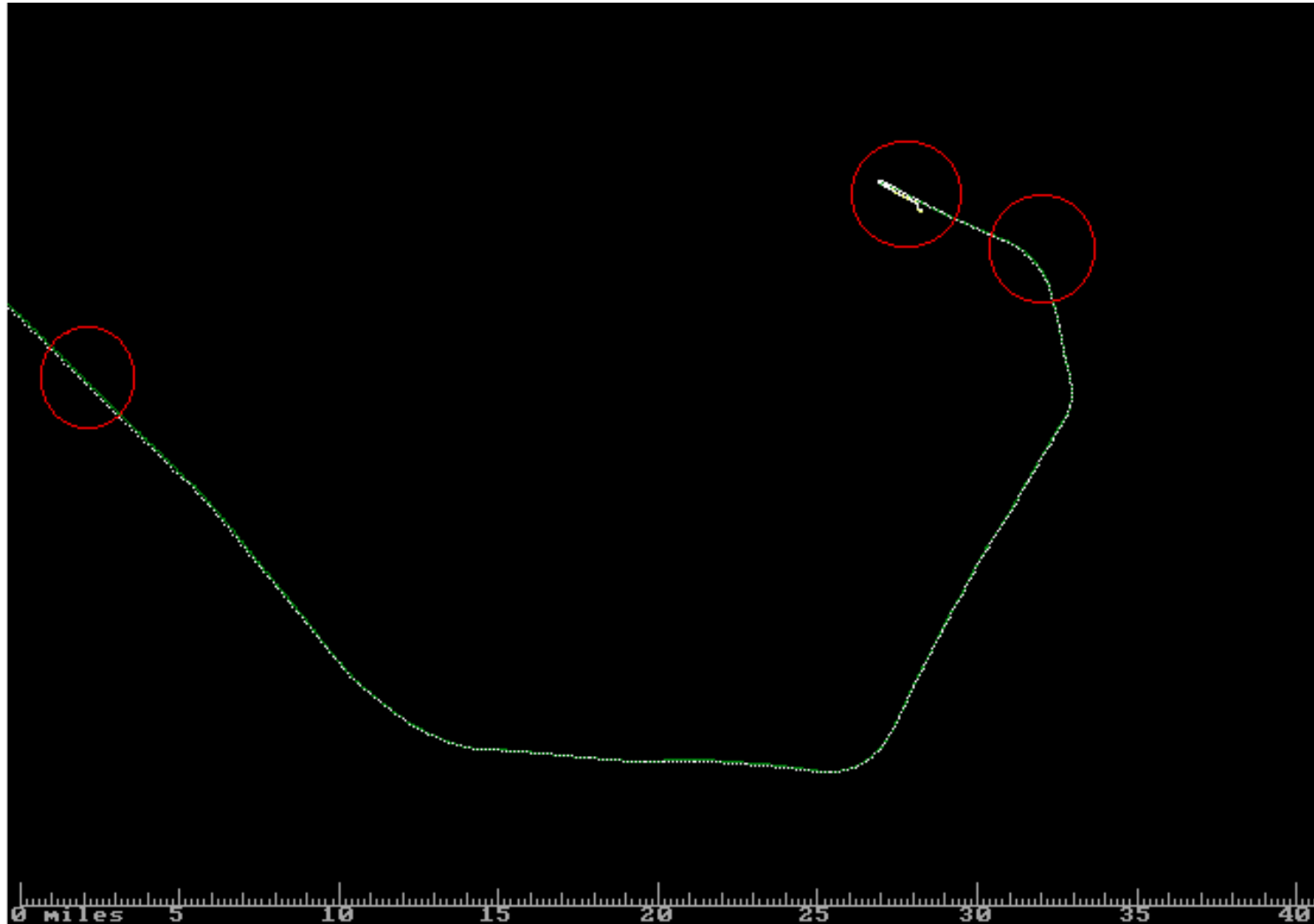


SatMate and Legacy Receivers

# Derivation of “Quasi-ASFs” and Example Application to Flight Data

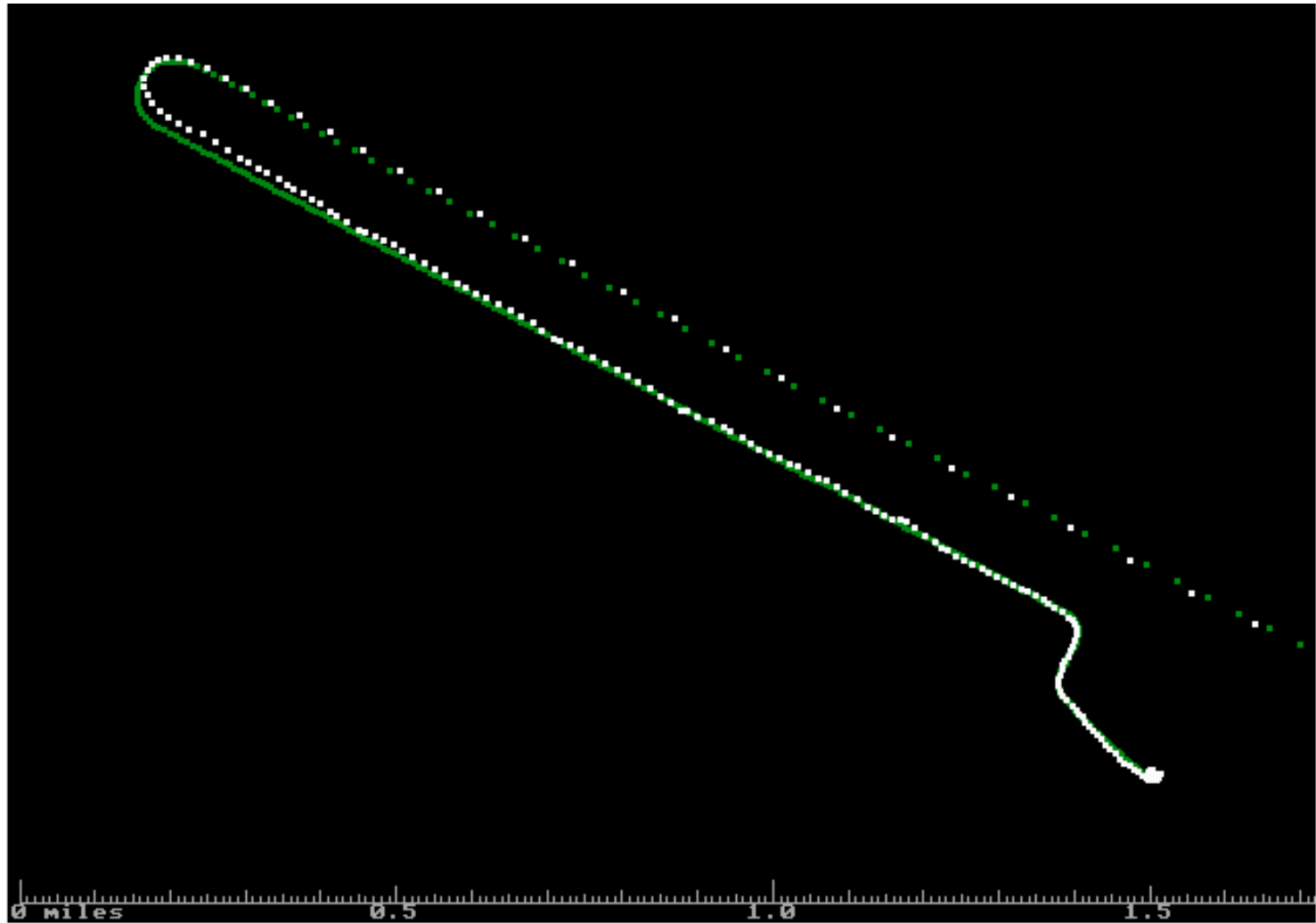
- Create plot with nav conductivity set at 5 Siemens (sea water)
- Calculate position offset of Loran vs. GPS at single airport location
- Subtract measured TOA from calculated TOA to obtain ASF
- Apply ASFs to SatMate data
- Create plot using ASF corrections

# Example SatMate Quasi-ASF Results around Atlantic City Airport



GPS and SatMate

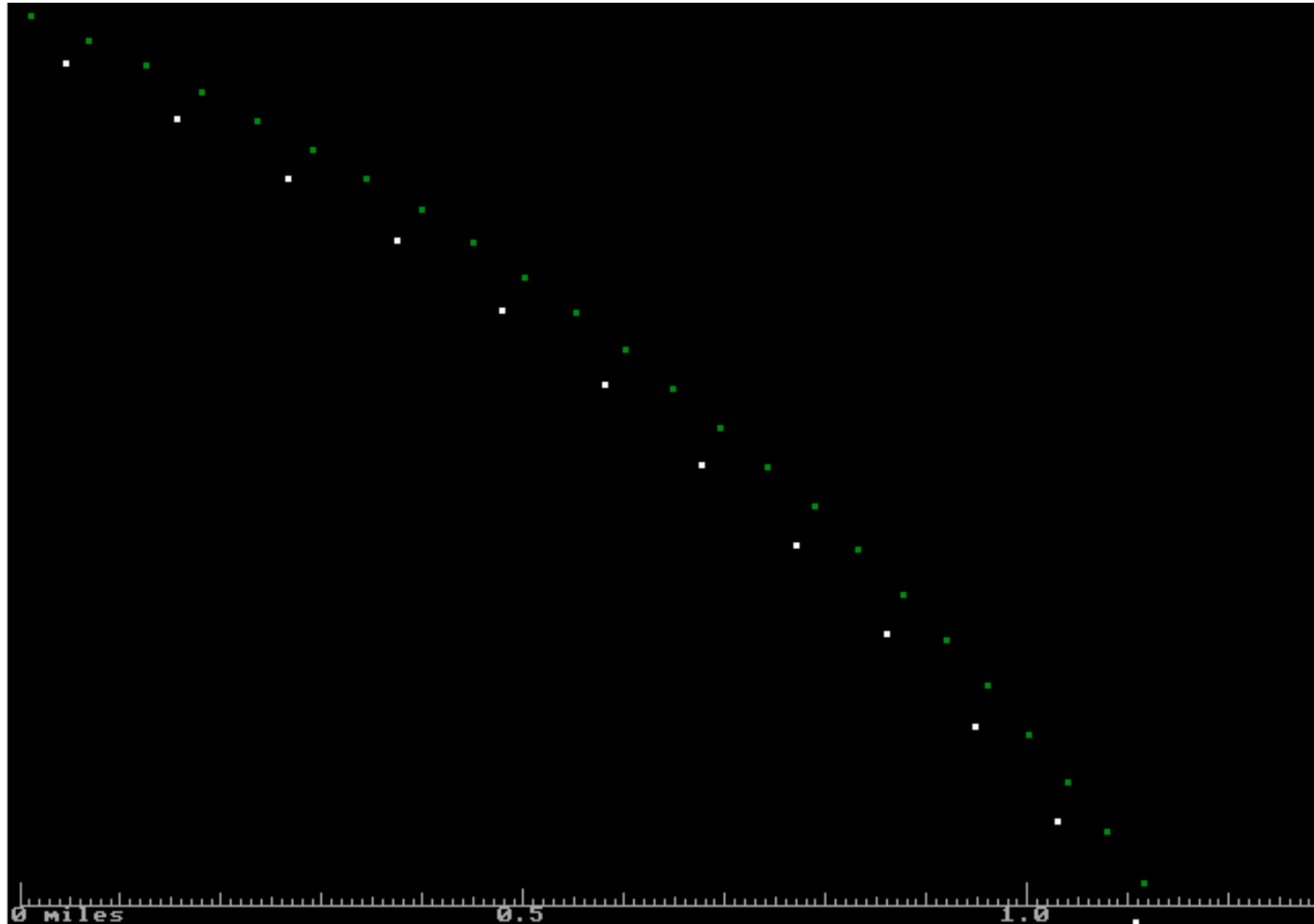
# Example SatMate Quasi-ASF Results Close-up of Atlantic City Airport



GPS and SatMate

# Example Quasi-ASF Results

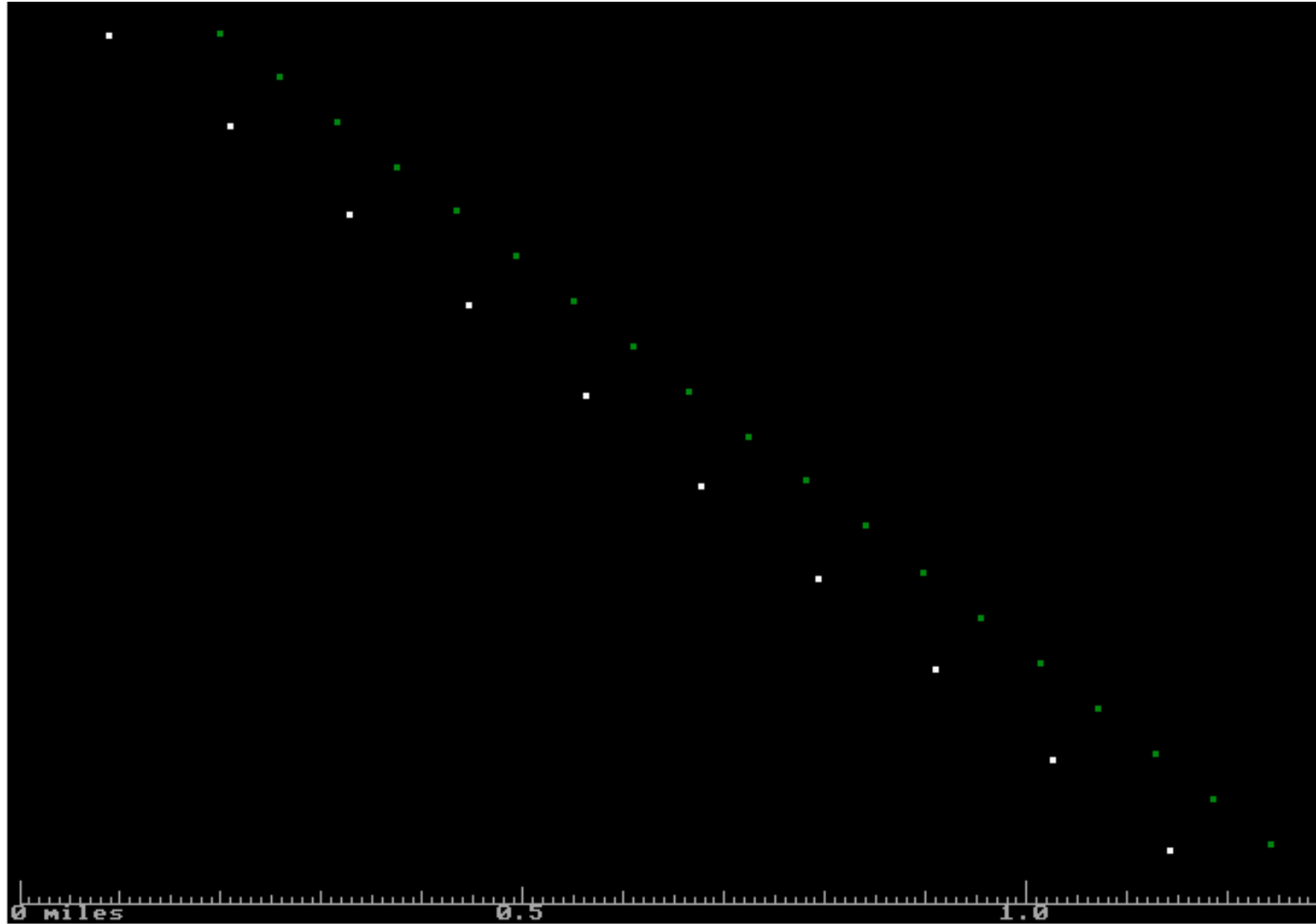
## Close-up ~ 5 miles from Atlantic City



GPS and SatMate

# Example Quasi-ASF Results

Close-up ~ 25 miles from Atlantic City



GPS and SatMate

# Preliminary Conclusions

## “New Loran” vs. “Legacy Loran”

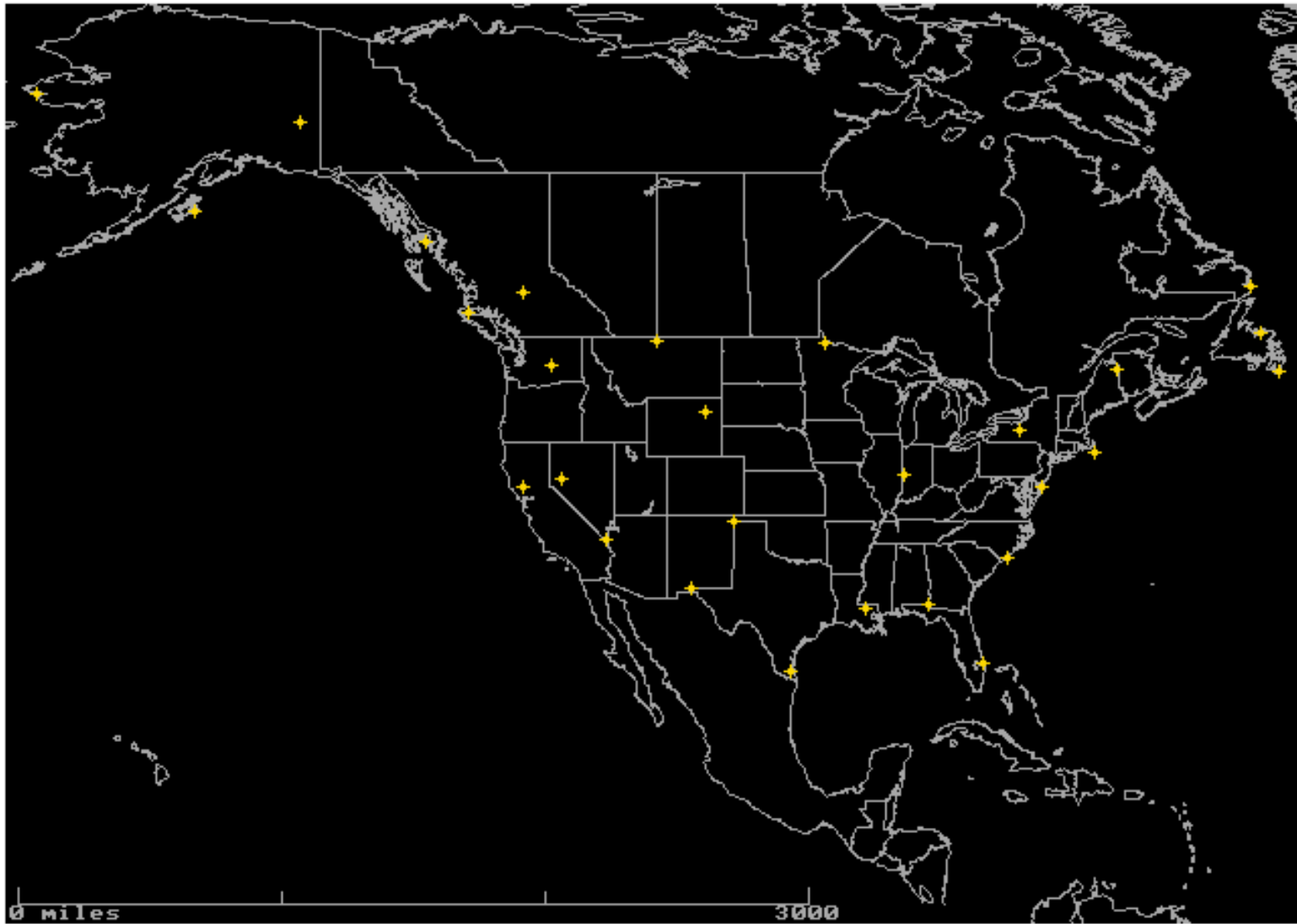
- Modern, multi-chain digital Loran receivers provide substantially better:
  - availability and coverage
  - dynamic performance
  - absolute and repeatable accuracy
  - precision - faster and better data processing
- A modernized U.S. Loran infrastructure (currently underway) will also improve modern Loran’s availability and accuracy
- As documented in earlier paper, comparisons of SatMate with H-field and E-field indicate:
  - H-field - Higher signal levels and SNR
  - H-field - Lower ECD
  - H-field - Improved interference immunity which provides more accurate tracking
- H-field results strongly suggest this system will provide better performance in aviation and other applications than E-field system performance documented here.

# Preliminary Conclusions:

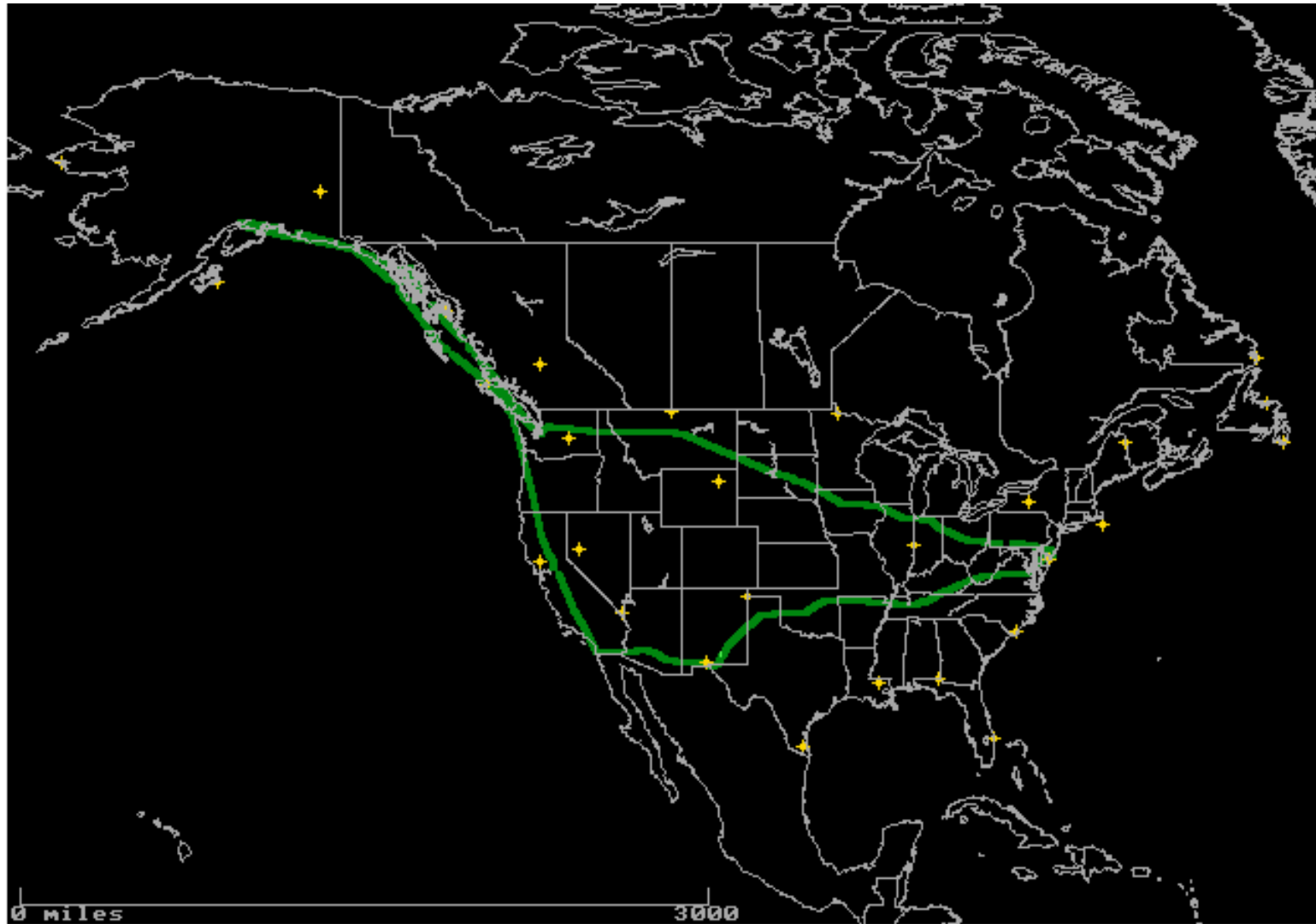
## Combining GPS and the “New Loran”

- It is easy to derive and apply “quasi-ASF” corrections using a single GPS data point and TOAs derived from an all-in-view Loran receiver.
- Application of these quasi-ASF corrections in modern Loran receivers provides extremely good absolute accuracy, certainly sufficient to meet NPA standards.
- These ASF corrections work well over substantial distances (e.g. 50 km), assuming there are no dramatic changes in terrain.
- These results document that a hybrid GPS/Loran system can provide substantially better overall performance (i.e. availability, continuity, coverage, etc.) than either system alone.
- These results also demonstrate that if GPS is temporarily unavailable, a modern Loran can perform extremely well.

# Loran-C Stations in North America



# Flight Path with Loran-C Stations



# Comant CI-121SP E-field Antenna



# Comant CI-121SP E-field Antenna

