



Multifacility TMA: Adaptation for Philadelphia Installation

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Final Meeting
March 26, 2001

- Summary of Task Conduct
- Update Since Last Final Meeting
 - TEC Analysis
 - Center Sector Delay Analysis
 - TRACON Delay Analysis
- Future Issues

TRACON-Centric Adaptation

- Initial MC-TMA Adaptation was Developed
 - Assumed Minimal CTAS Changes Before Simulation
- TRACON-Centric Adaptation Uses Single Center Approach
 - A Single Adaptation Covering ZNY, ZDC and ZOB was Created
- AVA was Used for Part of the Adaptation Development
 - Rapid Generation of Limited Amount of Adaptation Data
 - Remaining Adaptation Data was Created Manually

Single Center Adaptation Approach

- Separate Adaptations were Generated for:
 - ZNY, ZDC and ZOB Airspace
 - each with PHL as Primary Airport
 - ZBW Adaptation was also recently created
 - All Adaptations were Generated to ‘Initial Completion’
 - ETAs and TMA Schedules Generated
- Same Set of Arrival Fixes were used for All Adaptations
 - Even meter fixes in a different ARTCC
 - This simplified the merge process
- Adaptations were merged to create a single adaptation covering ZNY, ZDC and ZOB

Transition Concept Adaptation

- We Considered the 'Transition' Concept to include a New McTMA Architecture
 - Multi-Center Architecture for ETA Computation and Scheduling
- We Generated a Prototype of this Architecture
 - Each ARTCC has its own CTAS, with Independent Adaptation
 - The CTAS systems are interfaced to each other
 - via CM to CM communication in the prototype
- The Single Center Adaptations for ZNY and ZDC were used to demonstrate the Transition Architecture

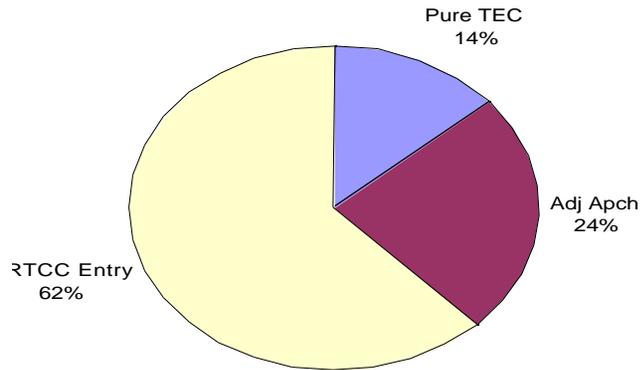
CTAS Playback Files for PHL

- CTAS Playback Files:
 - We Created Conversion Utilities to Read Processed SAR Data and Convert it to CTAS Playback Format
 - SAR Data from ZNY, ZDC and ZOB is Available and includes Flight Plan and Track data
 - Our Conversion Utility does not yet handle AK routes
 - However, AK routes are in the raw SAR data
 - Separate CTAS Playback Files for each ARTCC have been Generated from Host SAR Data
 - Using the 'old' CTAS cm_sim format
 - Merged CTAS Playback Files with Flight Plans and Tracks from ZNY, ZDC and ZOB Also Created
 - Using SAR data from Overlapping Time Periods for Each of the Following Days:
 - 9/5/00, 9/6/00, 11/9/00 and 11/10/00

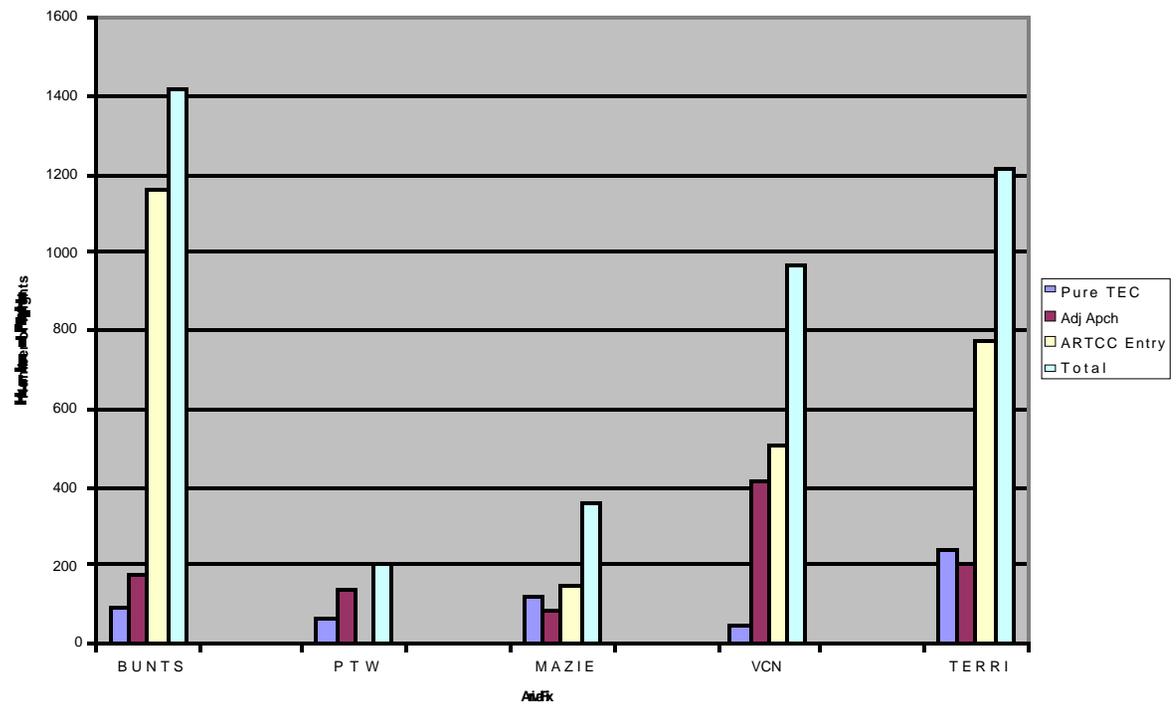
- Effect of TEC Procedures has been an McTMA Unknown
 - Tower En-Route Control (TEC) Flights can Refer to Flights that are Never Controlled in an ARTCC Sector, or
 - TEC Flight can also be Handed-Off from the ARTCC to a Non-Arrival Approach Control Before Entering the Arrival Approach Control
- TEC Flights Generally Enter the TRACON at Different Altitudes
 - Any Type of Aircraft can be Either TEC or non-TEC
 - Thus, the Same Meter Fix, Runway, Engine Type combination could have a different Crossing Altitude
 - This is Not Currently Supported by CTAS Software and Adaptation
 - Previous Solutions (Build 1) Have Added a 'Flight_Distance' criteria to the determination of the stream class
 - And then crossing altitude restrictions are adapted dependent on stream class, rather than in the gates file

TEC Analysis (cont.)

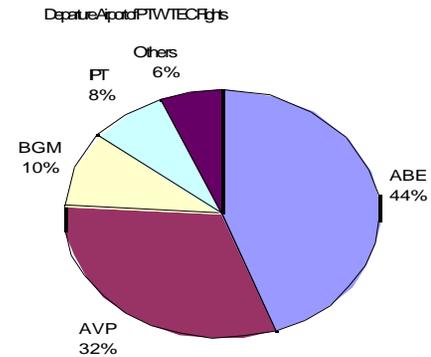
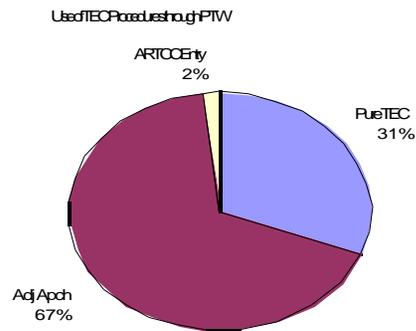
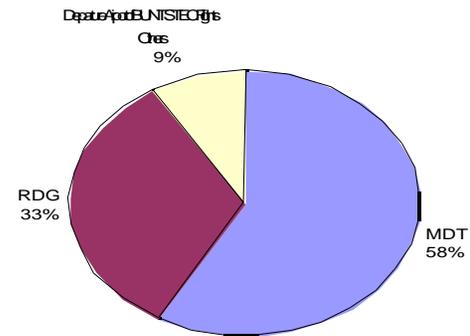
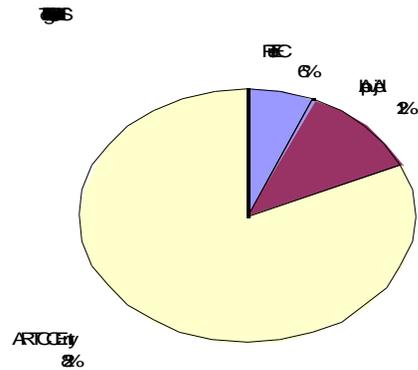
Use of Tower En-Route Control Procedures at PHL



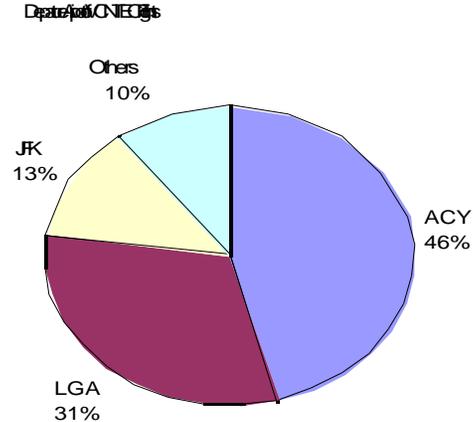
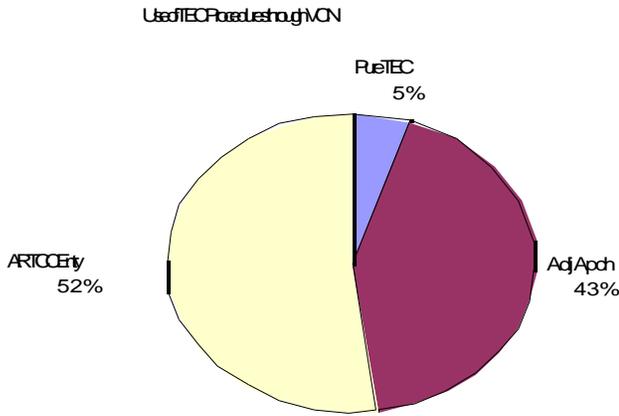
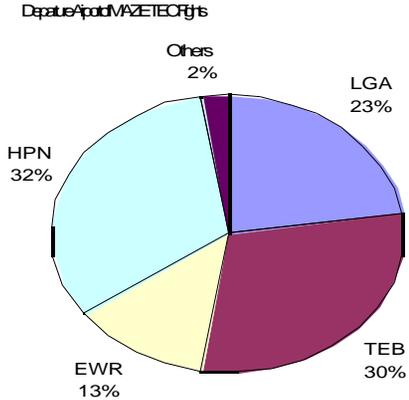
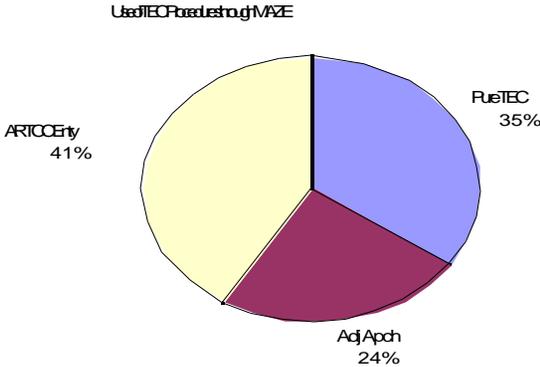
TEC Categories by Arrival Fix



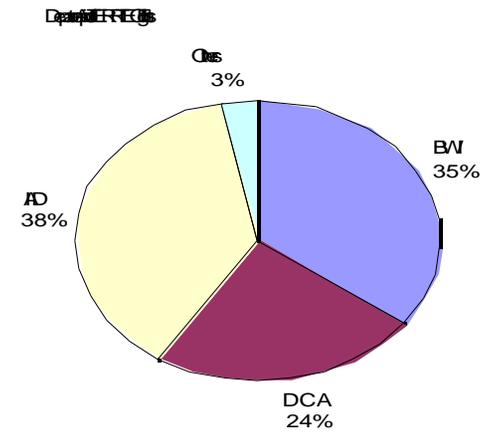
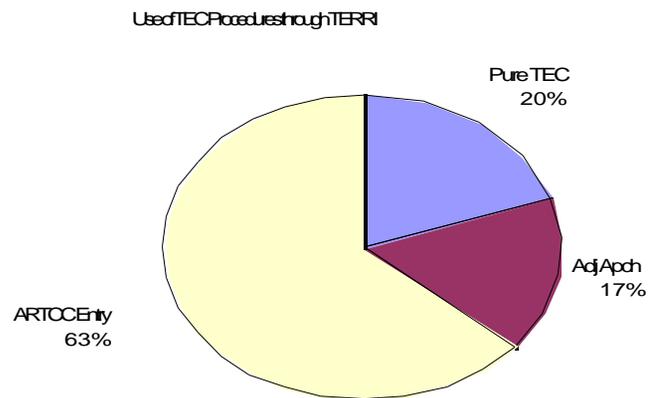
TEC Analysis (cont.)



TEC Analysis (cont.)



TEC Analysis (cont.)

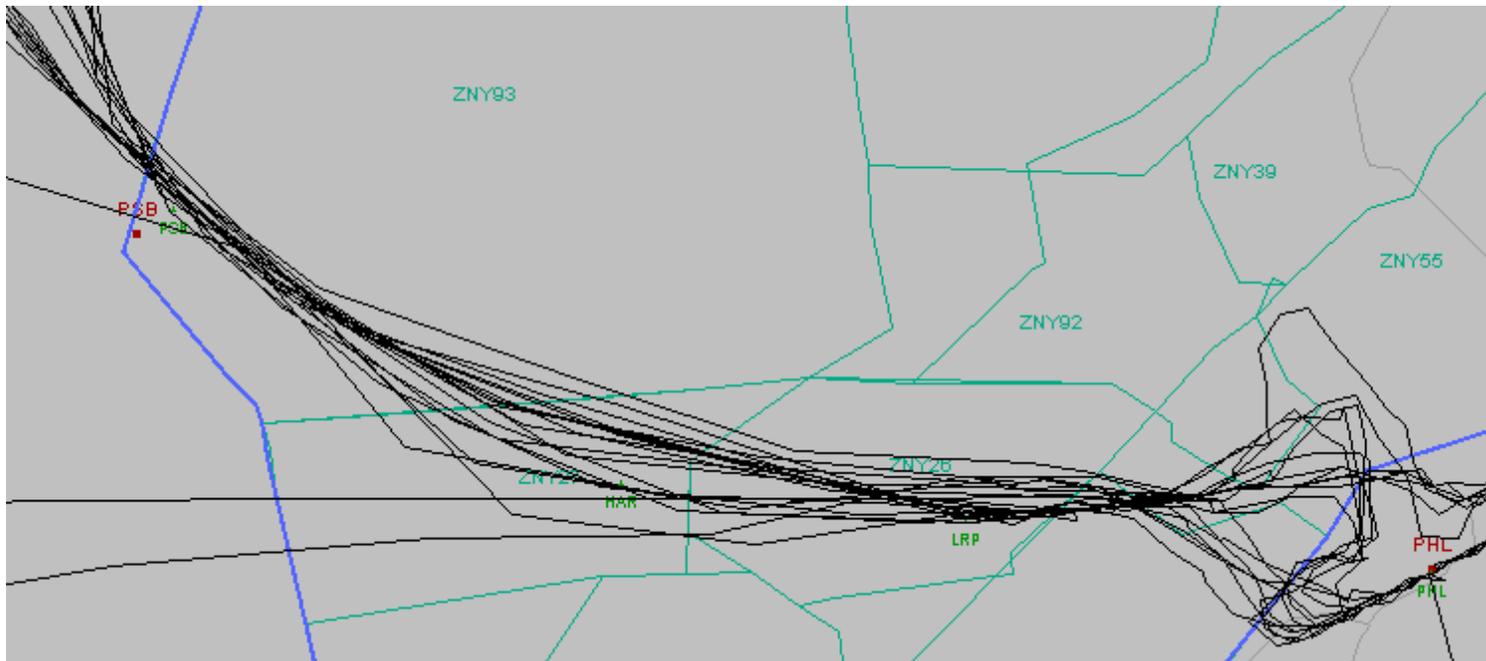


TEC Issues (cont.)

- TEC Flights are Generally not Sequenced and Laterally Separated from non-TEC Flights
 - Thus, they Need to be in a Separate Stream Class
 - The TEC Stream Classes Could be 'Ignored' from a Scheduling Perspective, or
 - Miles-in-Trail Restrictions could be applied to TEC flights, with Time-Based Metering for Other Flights
 - This is Not Currently Supported by CTAS Software and Adaptation
- TEC Predictability
 - Even if TEC Flights are 'Ignored', McTMA still Must Schedule ARTCC-Entry Flights 'Around' the TEC Flights
 - Thus, 'Reasonably Accurate' Prediction of Aggregate TEC Demand Must be Available
 - What Does 'Reasonably Accurate' Mean?
 - Each Error of a Single Flight may Result in a Lost Slot
 - This Depends on Whether or Not the Reliever Runways are Full

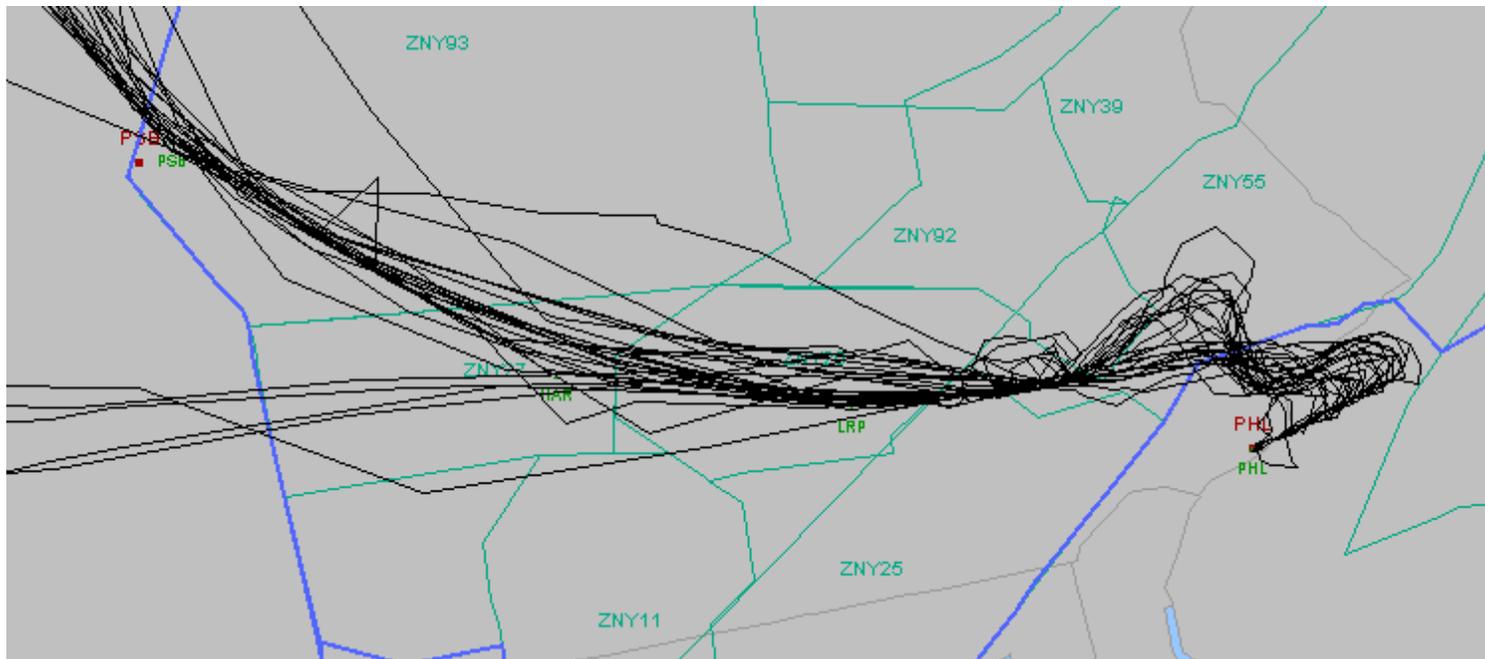
Routing from PSB to BUNTS

- PHL Arrivals Filed Over PSB
 - February 14, 2001



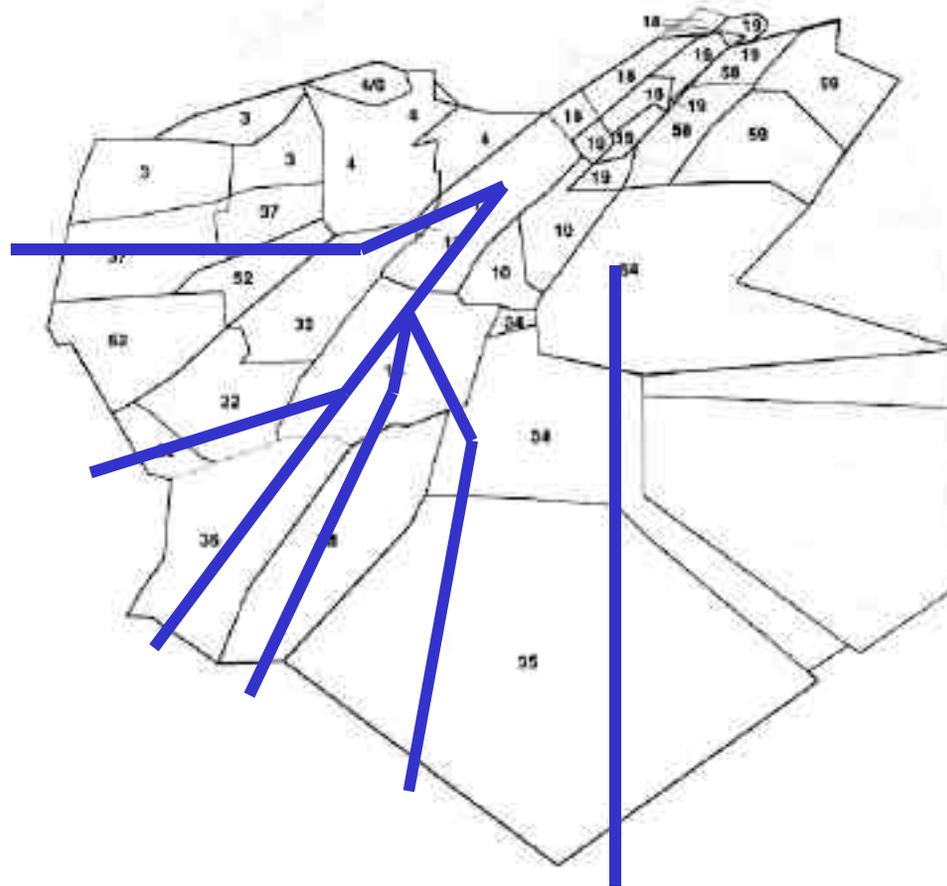
Routing from PSB to BUNTS (cont.)

- PHL Arrivals Filed Over PSB
 - February 15, 2001



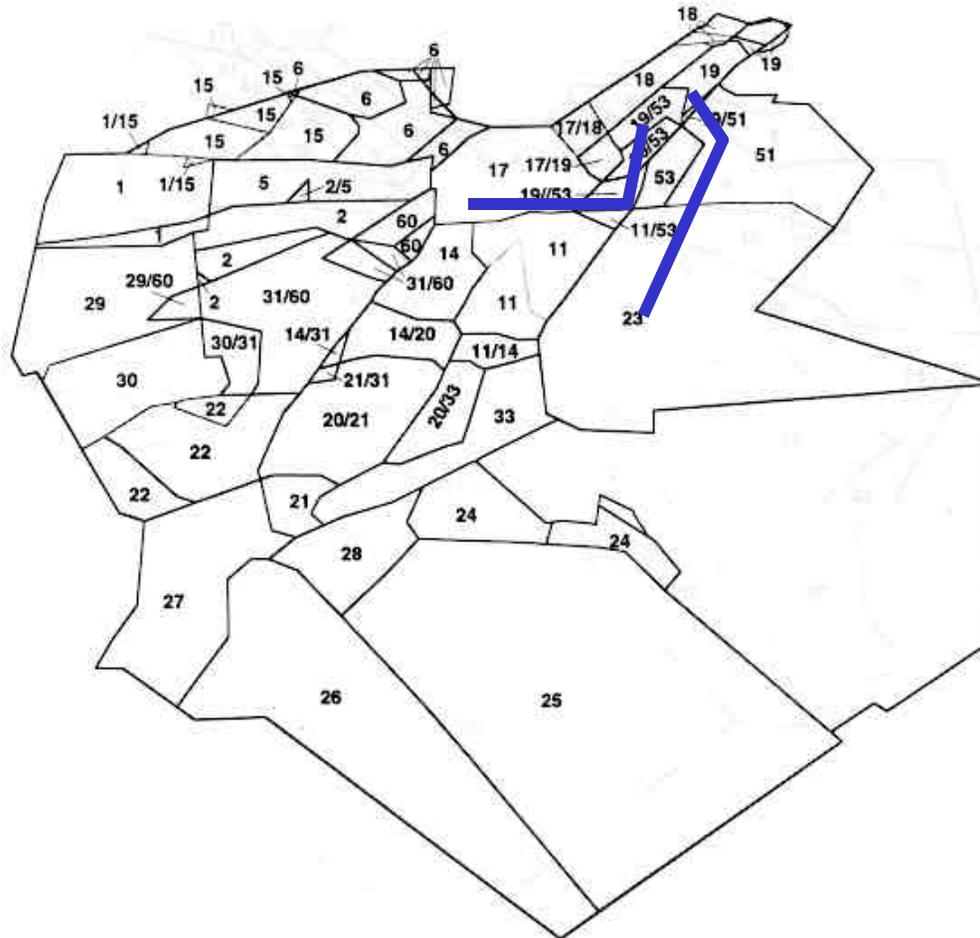
PHL Arrival Flows in ZDC High Altitude Sectors

ZDC HIGH ALTITUDE SECTOR BOUNDARIES



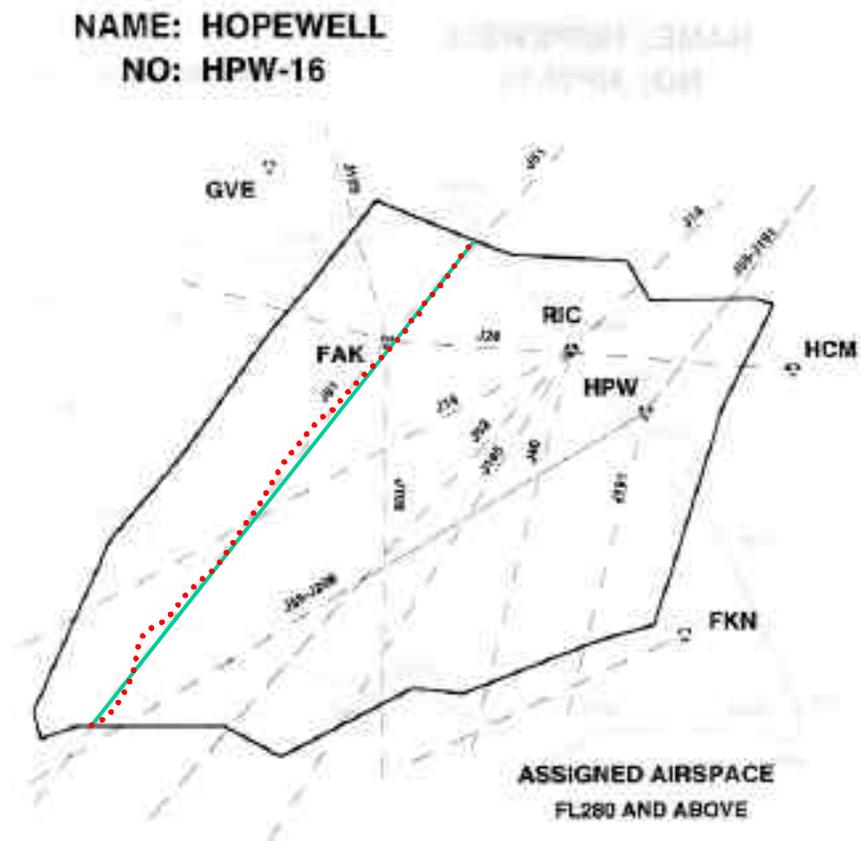
PHL Arrival Flows in ZDC Low Altitude Sectors

ZDC LOW ALTITUDE SECTOR BOUNDARIES

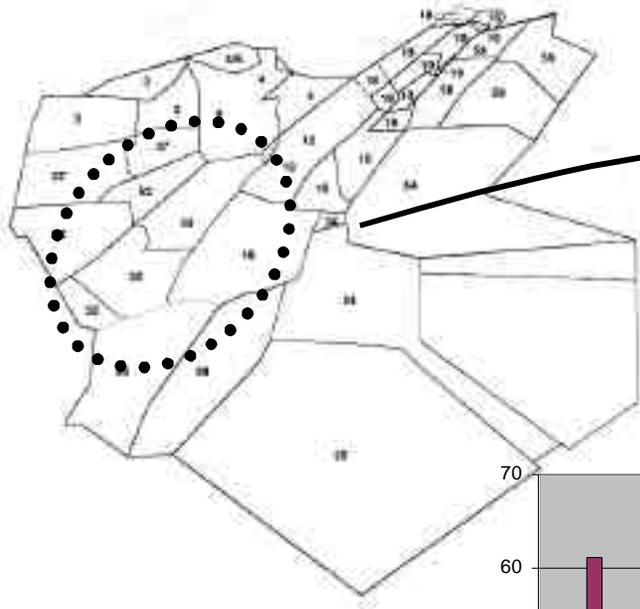


Center Sector Delay Analysis

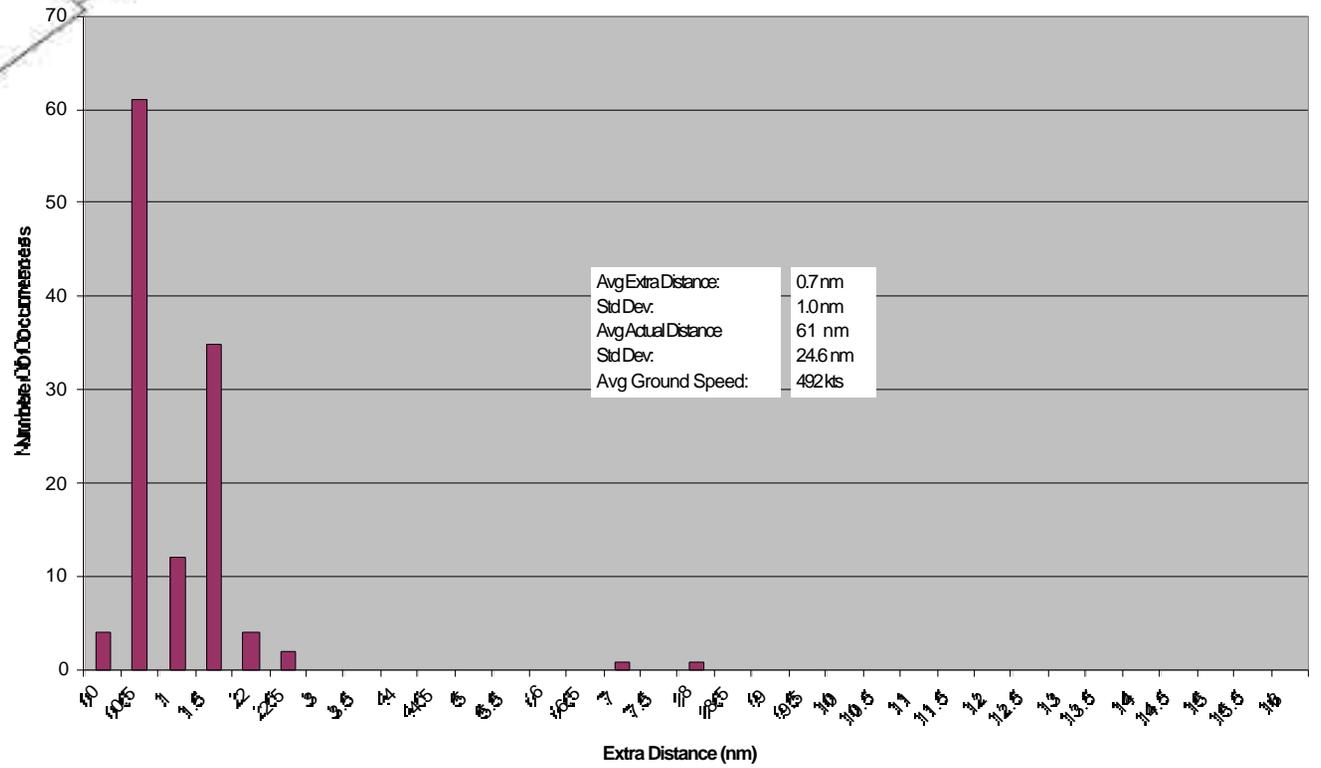
- Approach
 - Analysis of SAR Data
 - from 11/9/00 and 11/10/00
 - from ZNY and ZDC
 - For Each Sector and for Each PHL Arrival
 - Find Sector Entry and Exit Location
 - Compare Actual Distance Flown to Straight Distance



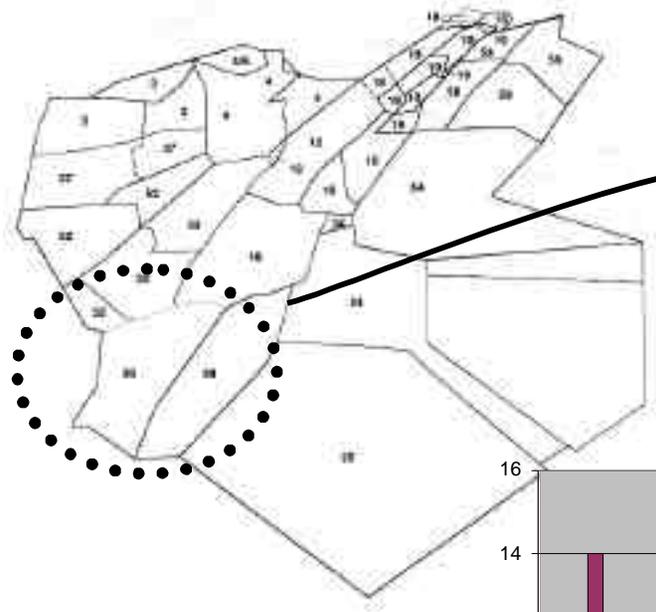
ZDC HIGH ALTITUDE SECTOR BOUNDARIES



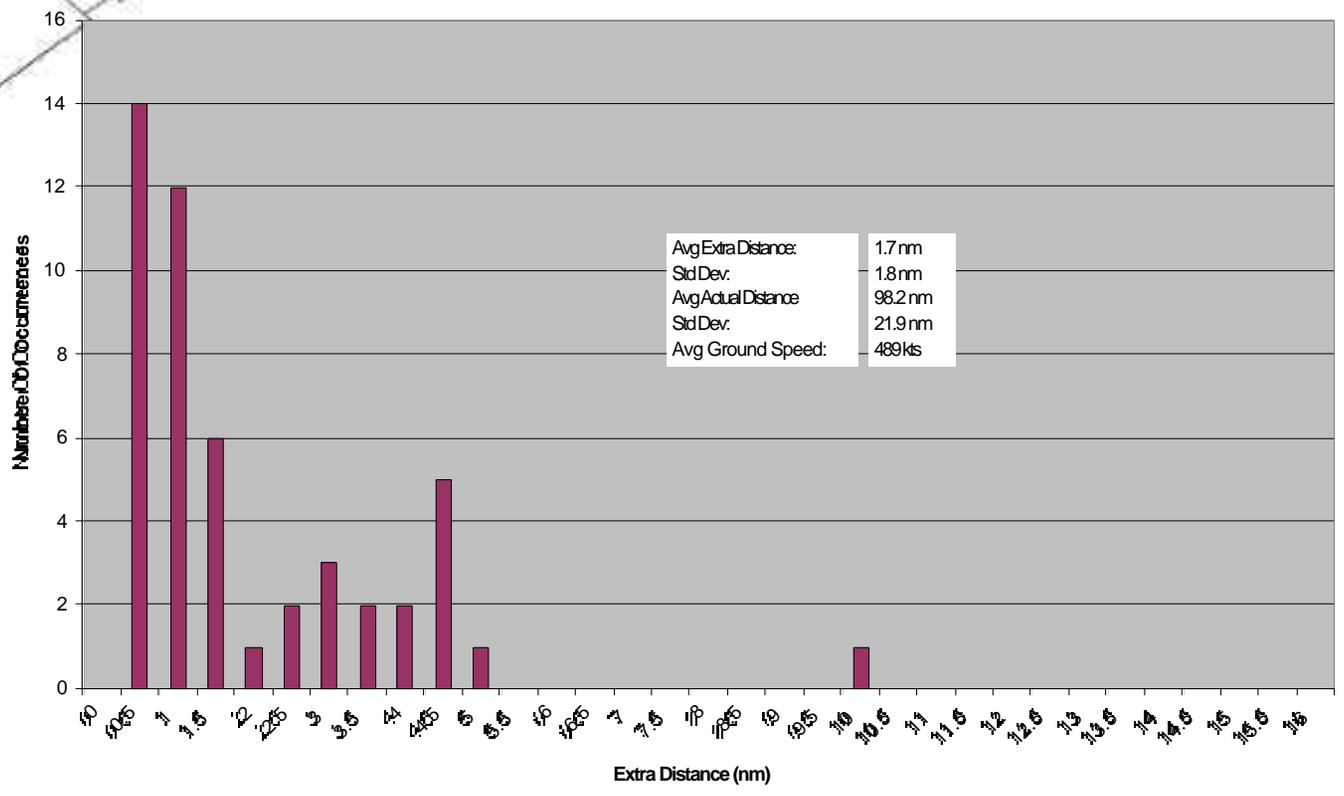
Histogram of Extra Distance
Sector ZDC32



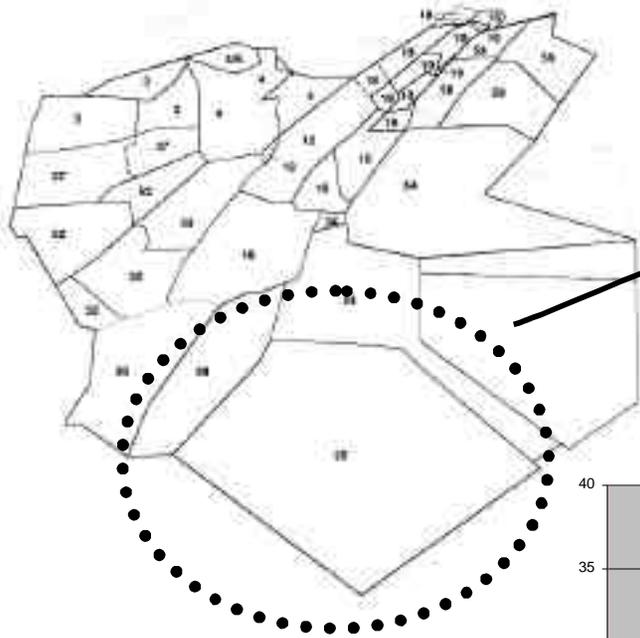
ZDC HIGH ALTITUDE SECTOR BOUNDARIES



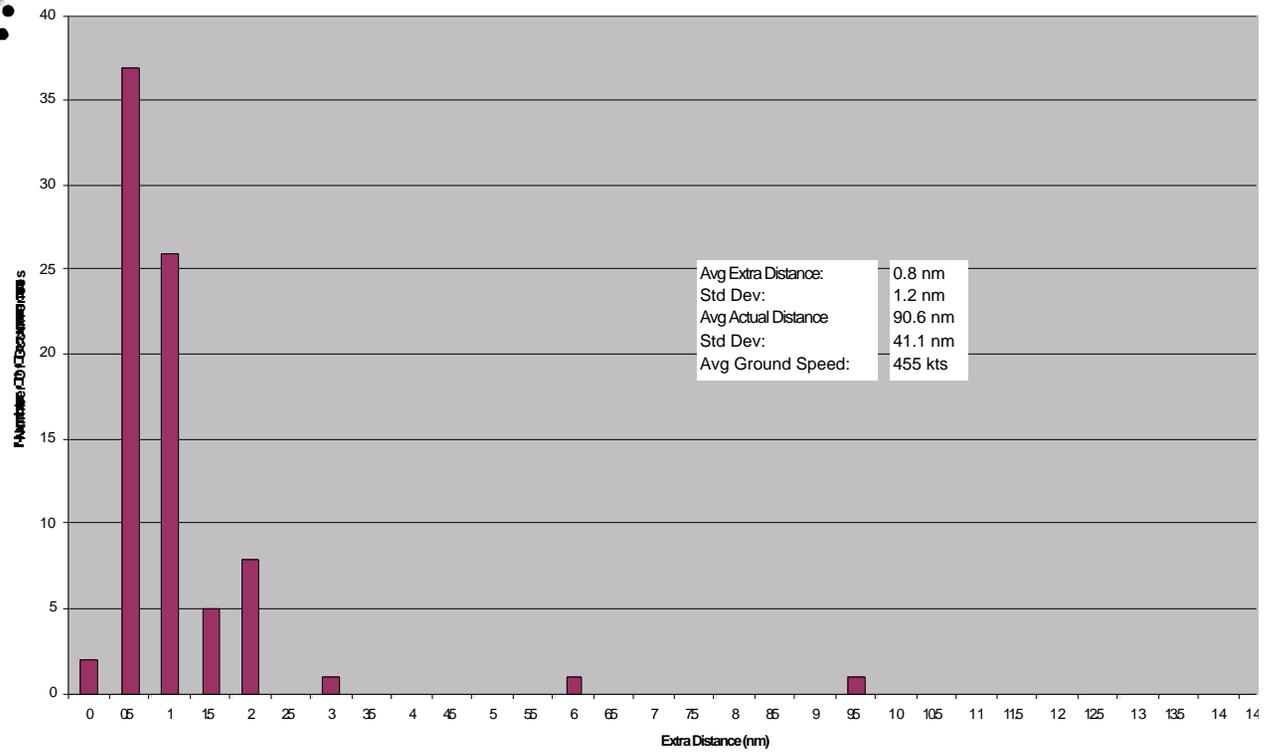
Histogram of Extra Distance
Sector ZDC36



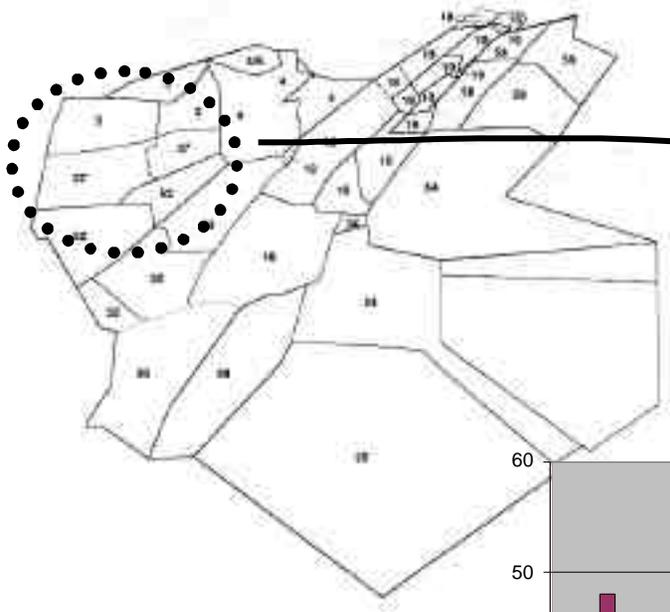
ZDC HIGH ALTITUDE SECTOR BOUNDARIES



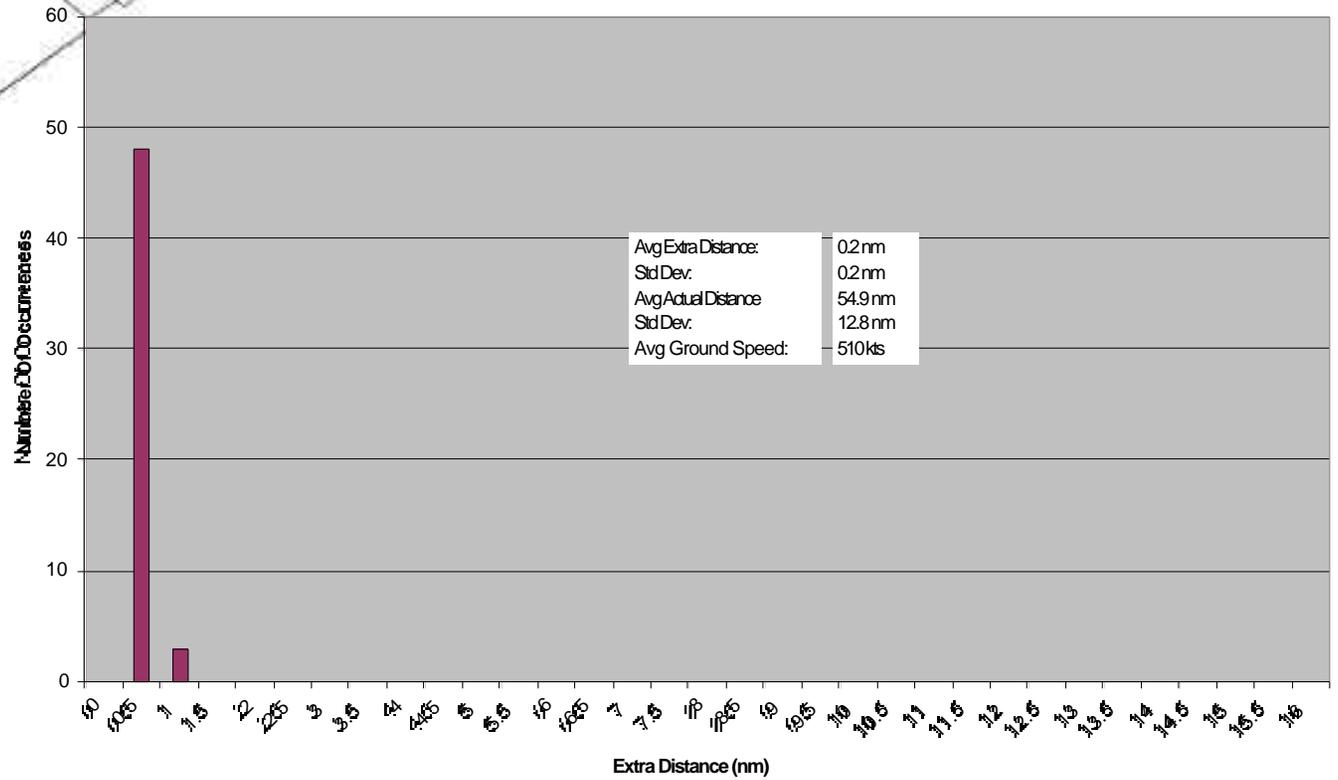
Histogram of Extra Distance
Sector ZDC35



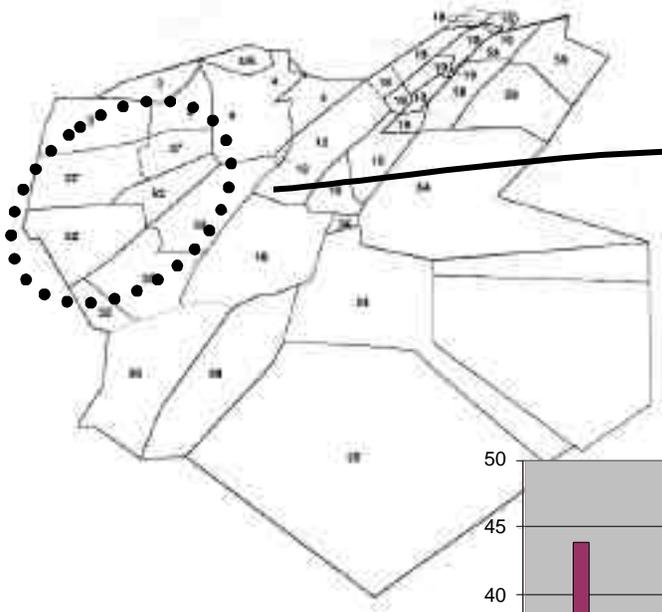
ZDC HIGH ALTITUDE SECTOR BOUNDARIES



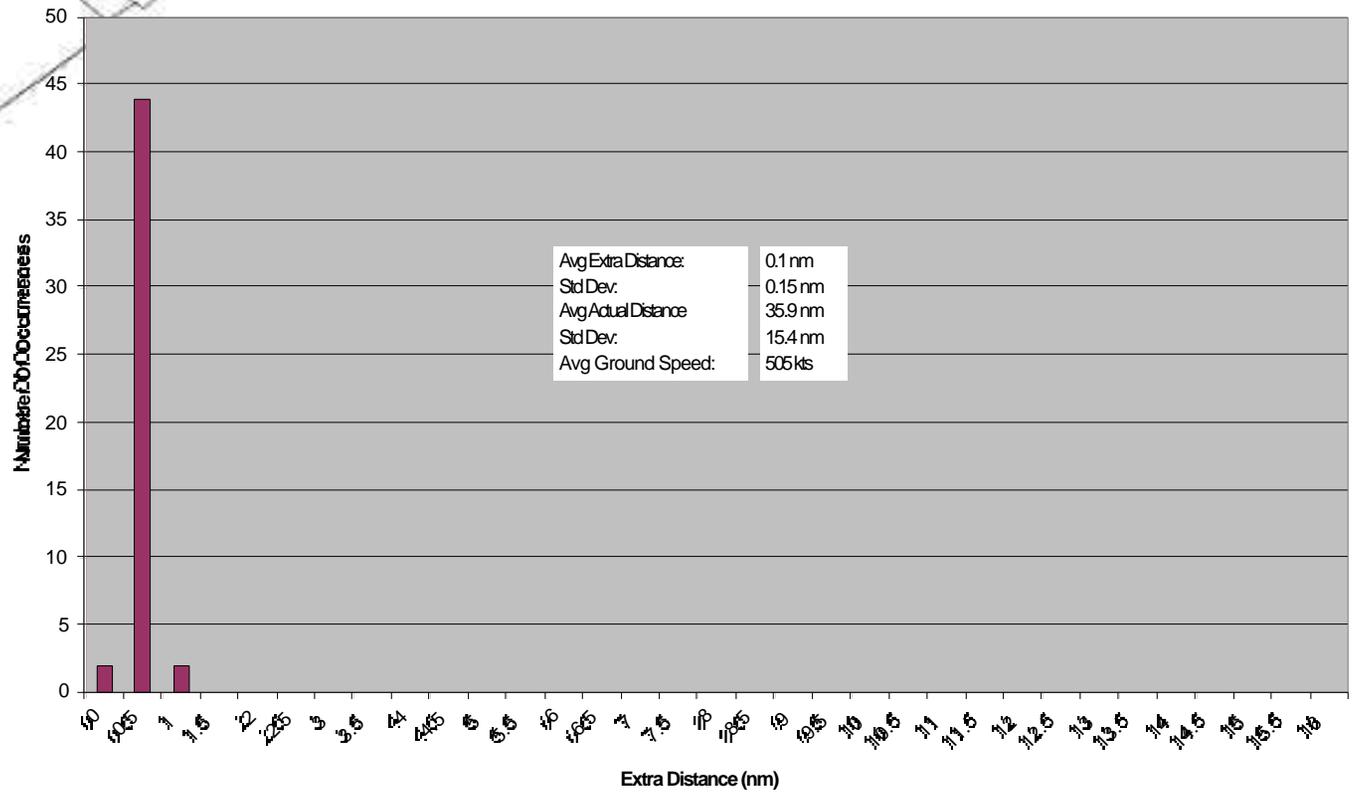
Histogram of Extra Distance
Sector ZDC37



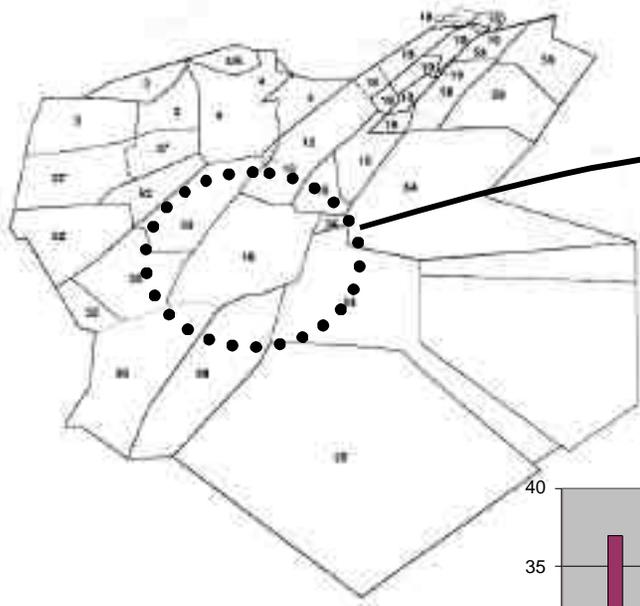
ZDC HIGH ALTITUDE SECTOR BOUNDARIES



Histogram of Extra Distance
Sector ZDC52



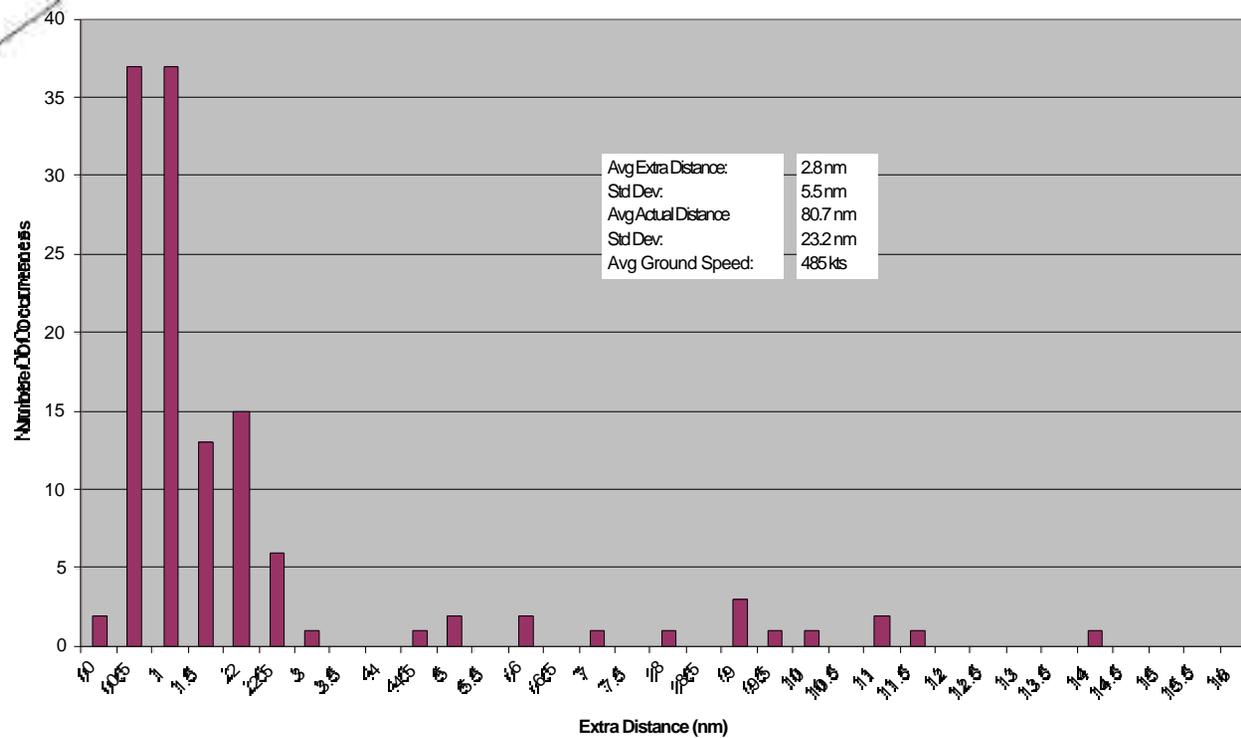
ZDC HIGH ALTITUDE SECTOR BOUNDARIES



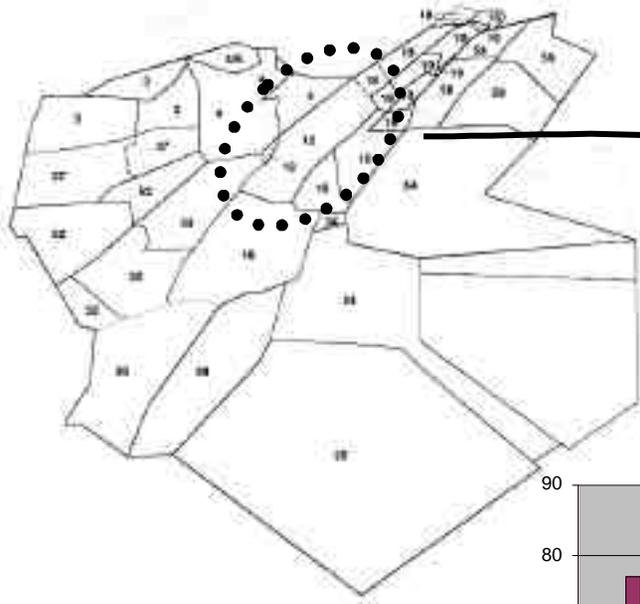
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NO: HPW-16



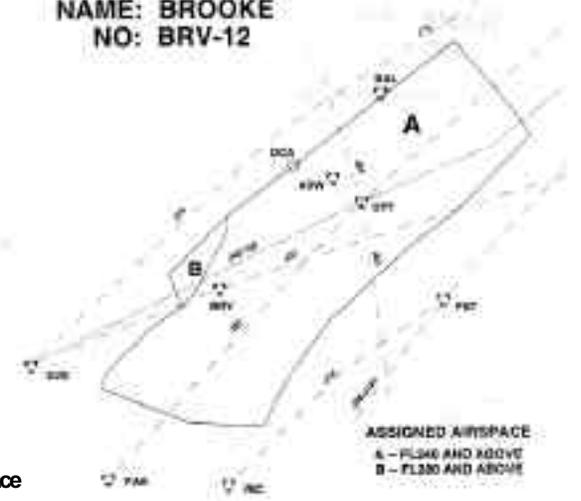
Histogram of Extra Distance
Sector ZDC16



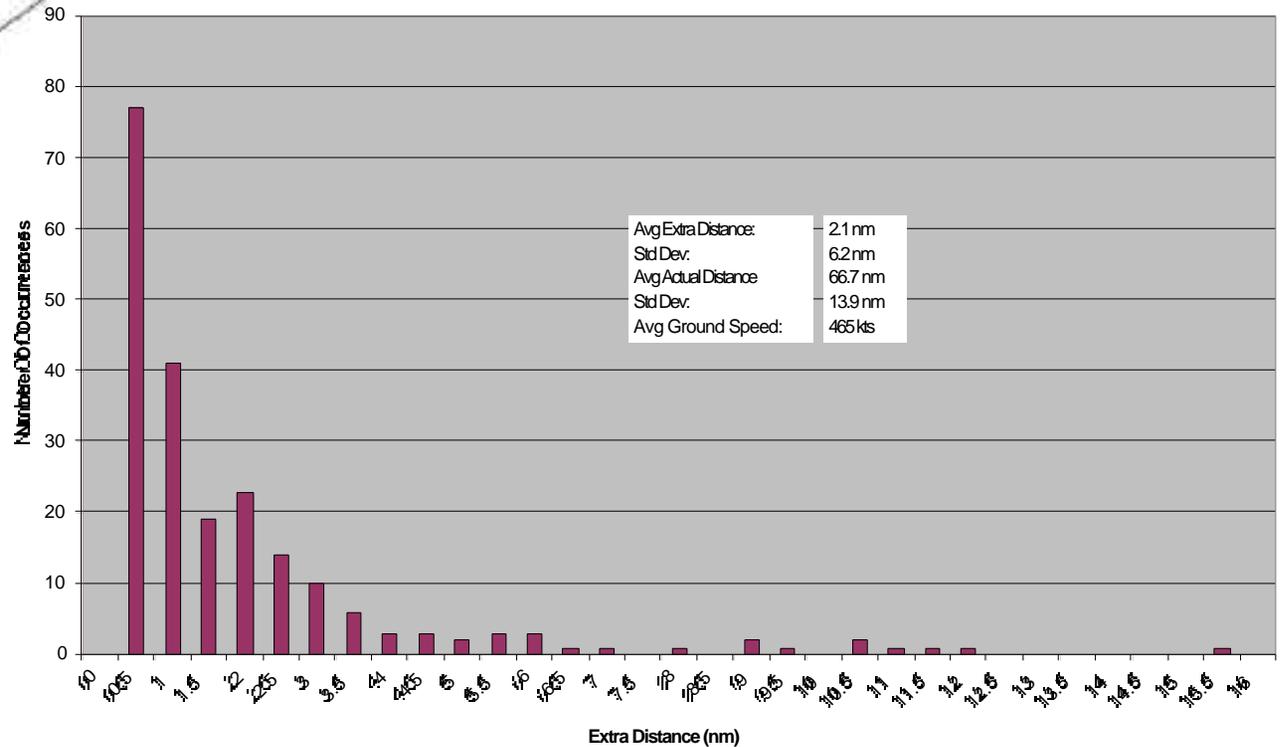
ZDC HIGH ALTITUDE SECTOR BOUNDARIES



**NAME: BROOKE
NO: BRV-12**

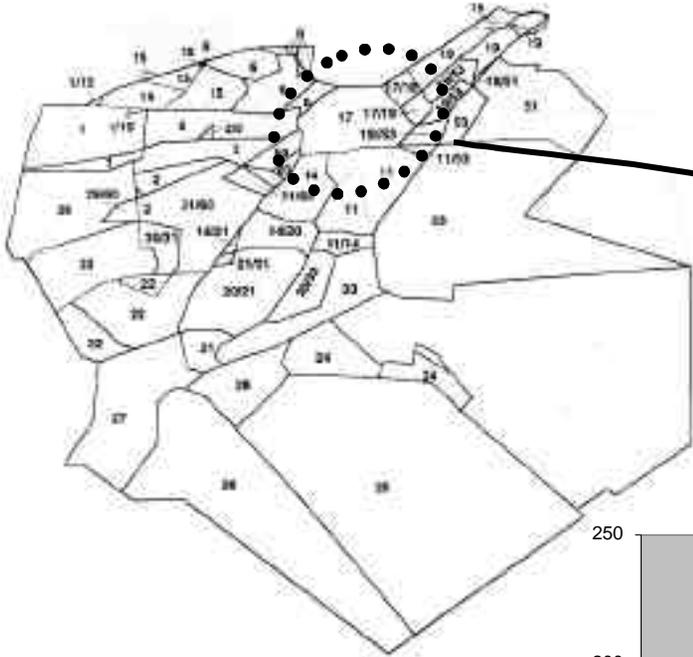


**Histogram of Extra Distance
Sector ZDC12**

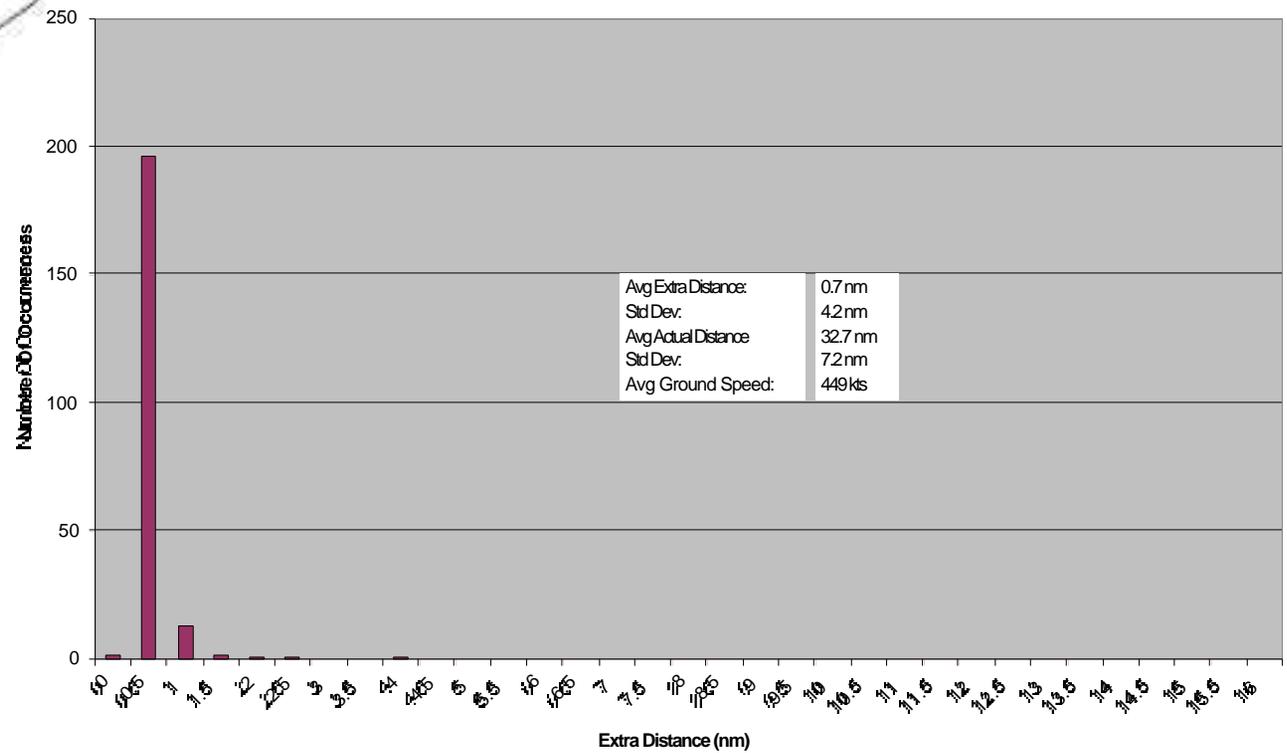


ZDC LOW ALTITUDE SECTOR BOUNDARIES

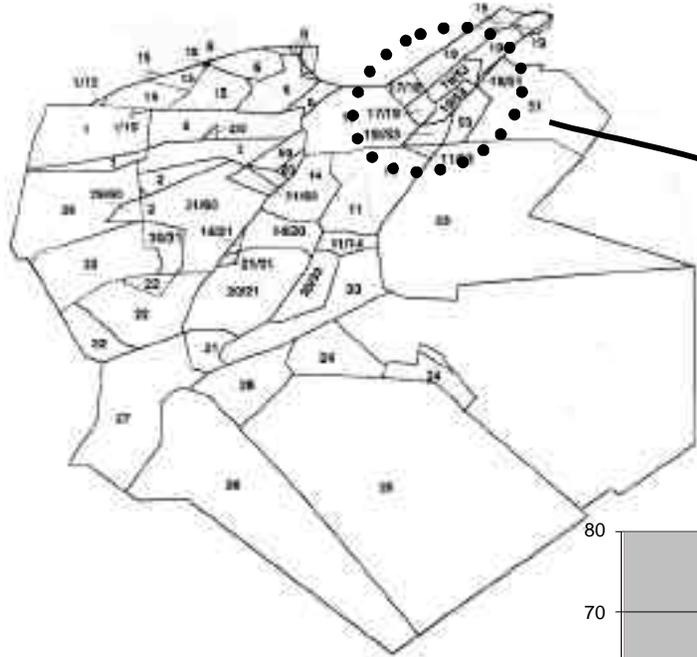
**NAME: SWANN
NO: SWN-17**



**Histogram of Extra Distance
Sector ZDC17**



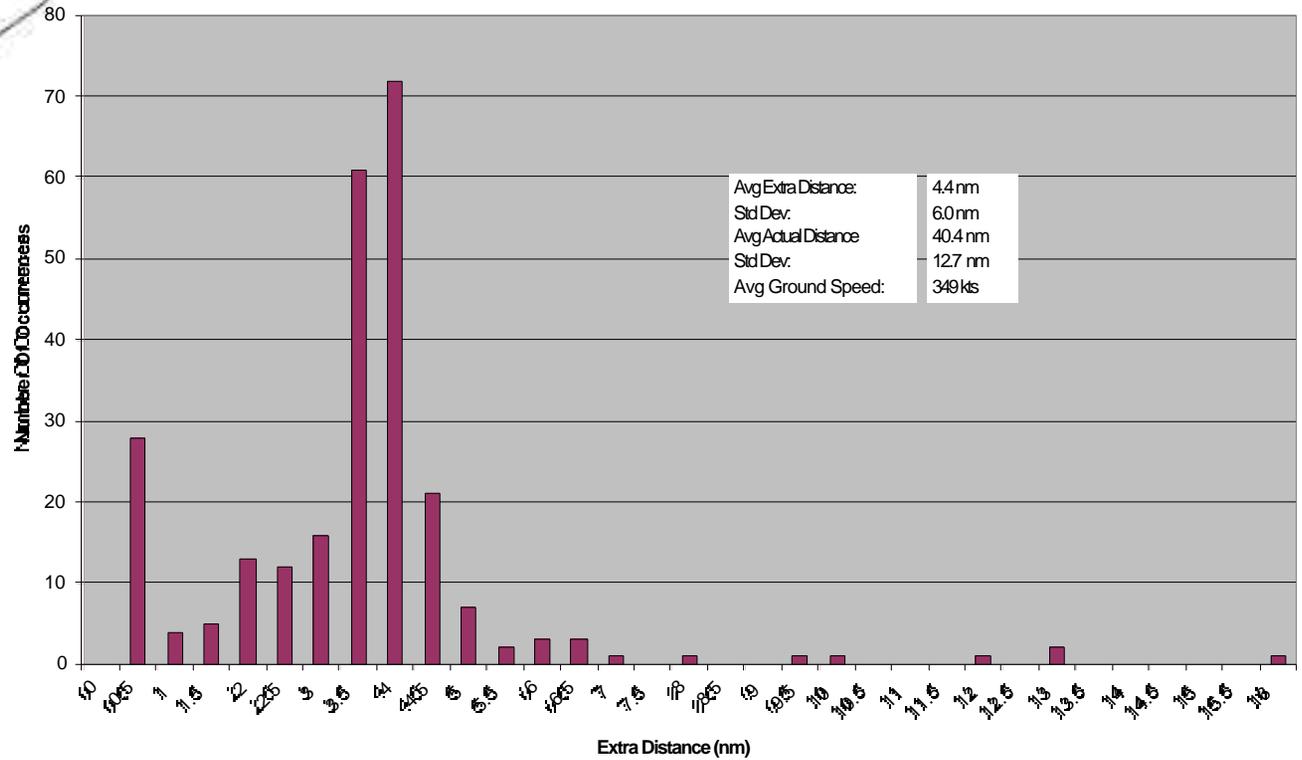
ZDC LOW ALTITUDE SECTOR BOUNDARIES



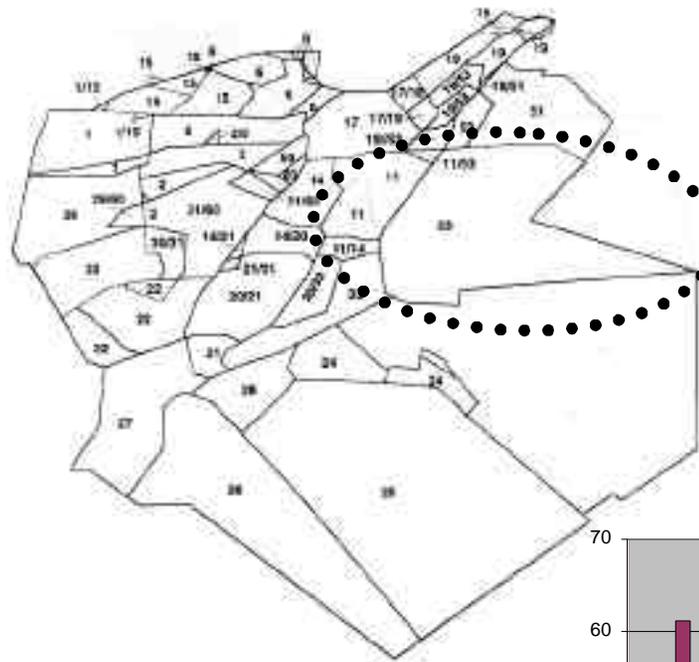
NAME: KENTON
NO: ENO-53



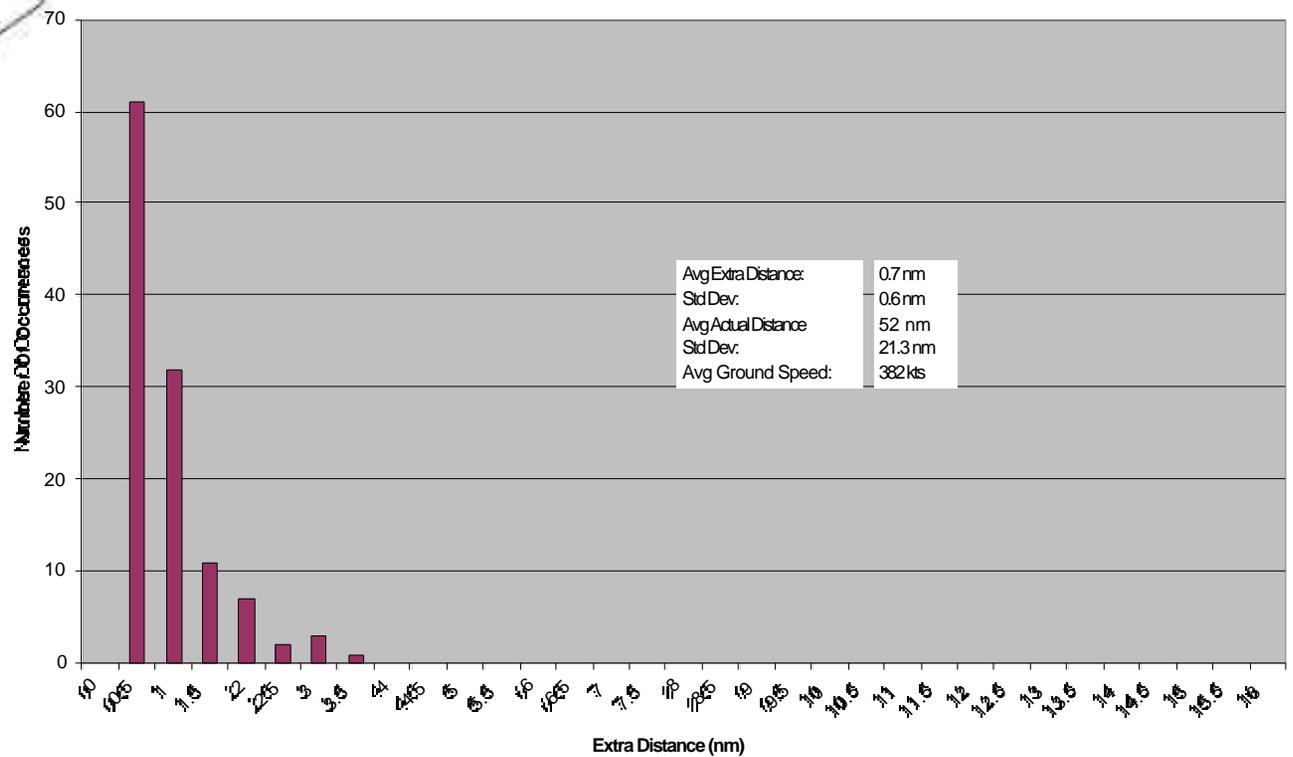
Histogram of Extra Distance
Sector ZDC53



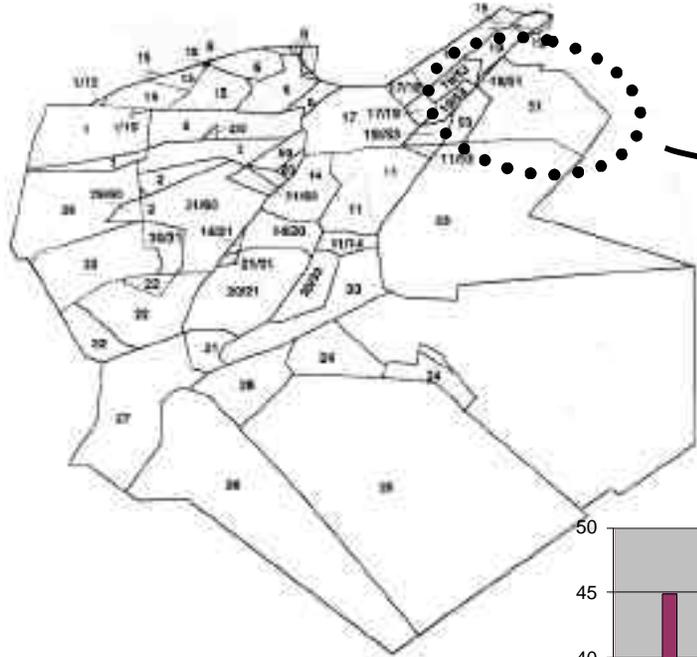
ZDC LOW ALTITUDE SECTOR BOUNDARIES



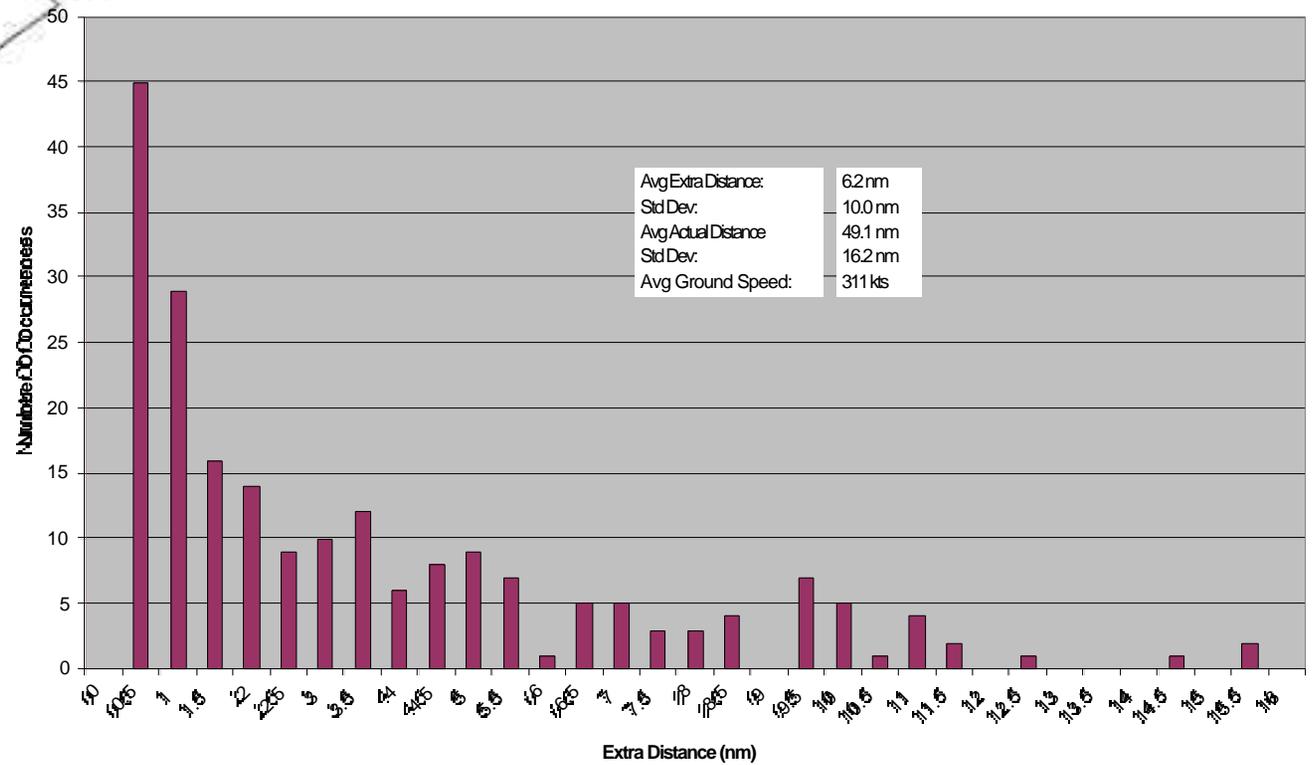
Histogram of Extra Distance
Sector ZDC23



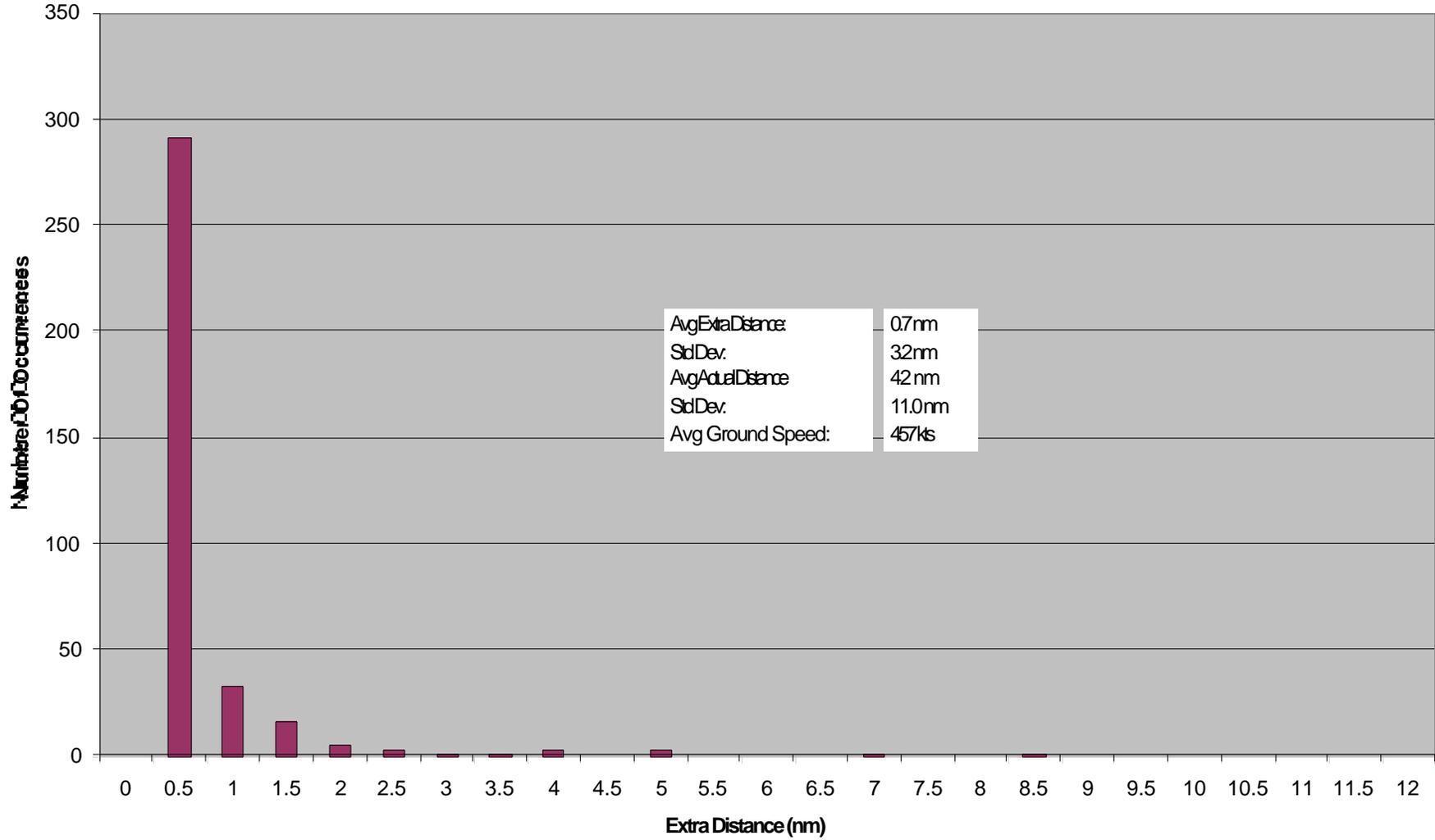
ZDC LOW ALTITUDE SECTOR BOUNDARIES



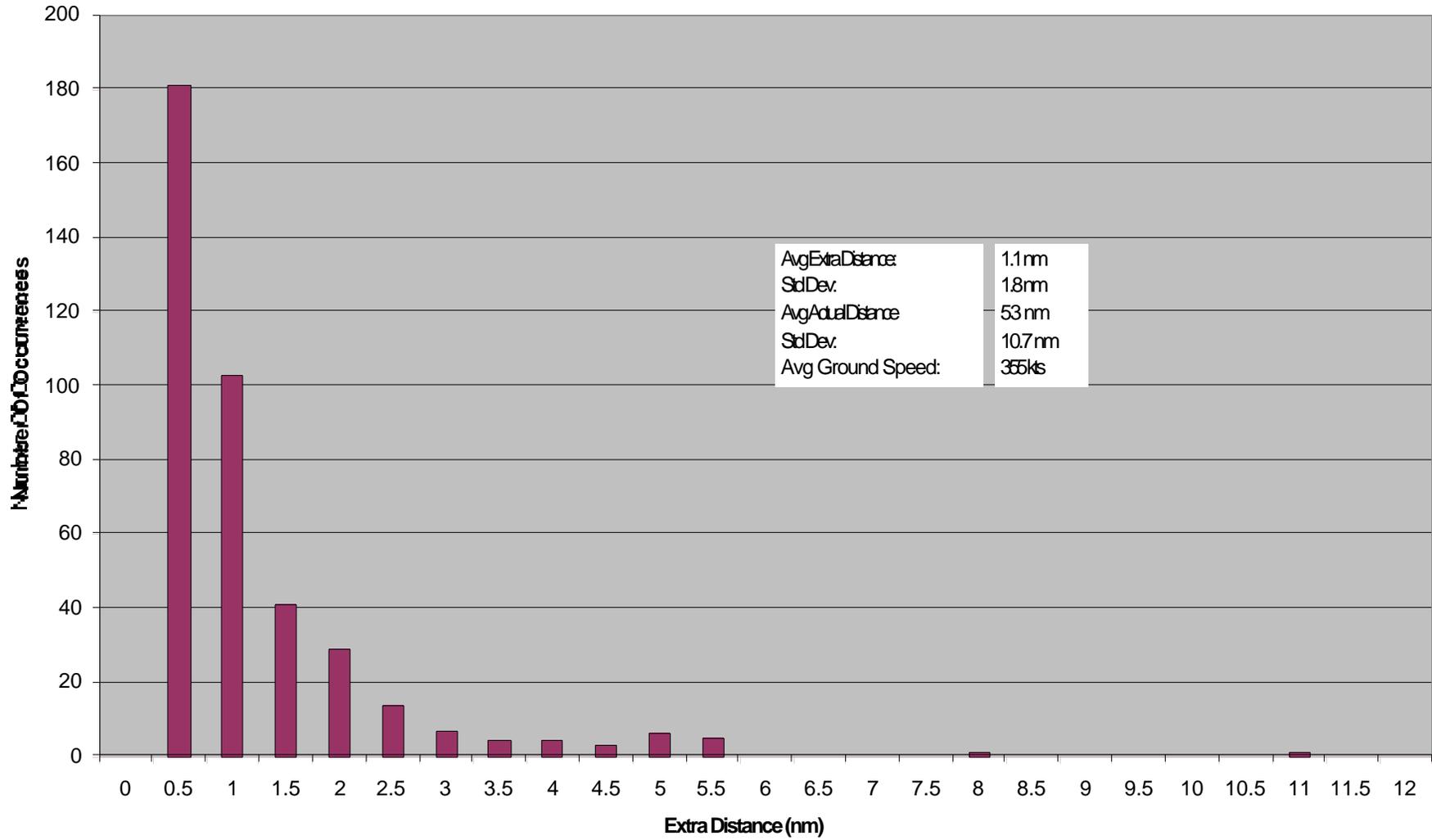
Histogram of Extra Distance
Sector ZDC51



Histogram of Extra Distance Sector ZNY27

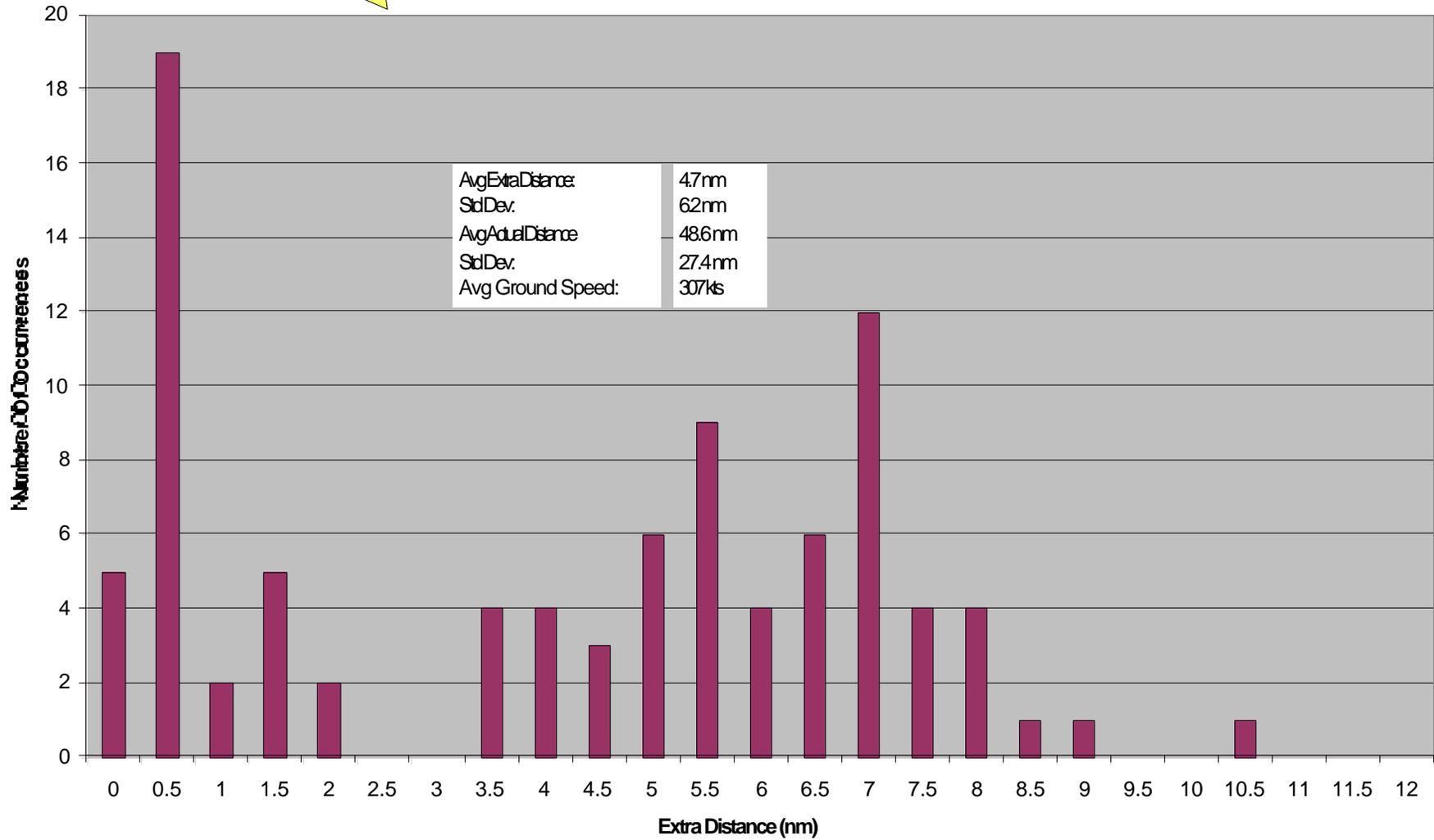


Histogram of Extra Distance Sector ZNY26

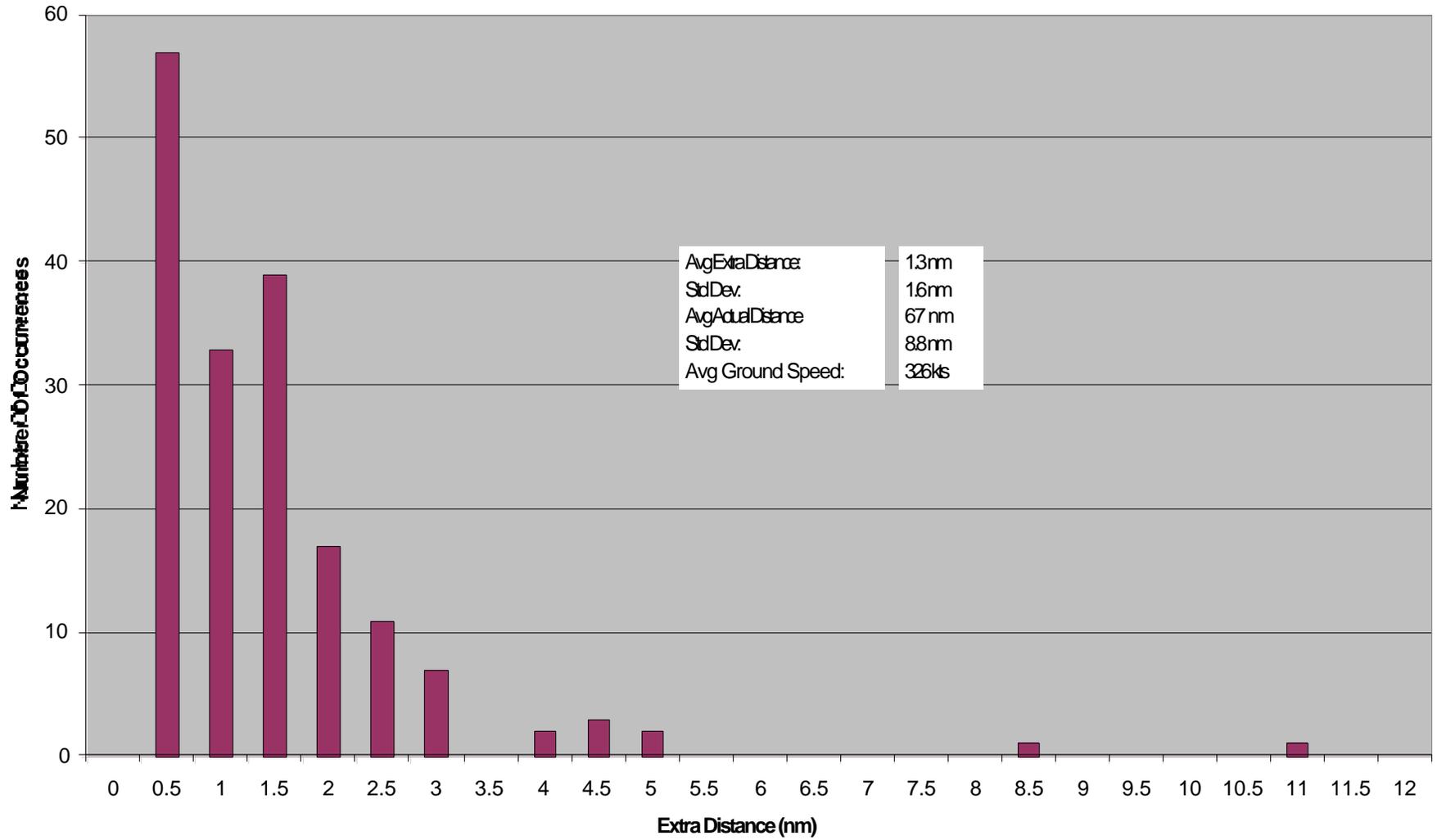


Caveats:
 - Note the Low Traffic Level
 - Many Internal Departures
 - With circuitous departure routings

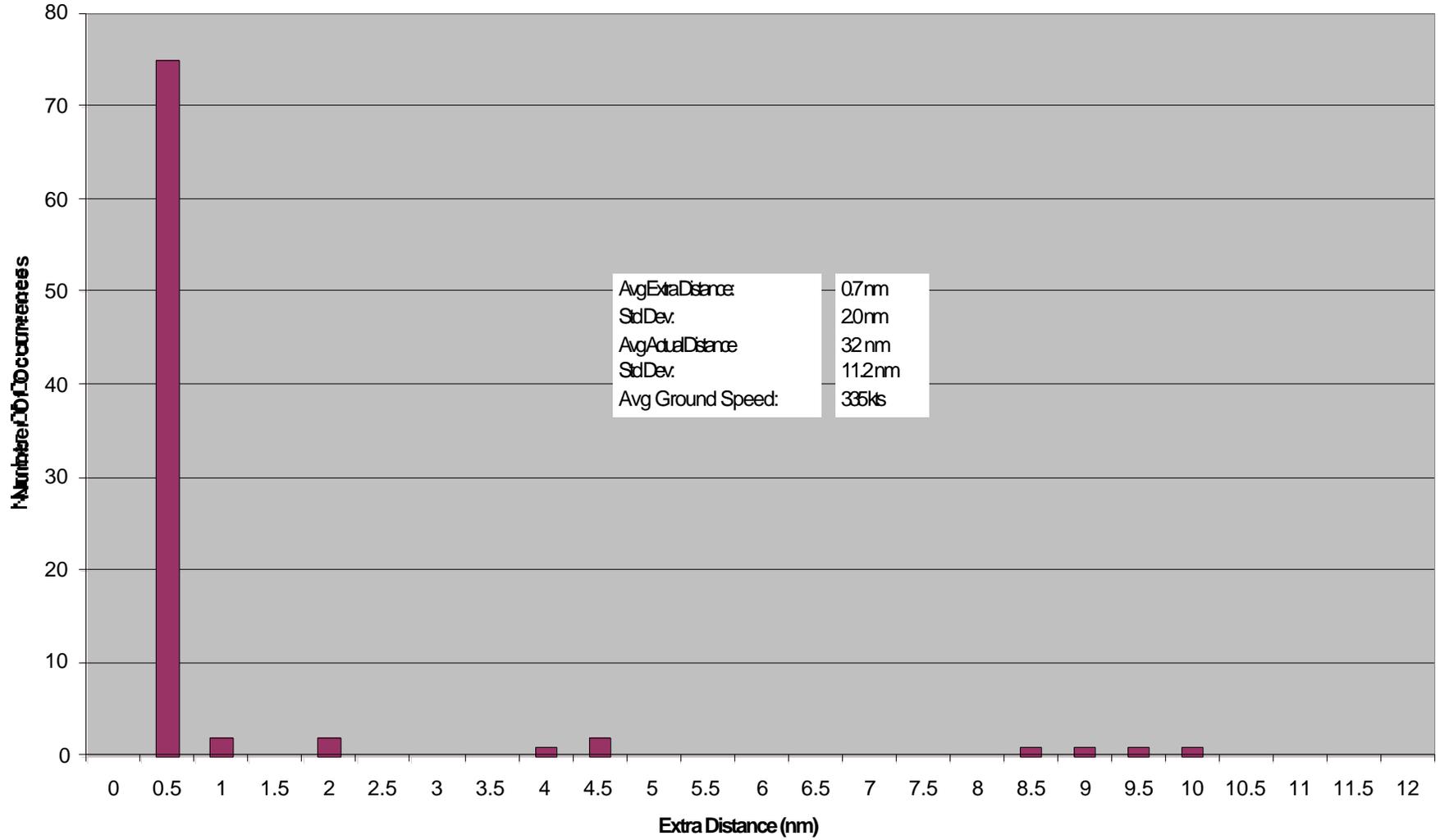
Histogram of Extra Distance
 Sector ZNY92



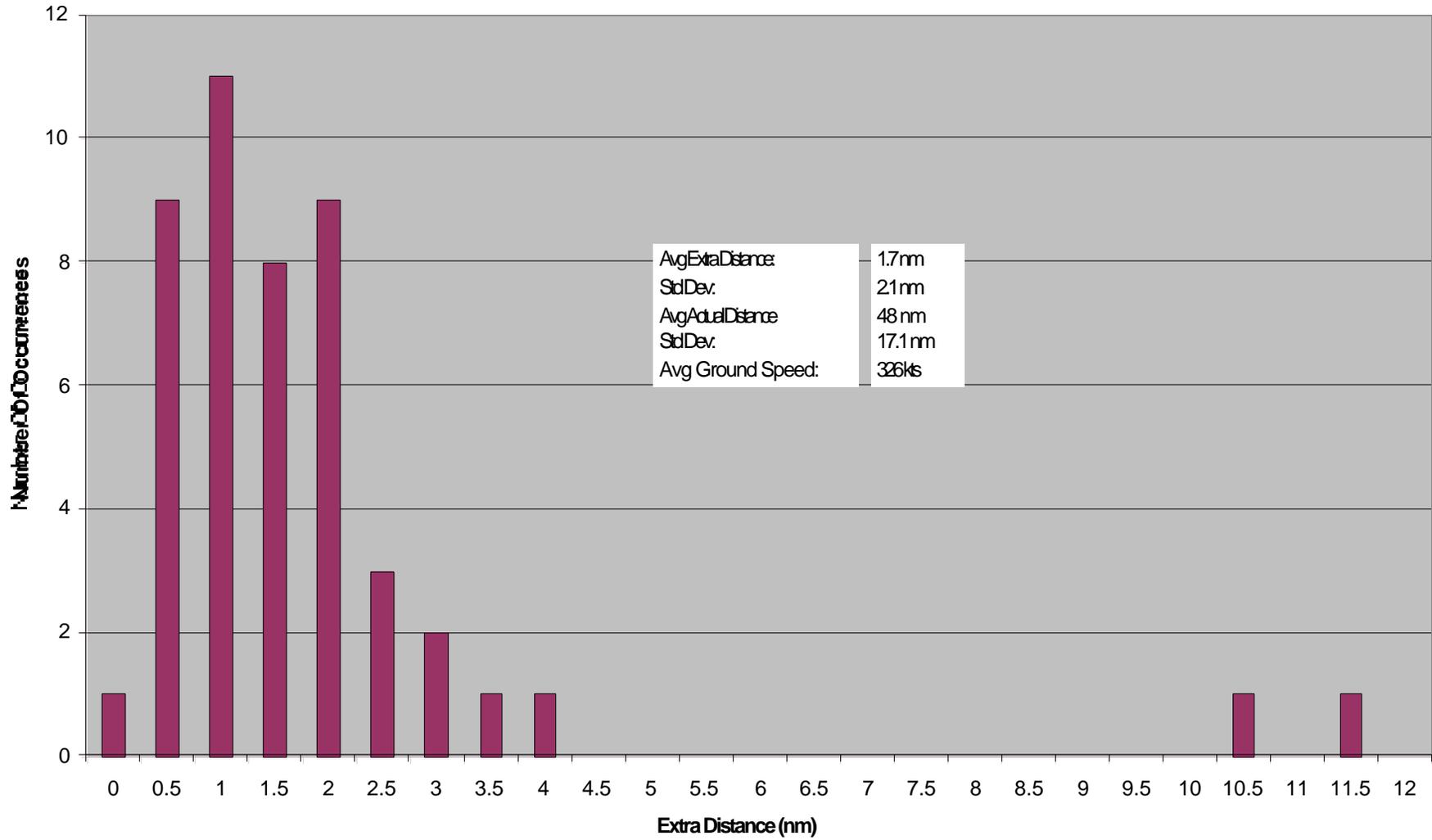
Histogram of Extra Distance Sector ZNY66



Histogram of Extra Distance Sector ZNY51

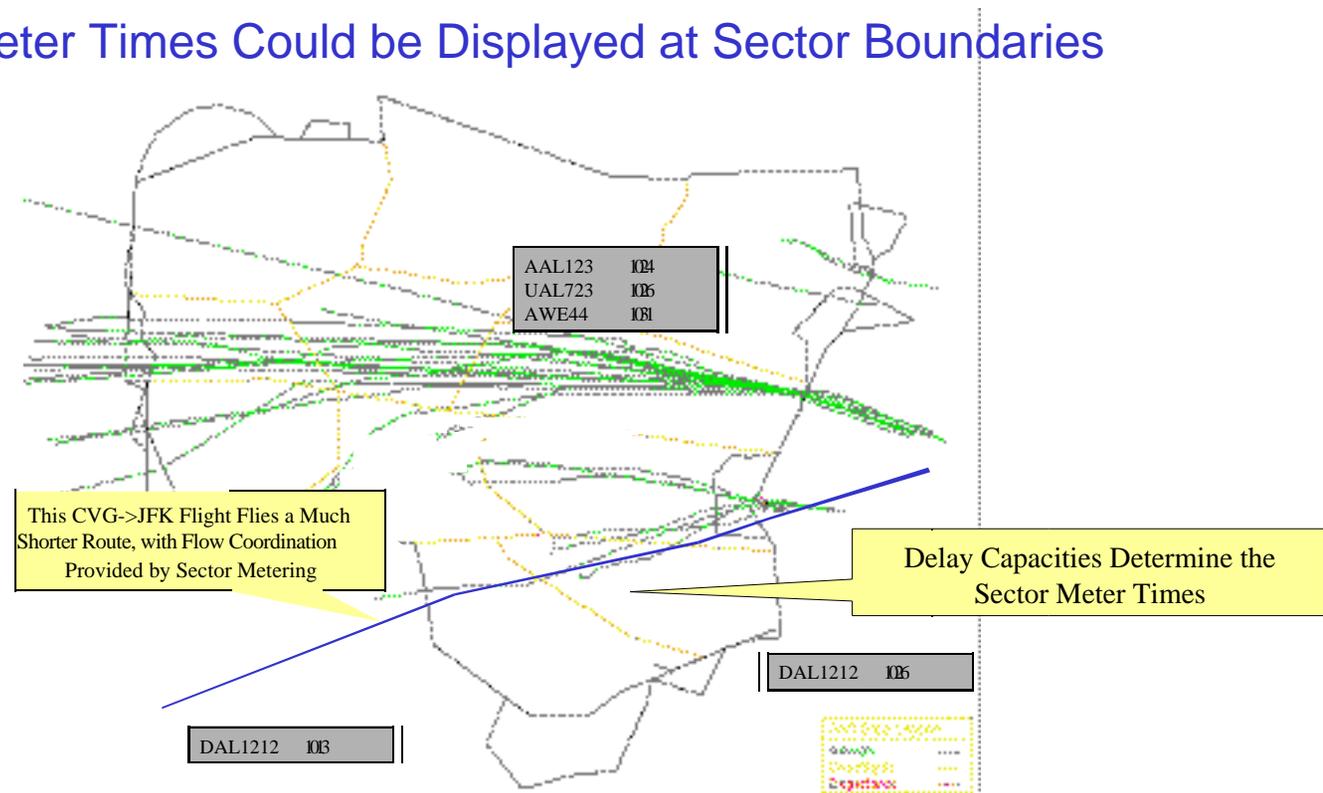


Histogram of Extra Distance Sector ZNY50



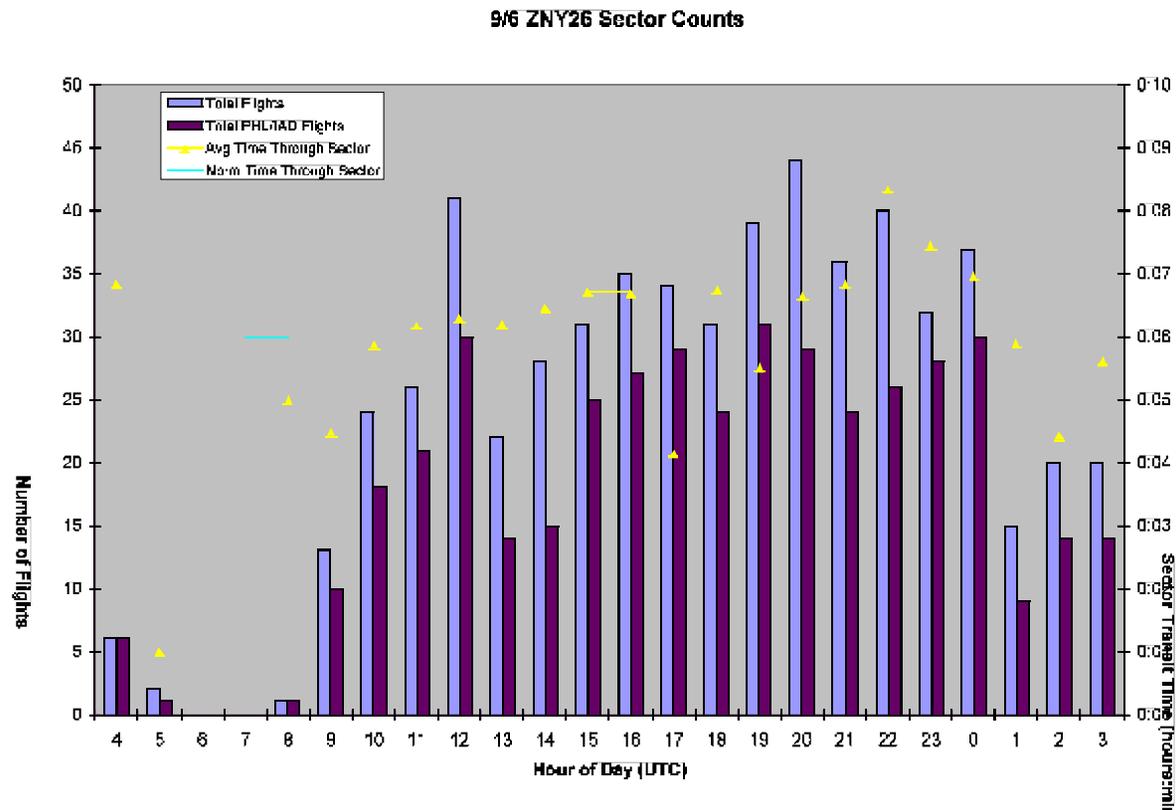
Center Sector Analysis Issues

- Using the Center Sector Delay Data, 'Delay Capacities' Could be Assigned for Each Sector
 - McTMA Outer Fix Scheduling Could be Modified to Schedule on a Sector-by-Sector Basis
 - Sector Meter Times Could be Displayed at Sector Boundaries



Center Sector Analysis Issues (cont.)

- Note that the Center Sector Analysis Only Shows Results for PHL Arrivals
 - The 'Delay Capacity' of a Sector is Dependent on Other Sector Traffic As Well



Center Sector Analysis Issues (cont.)

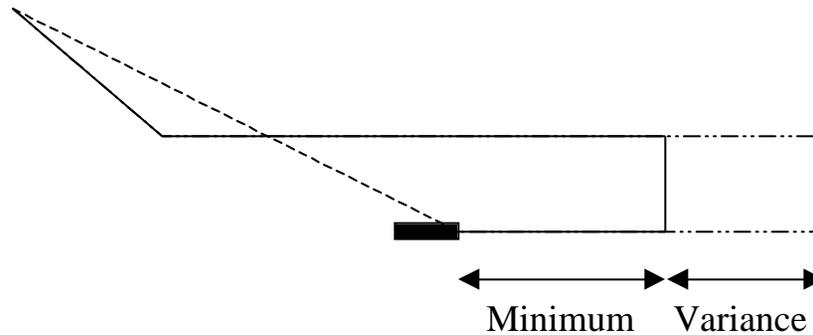
- McTMA Controllability of Complex Airspace Environment
 - Does McTMA Need to Schedule with Multi-Flow Dependence?
 - For Example, Must McTMA Generate Sector Meter Times for both PHL and IAD Flows in ZNY26 To Achieve Acceptability and Efficiency?
 - If So, What are the Objective Function and Constraints for Sector Metering?
 - Minimize Total Delay?
 - Subject to Maximum Number of Flights in Sector?
 - Subject to Maximum Delay in Sector?

Sector Metering

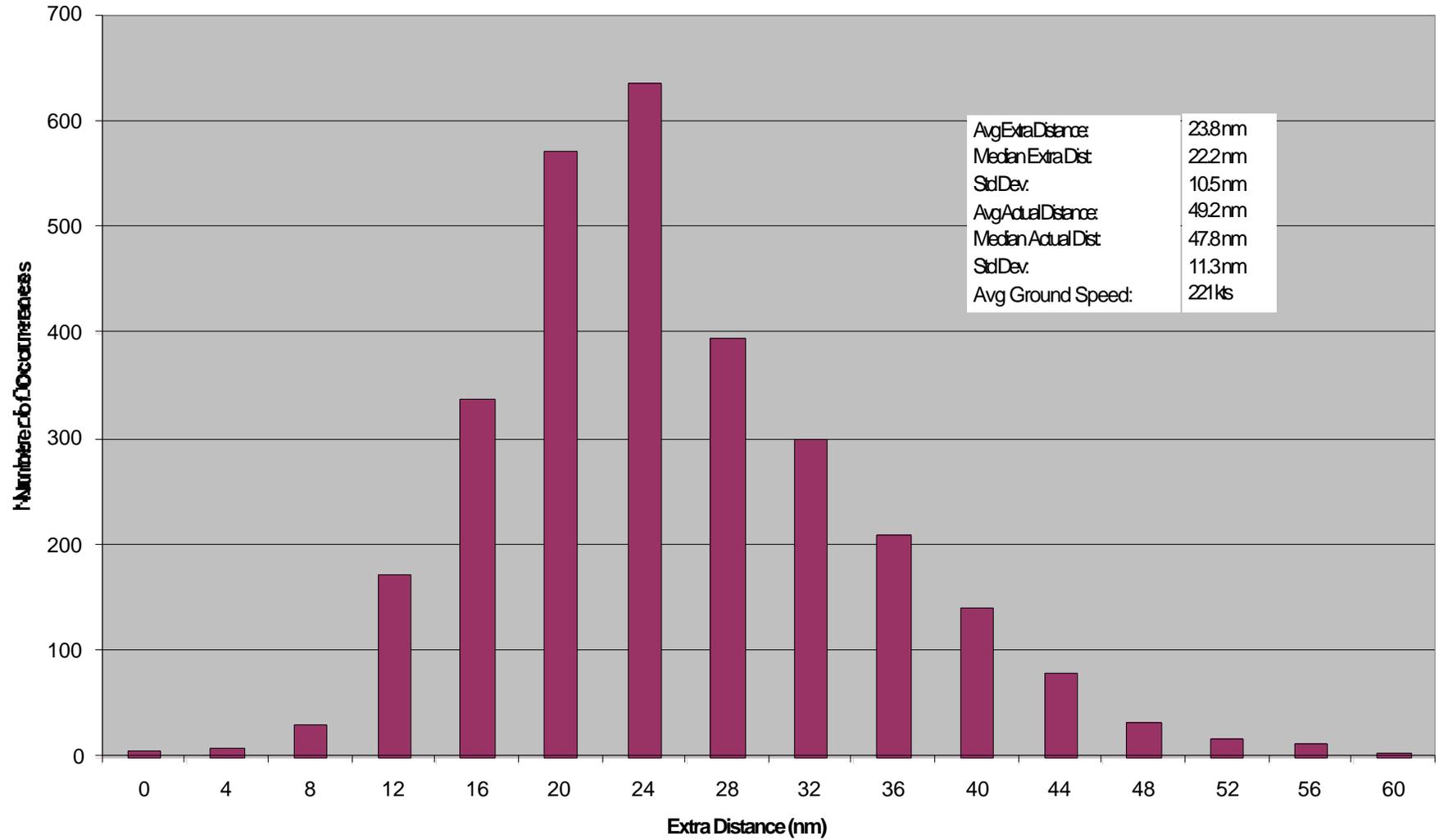
- Sector Metering Addresses the Following Problem:
 - Given a Set of Flights in the NAS,
 - $i = 1$ to N , represents Flights
 - $j = 1$ to M , represents Sectors
 - let $ETA(i, j)$ be the Estimated Time of Entry of Flight i into Sector j
 - let $S(j,t)$ be the Count of Flights in Sectors
 - let $D(j,t)$ be the Airborne Delay
 - let $MaxS(j)$ be the Maximum Count of Flights in Sectors
 - let $MaxD(j)$ be the Maximum Airborne Delay Capacity in Sectors
 - Assign $STA(i,j)$, the Scheduled Time of Entry of Flight i into Sector j , such that:
 - $S(j,t) \leq MaxS(j)$ for all t
 - $D(j,t) \leq MaxD(j)$ for all t
- The Solution Requires Consideration of Network Dependencies in the Scheduling Process
 - A Prototype Sectoring Metering Algorithm has been Developed as Part of our CDM Analysis of System Impact Assessment Algorithms

TRACON Delay Analysis

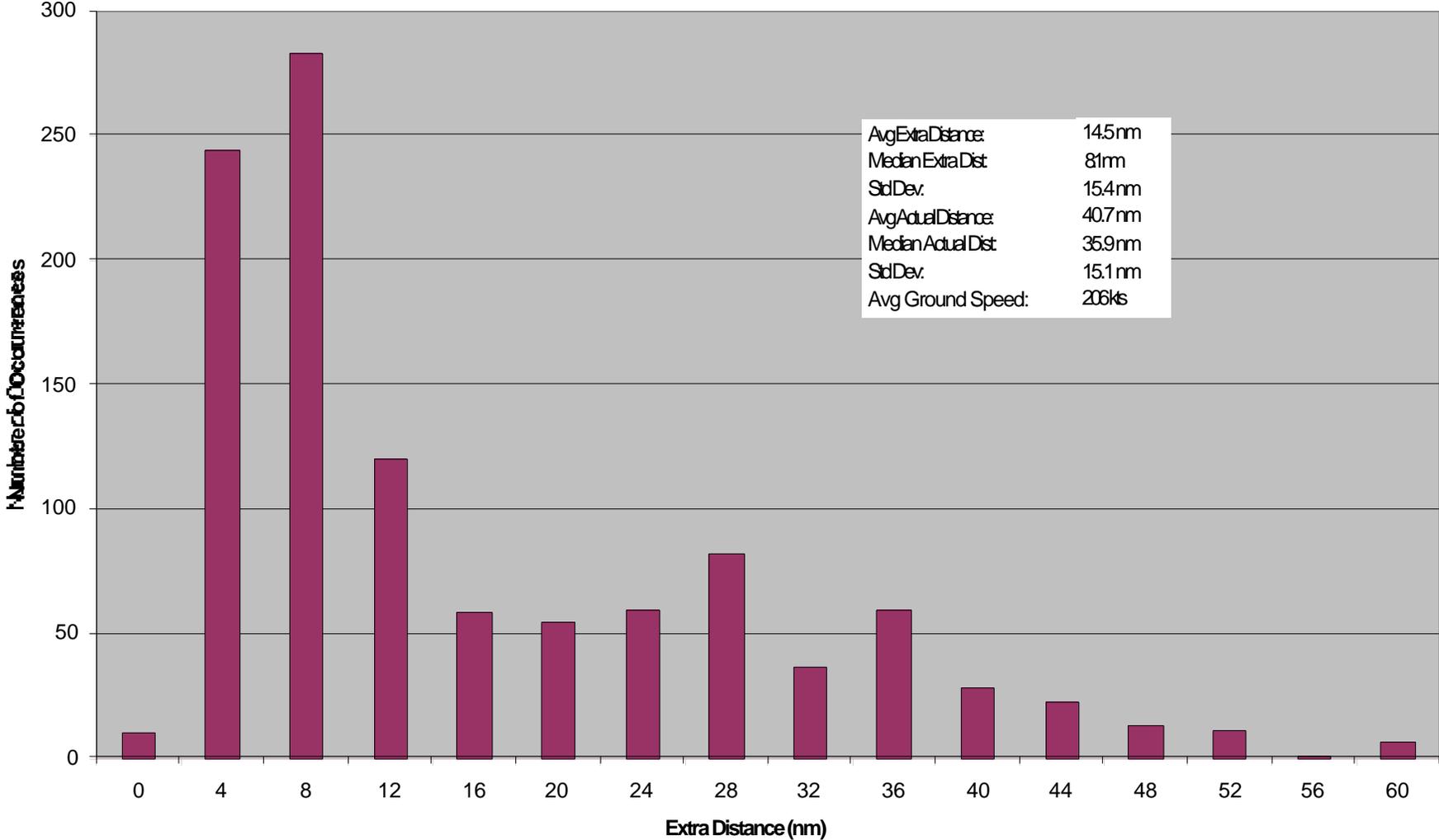
- Approach
 - Approximately One Month of PHL SMA/ARTS Data was Used
 - Meter Fix and Landing Runway Identified for All Arrivals
 - ‘Extra Distance’ Computed Between Meter Fix and Runway
 - The Extra Distance is the Amount that the Actual Distance Flown in the TRACON Exceeds the Straight Line Distance



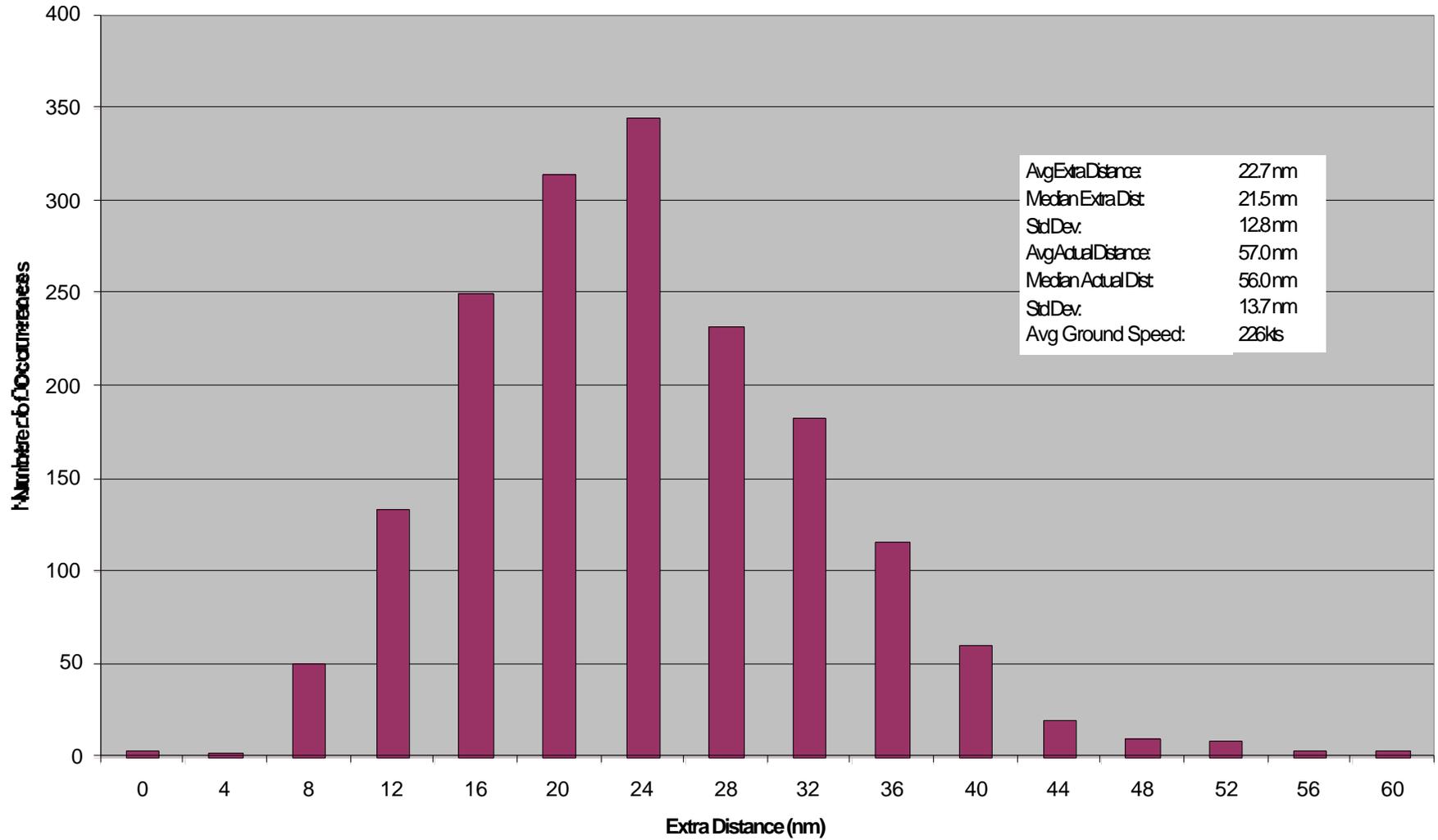
Histogram of Extra Distance BUNTS/ZNY26 to 27/26 Runways



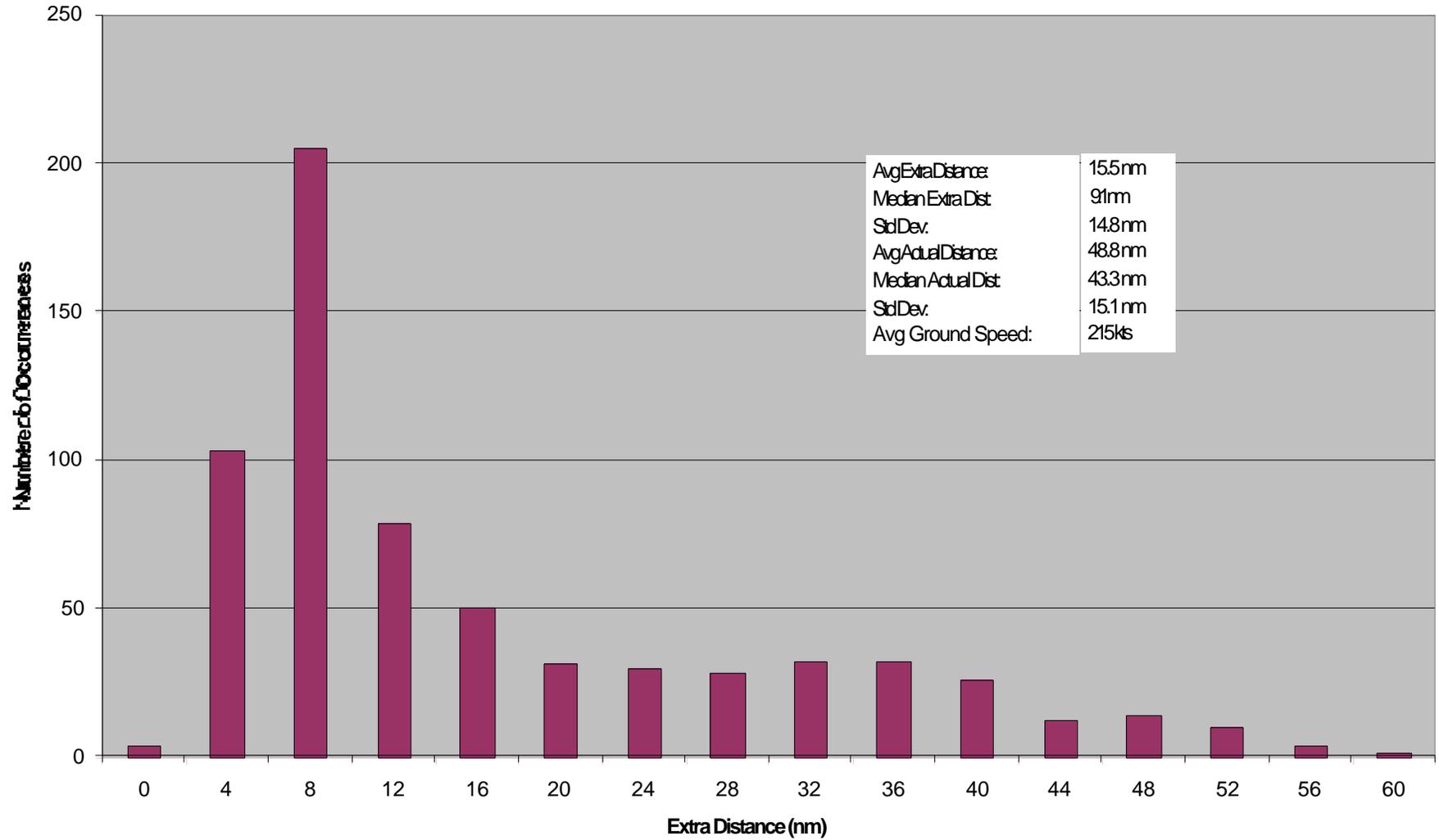
Histogram of Extra Distance BUNTS/ZNY26 to 9/8 Runways



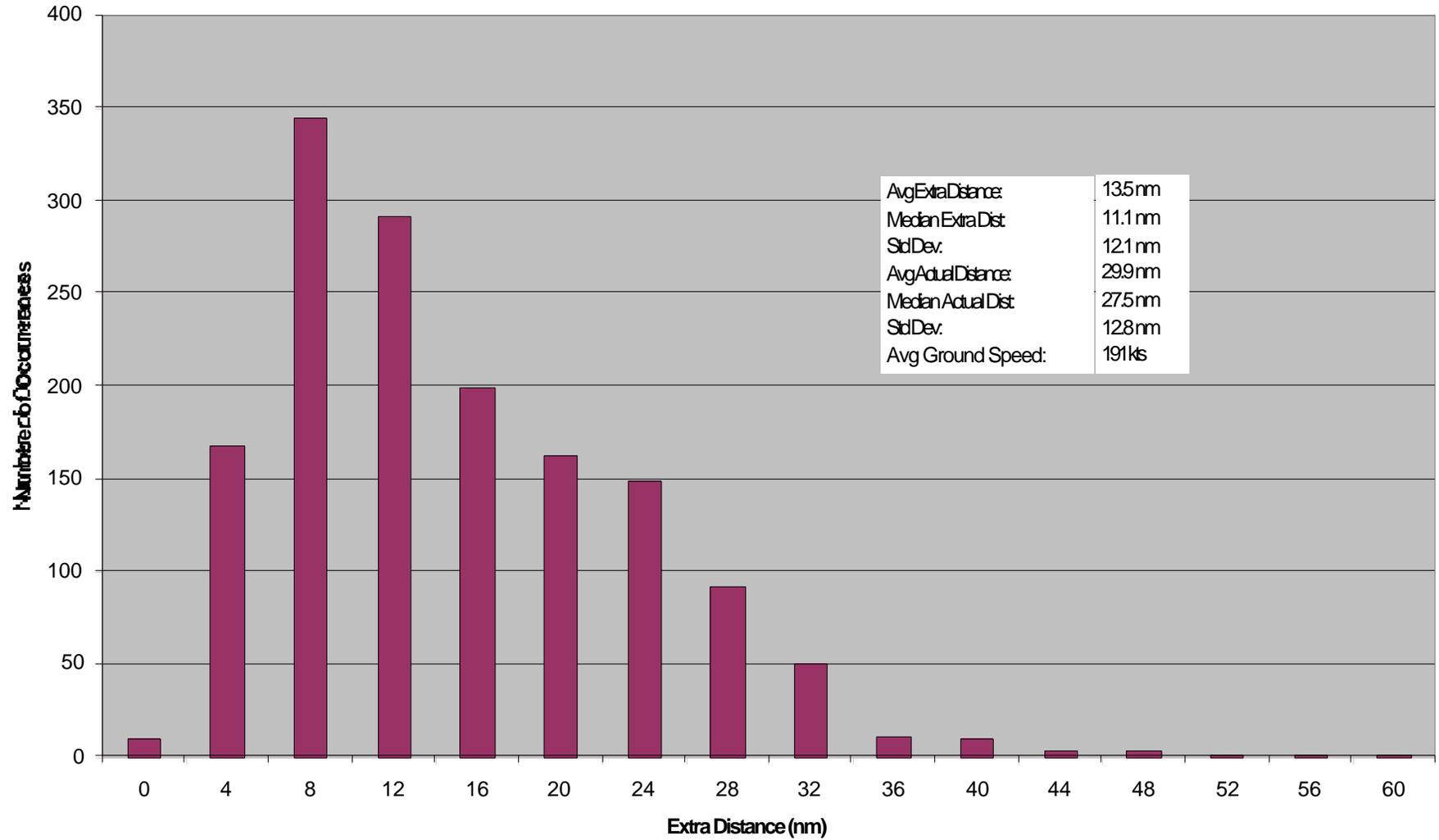
Histogram of Extra Distance TERRI/ZDC53 to 27/26 Runways



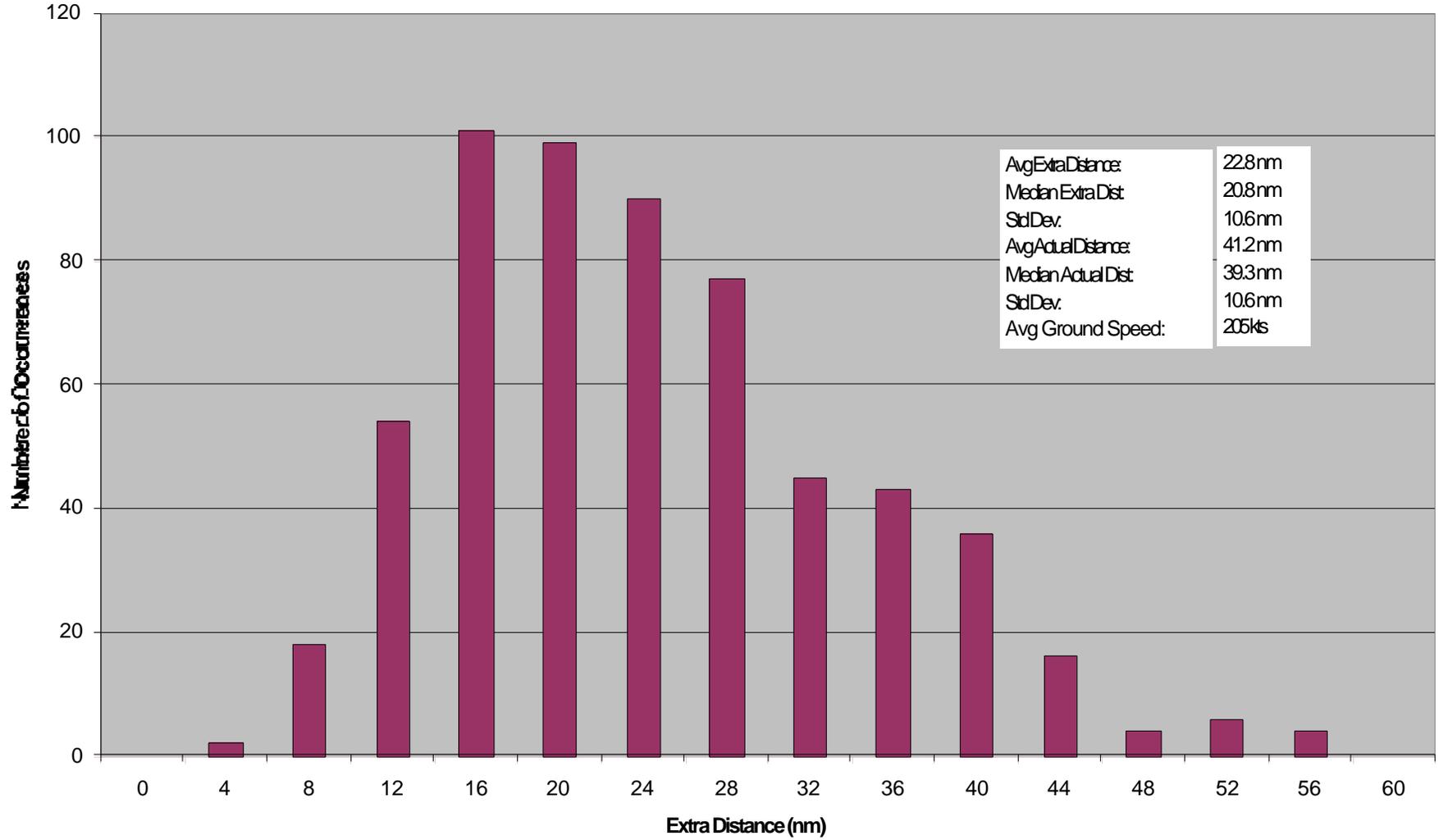
Histogram of Extra Distance TERRI/ZDC53 to 9/8 Runways



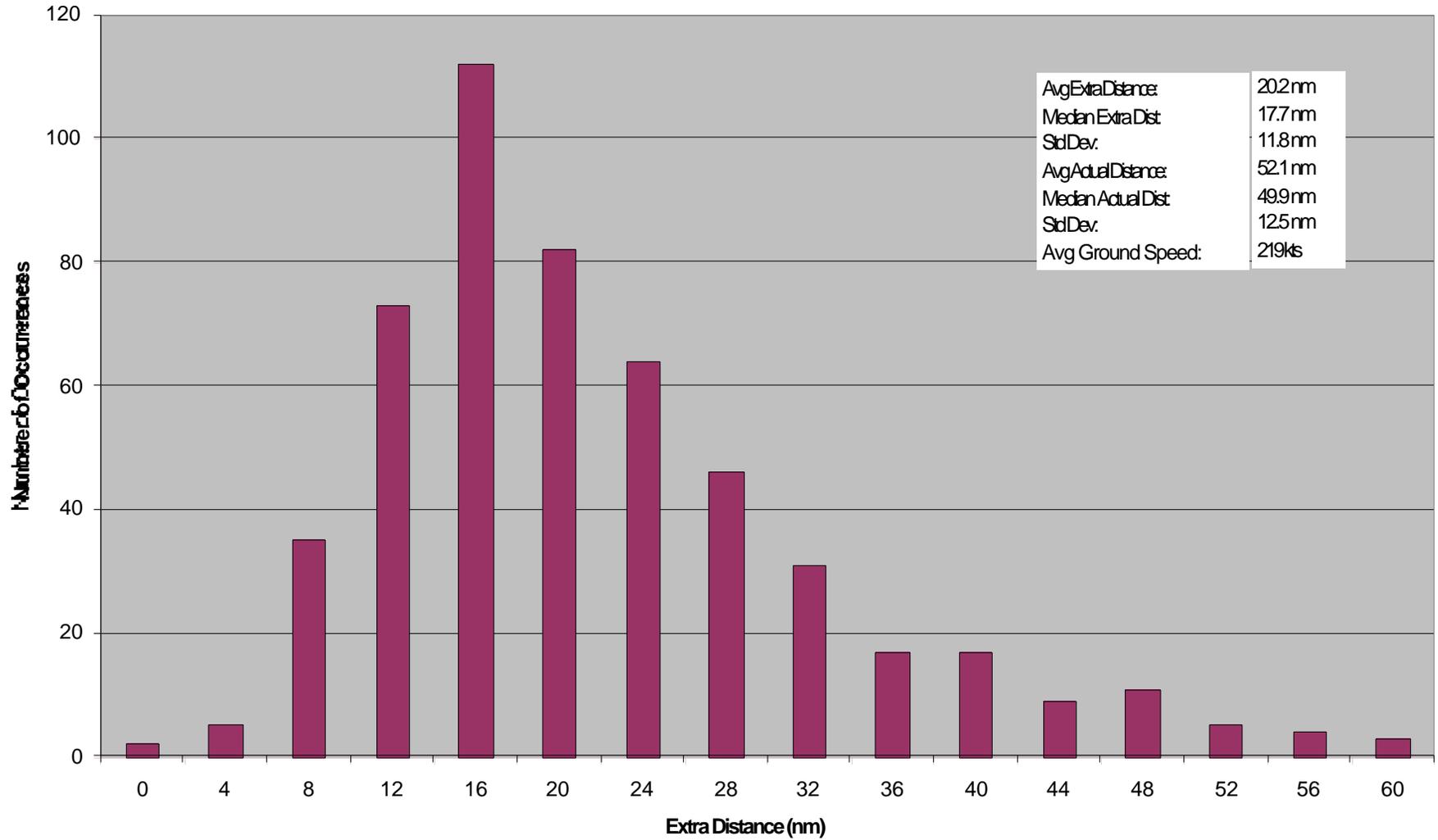
Histogram of Extra Distance
VCN/ZDC51 to 27/26 Runways



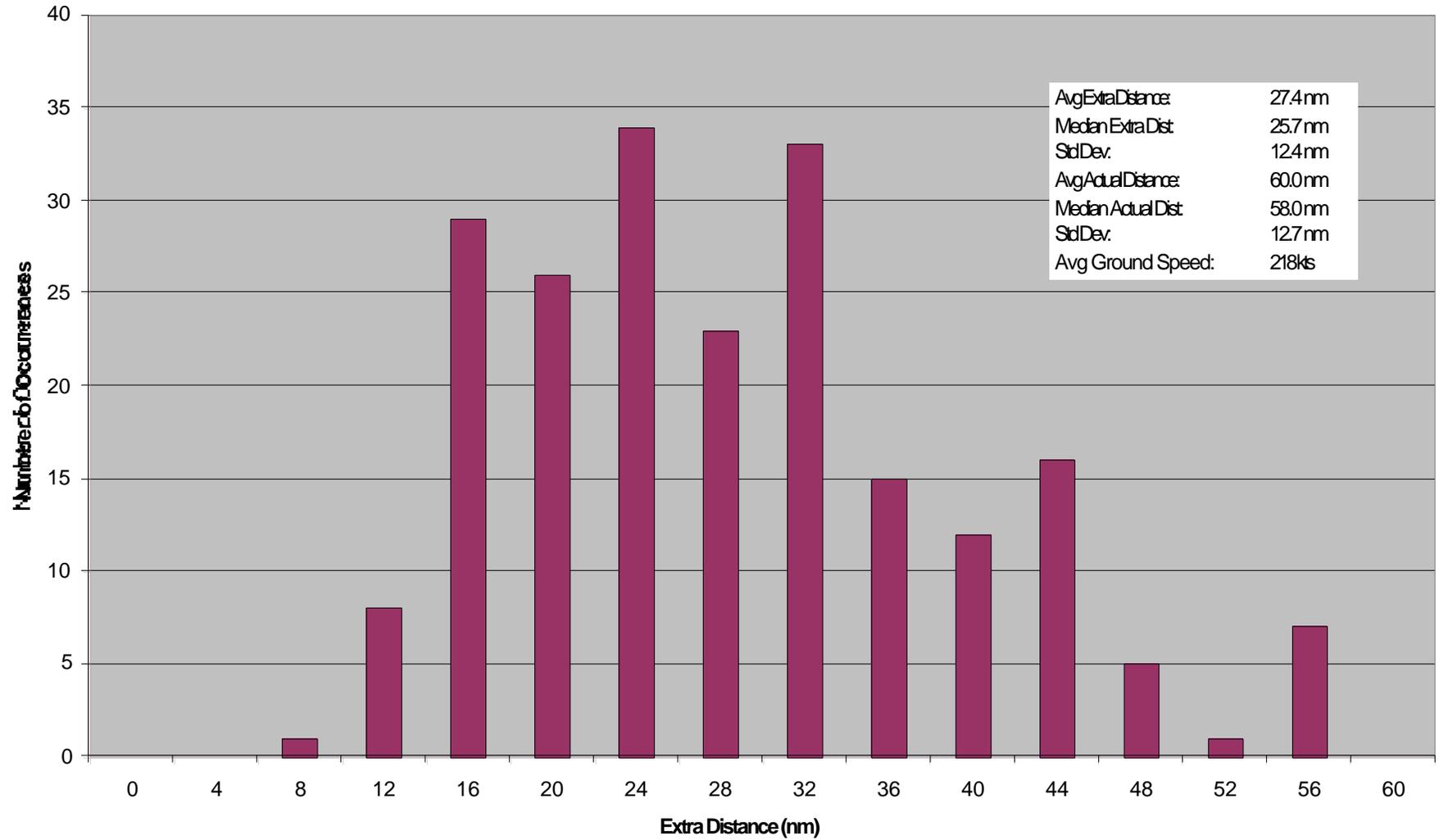
Histogram of Extra Distance
VCN/ZDC51 to 9/8 Runways



Histogram of Extra Distance
MAZIE/PTW/ZNY92 to 27/26 Runways



Histogram of Extra Distance
MAZIE/PTW/ZNY92 to 9/8 Runways



Conclusions

- Significant Adaptation and Analysis of McTMA Issues have been Conducted during this Task
- However, Much Research Remains to be Done to Resolve McTMA Issues
 - How to Handle TEC Flights?
 - Predictability?
 - Scheduling?
 - How Should Time-Based Metering Work in Complex Airspace?
 - Must Multi-Flow Dependencies be Considered in Scheduling?
 - How Could Sector Metering be Designed to Address these Dependencies?
 - What are the Operational Issues?