State of the National Airspace Infrastructure

National Airspace System Performance Workshop

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Why Do We Need Reliable and Modern Aviation Infrastructure?

- The United States accounts for approximately 30 percent of all commercial aviation and 50 percent of all general aviation activity in the world.
- Prior to September 11, 2001 the NAS handled 1.9 million passengers traveling on 60,000 flights daily.
- NAS moves over 600 million passengers per year. Projected enplanements in year 2013 is over 900 million.
- NAS conducts over 26 million operations per year. Projected number of operations in 2013 is over 33 million.

Source: ACE 2002

Background

- 546 commercial service airports:

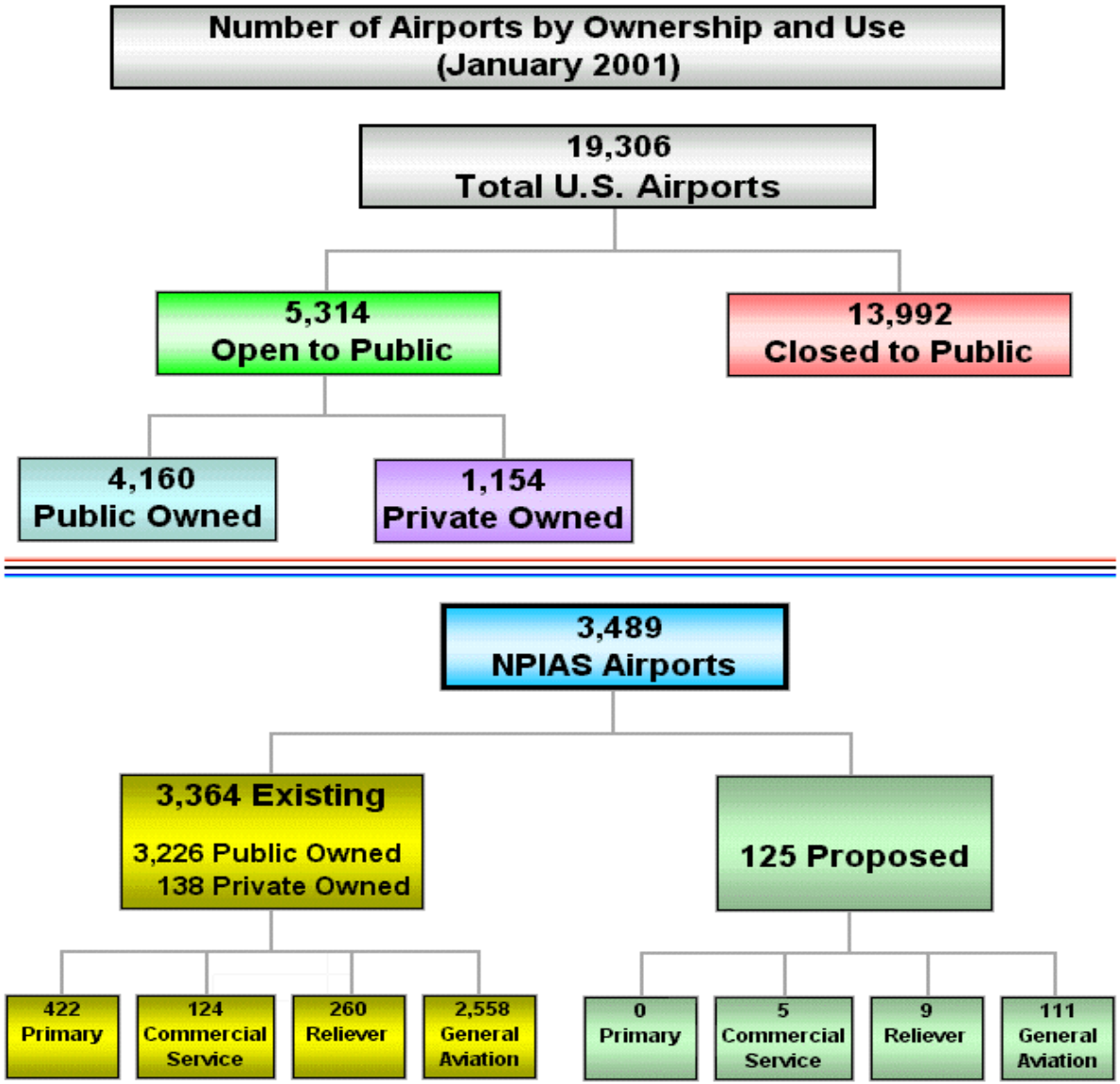
  422 have more than 10,000 enplanements and are classified as primary airports (Commercial service airports are defined as public airports receiving scheduled passenger service and having 2,500 or more enplaned passengers per year).

- 31 large hub airports account for 70 percent of all passenger enplanements.
- 37 medium hub airports account for 19 percent of all enplanements
- 74 small hub airports account for 8 percent of all enplanements

Source: NPIAS

- 50 airlines

Background



Source: NPIAS

Background

Airport	Runway	FY Runway to Open
Minneapolis (MSP)	17/35	2006
Cincinnati (CVG)	17/35	2006
St. Louis (STL)	12R/30L	2006
Atlanta (ATL)	10/28	2006
Boston (BOS)	14/32	2006
Washington (IAD)	1W/19W	2008
Seattle (SEA)	16W/34W	2009

New Runways in OEP

Source: OEP

NAS Inventory

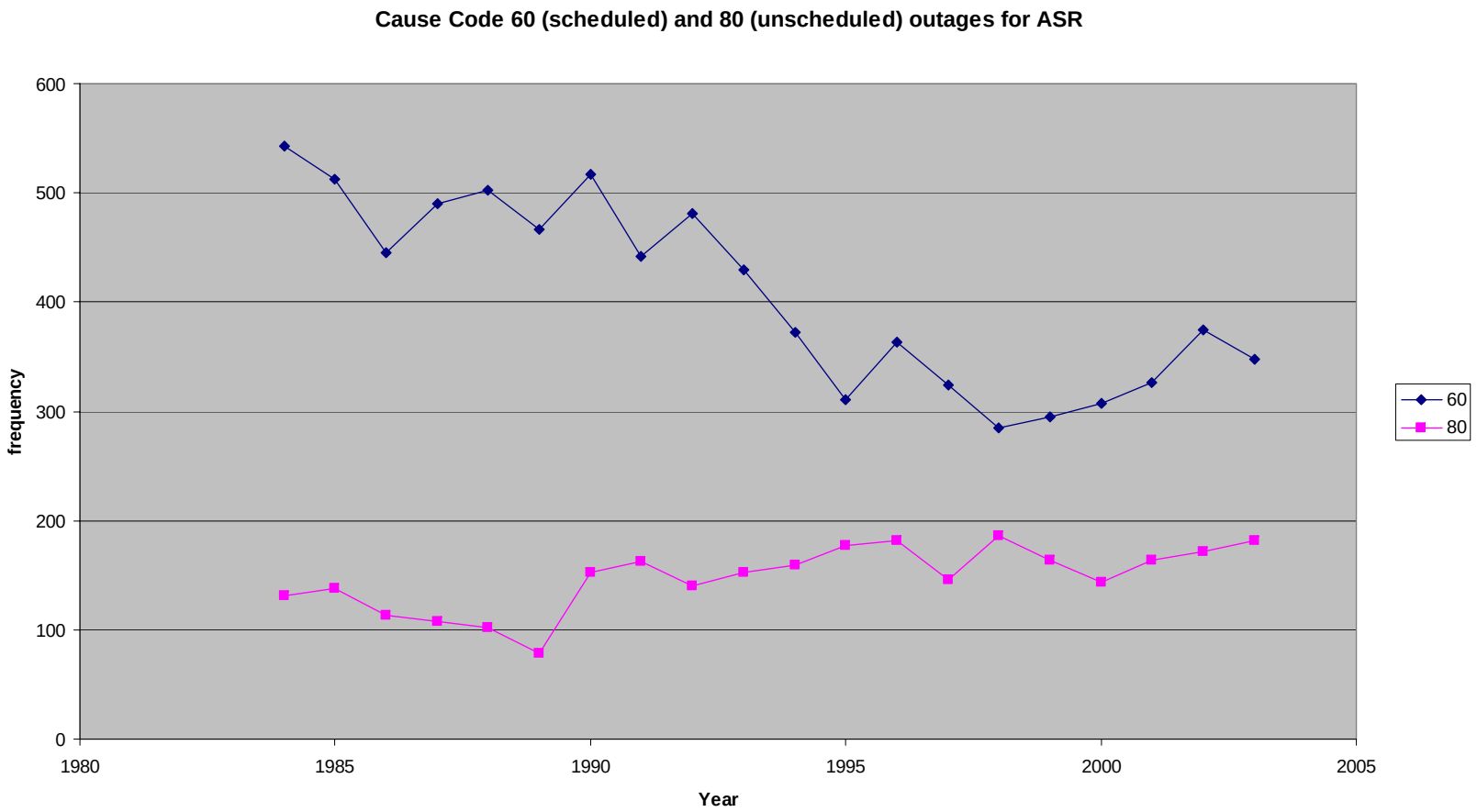
- NAS has about 44,000 pieces of equipment and services that provide air traffic management (ATM) services.

Source: http://www.faa.gov/ats/aaf/

- NAS' large inventory of capital assets are in various stages of approaching physical or technical obsolescence.

Background

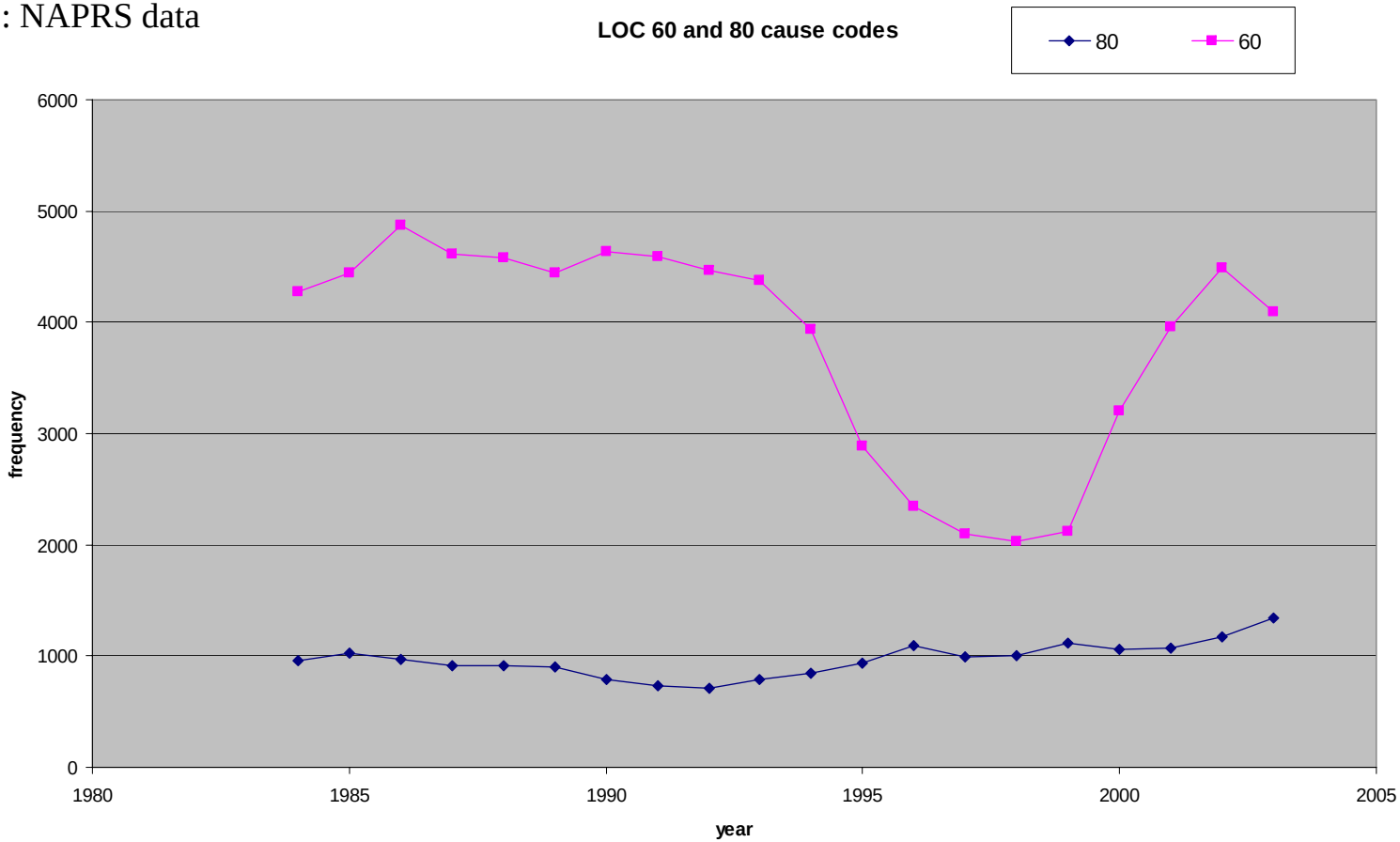
Source: NAPRS data



Frequencies of Scheduled (Cause Code 60) and Unscheduled Outages (Cause Code 80) for Airport Surveillance Radars (ASR)

Background

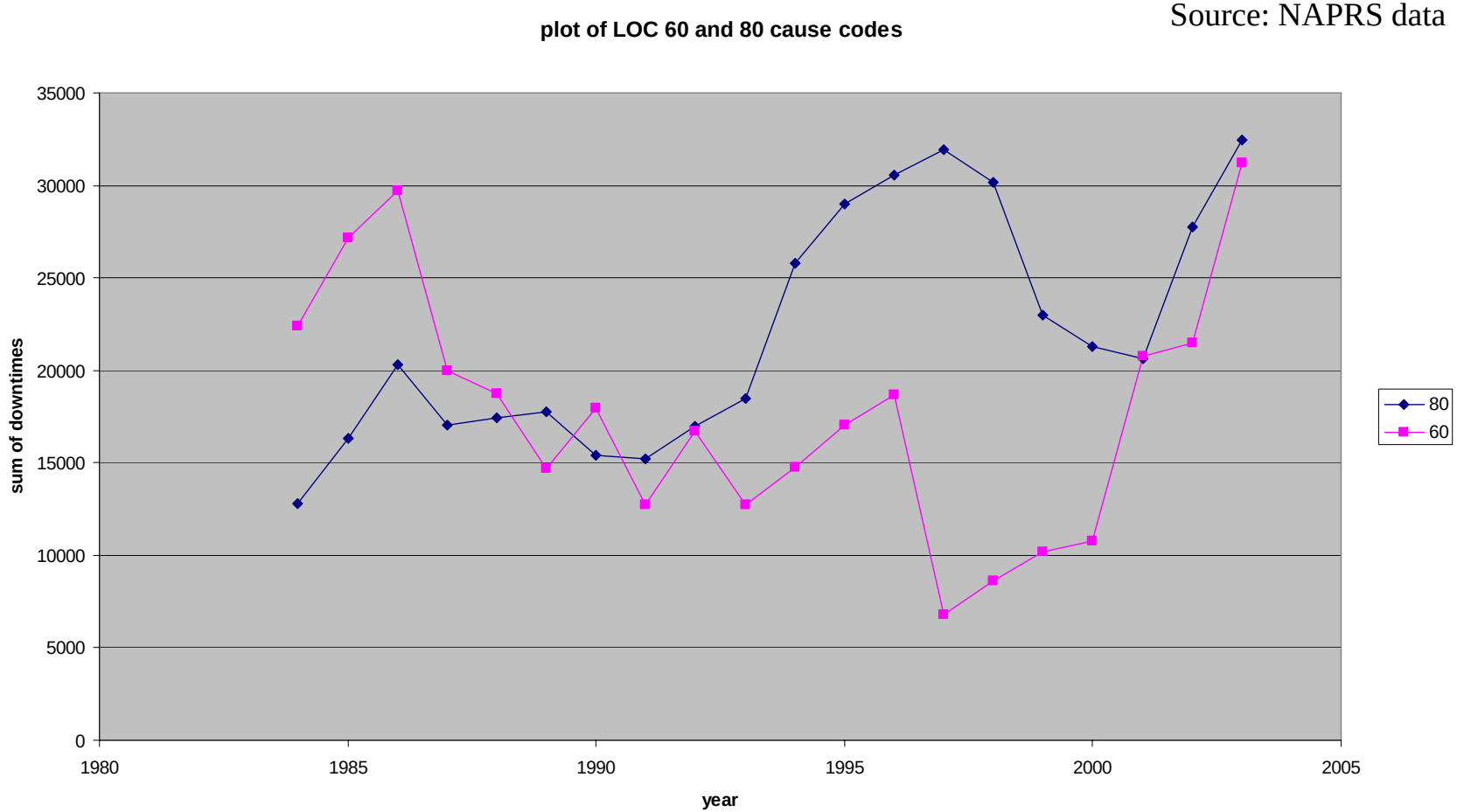
Source: NAPRS data



Frequency of Scheduled (Cause Code 60) and Unscheduled Outages (Cause Code 80) for Localizers (LOC)

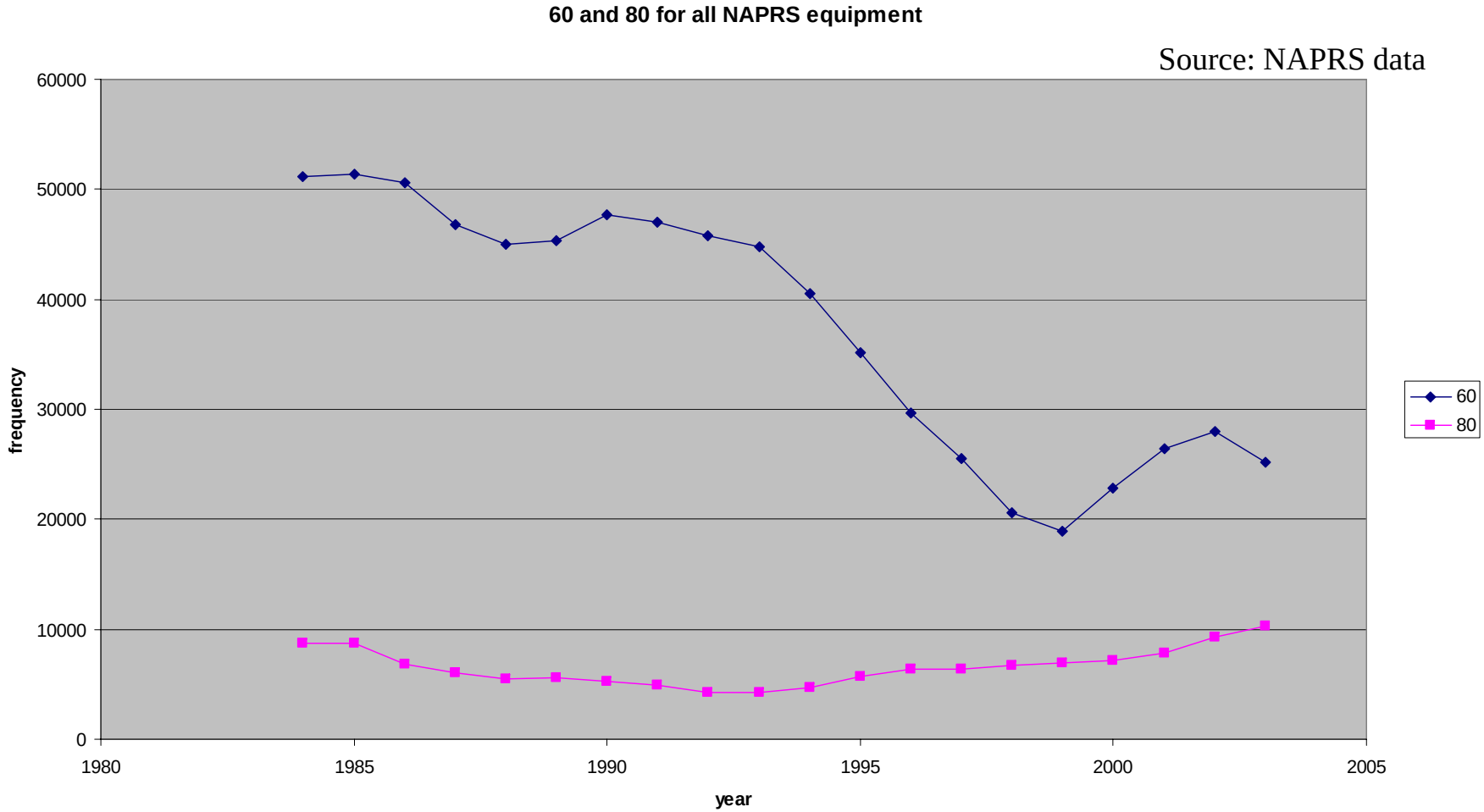
Background

Source: NAPRS data



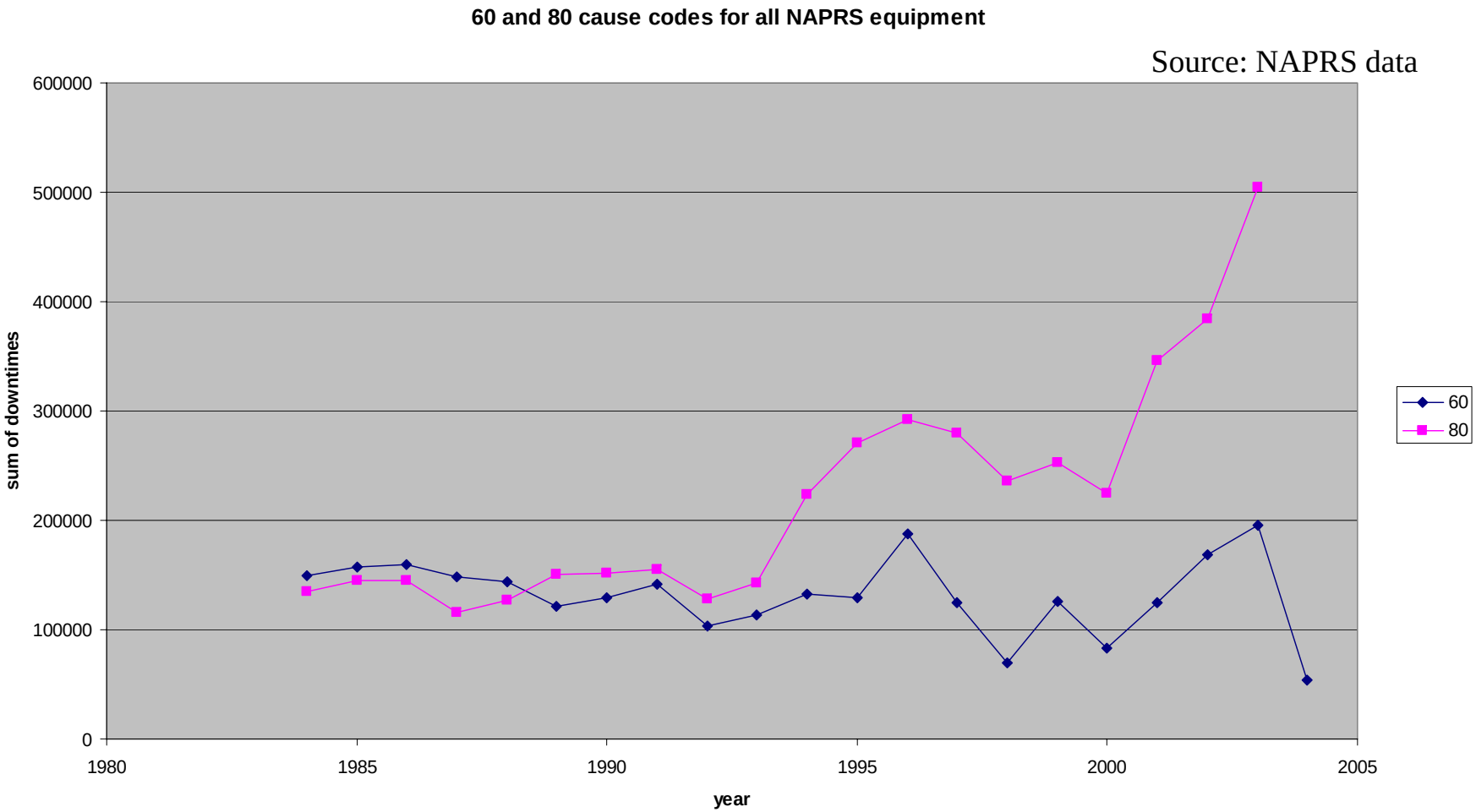
Downtimes of Scheduled (Cause Code 60) and Unscheduled Outages (Cause Code 80) for Localizers (LOC)

Background



Frequency of Scheduled (Cause Code 60) and Unscheduled Outages (Cause Code 80) for All NAPRS Equipment

Background



Downtimes of Scheduled (Cause Code 60) and Unscheduled Outages (Cause Code 80) for All NAPRS Equipment

NAS Inventory

- ~ 500 FAA Managed Air Traffic Control Towers
- ~ 180 Terminal Radar Control Centers (TRACONs)
- > 730 Sectors
- ~ 60 Flight Service Stations

NAS Inventory

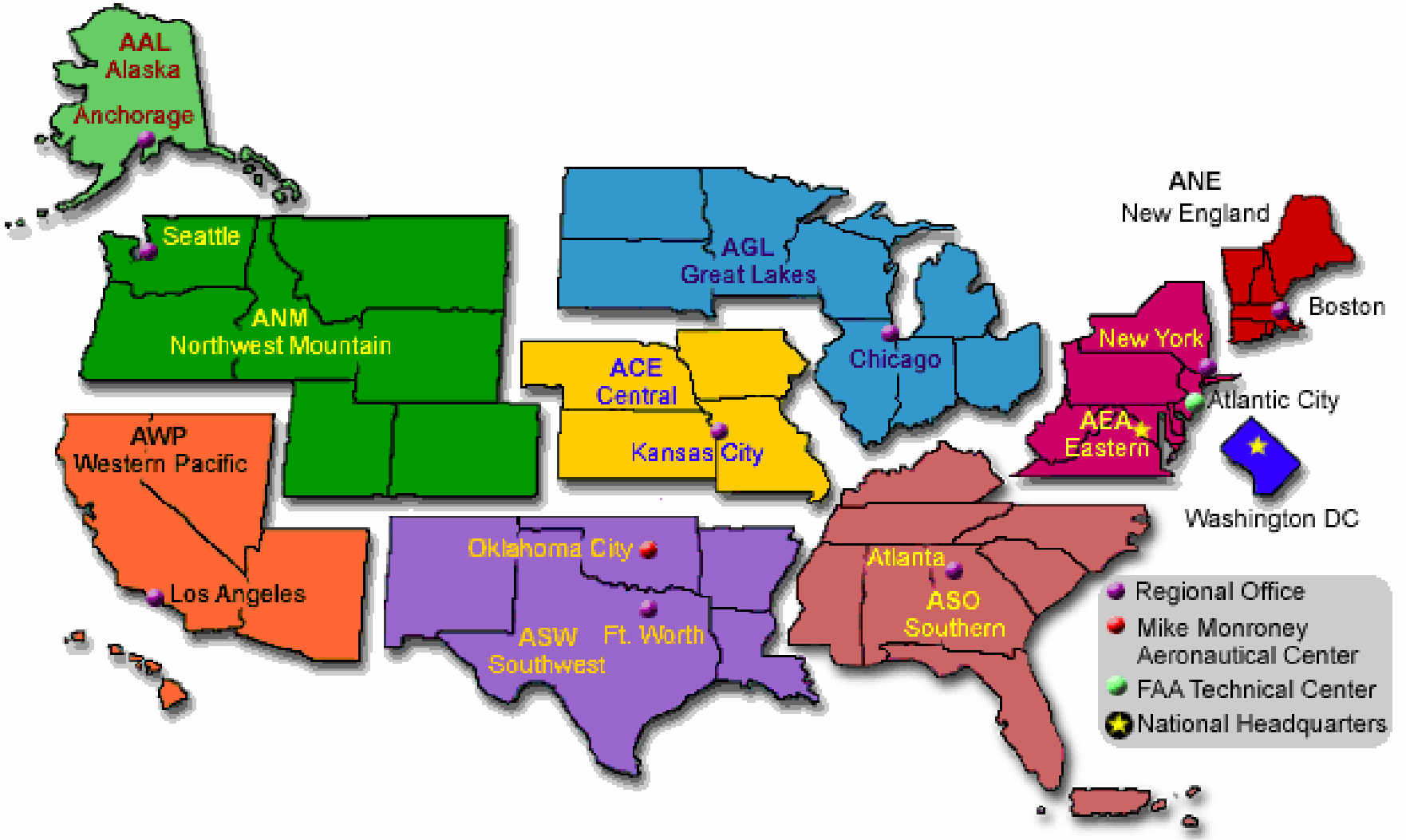
- 20,000 – 25,000 administrative and mission support computers
- 1,800 people to maintain and operate NAS software
- $100 million contract costs to maintain NAS software

NAS Inventory

NAS building and building systems infrastructure is made up of:

- 21 Air Route Traffic Control Centers (ARTCCs)
- 3 Center Approach Control (CERAPs)
- 1 Combined facility (ATC/TRACON/CERAP)
- 519 Terminal facilities
- 3 Automated Flight Services Stations (Alaska)
- 14 Flight Service Stations (Alaska)
- 9,000 General National Airspace unstaffed facilities
- Power systems
    - 3800 engine generators
    - 587 uninterruptible supply systems
    - 77,000 batteries

NAS Inventory



Division of the NAS into 9 different regions

Type of Facility		TOTAL	Facilities Reported by Region								
			AAL	ACE	AEA	AGL	ANE	ANM	ASO	ASW	AWP
Terminal Radars	ASR	249	2	10	33	38	12	21	70	30	33
	TDWR	33		3	5	6	1	1	15	1	1
	ASDE (Remote)	27	2	2	0	3	0	4	12	1	3
Enroute Radars	ARSR	136	1	14	12	17	5	23	39	15	10
Communi-cations	RCAG	633	41	27	68	107	21	81	145	82	61
	RTR	1030	16	33	166	195	83	121	170	122	124
	RCL / TML / RML	1009	44	65	91	116	116	48	294	131	104
Navigation Aids	VOR / VORTAC	967	40	67	127	158	37	133	143	139	123
	LOC	1150	29	73	167	190	73	108	285	133	92
	GS	914	17	61	140	183	53	60	210	118	72
	Markers	1905	19	132	296	371	136	224	407	236	84
Lighting Facility	ALS	126	4	6	18	21	9	14	38	9	7
	MALS / SSALS	711	24	59	84	153	48	78	10	193	62
Weather Facility	AWOS / ASOS	600	72	9	79	41	78	48	220	16	37
	NEXRAD	3	2						1		
	LLAWS	119		9	19	15	2	7	46	18	3
TOTALS		9612	313	570	1305	1614	674	971	2105	1244	816

List of Facilities, Split on the Basis of Type and Region

Abbreviation	Facility Type
TDWR	Terminal Doppler Weather Radar
ASR	Airport Surveillance Radar
ASDE	Airport Surface Detection Equipment
ARSR	Airport Route Surveillance Radar
RTR	Remote Transmitter Receiver
RCL	Radio Communication Link
RML	Remote Microwave Link
TML	Television Microwave Link
VOR	VHF Omnidirectional Range
VORTAC	VOR collected with TACAN
TACAN	Tactical Aircraft Control and Navigation
LOC	Localizer
ALS	Approach Light System
MALS	Medium Intensity Approach Lighting System
SSALS	Simplified Short Approach Lighting System
AWOS	Automated Weather Observation System
ASOS	Automatic Surface Observing System
NEXRAD	Next Generation Weather Radar
LLWAS	Low Level Wind Shear Alert System
RCAG	Remote Communication Air / Ground
GS	Glide Slope

NAS Regions

- Each of 9 regions signifies different climactic conditions.
- Adverse weather conditions vary a lot over the 9 different regions, including the large temperature changes in the Alaska region and strong winds in southern region.
- Varied weather patterns result in different deterioration patterns among same types of facilities.
- Conditions of the facilities vary.

Facility Assessments

Facility Condition Index (FCI)

$$FCI = \frac{\text{Dollar value of backlog (Maintenance \& repair)}}{\text{Current replacement value}}$$

NAS Inventory

There are about 800 facilities (ATCTs, ARTCCs, or TRACONs) in the NAS, with the average age between 16 and 40 years.

For example, average ages of specific facilities and equipment types are:

Facility	Average Age (Years)
Towers	30
TRACONS	34
Primary en-route radars	27
Secondary en-route radars	40
Primary terminal radars	16

NAS Infrastructure Management

• The maintenance of individual equipment or systems supporting air traffic control of the NAS requires technicians trained in many disciplines deployed over the entire country.

• Maintenance workforce is managed out of a national network of cost centers.

• Each cost center has a limited number of technicians who are responsible for providing scheduled and unscheduled maintenance and repair for the equipment assigned to that center.

NAS Infrastructure Management

- Different types of equipment have different repair time characteristics.
- Technicians are trained to repair specific types of equipment.
- To date there is no centralized system for equipment maintenance.

Does Periodic Maintenance Cause Unscheduled Outages?

An Investigation of the National Airspace System Equipment Outages

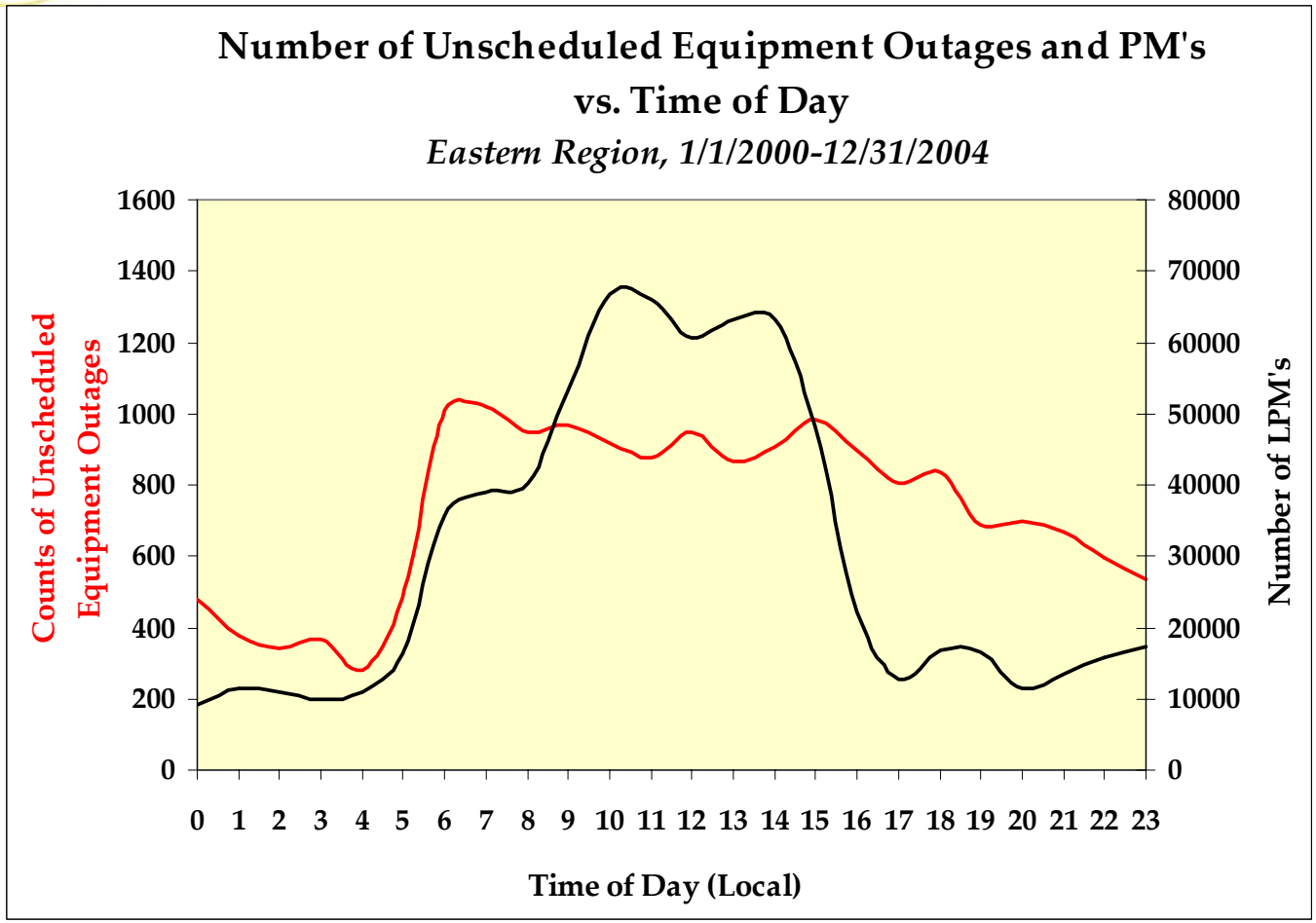
Motivation

More unscheduled outages during day

- Why?
- Hypothesis:

  Scheduled maintenance linked to outages

  “Maintenance-induced-maintenance”



Note: Eastern Region includes: New York, New Jersey, Pennsylvania, West Virginia, Virginia, Maryland, Delaware, and DC

Methods

Data from Maintenance Management System

Unscheduled outages from:

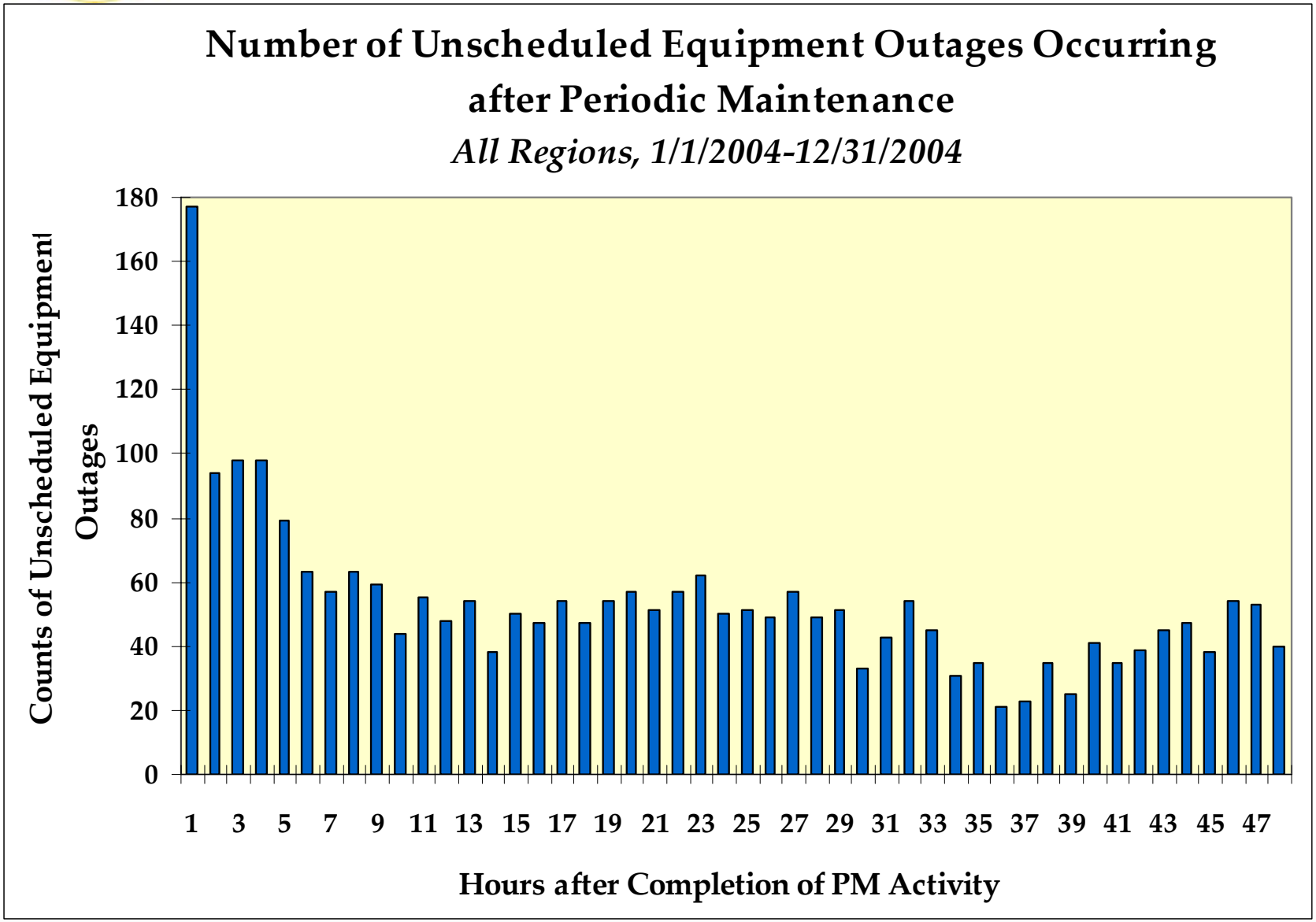
1. Equipment failure or malfunction
2. Unknown cause

Find time between each PM and next outage on given equipment

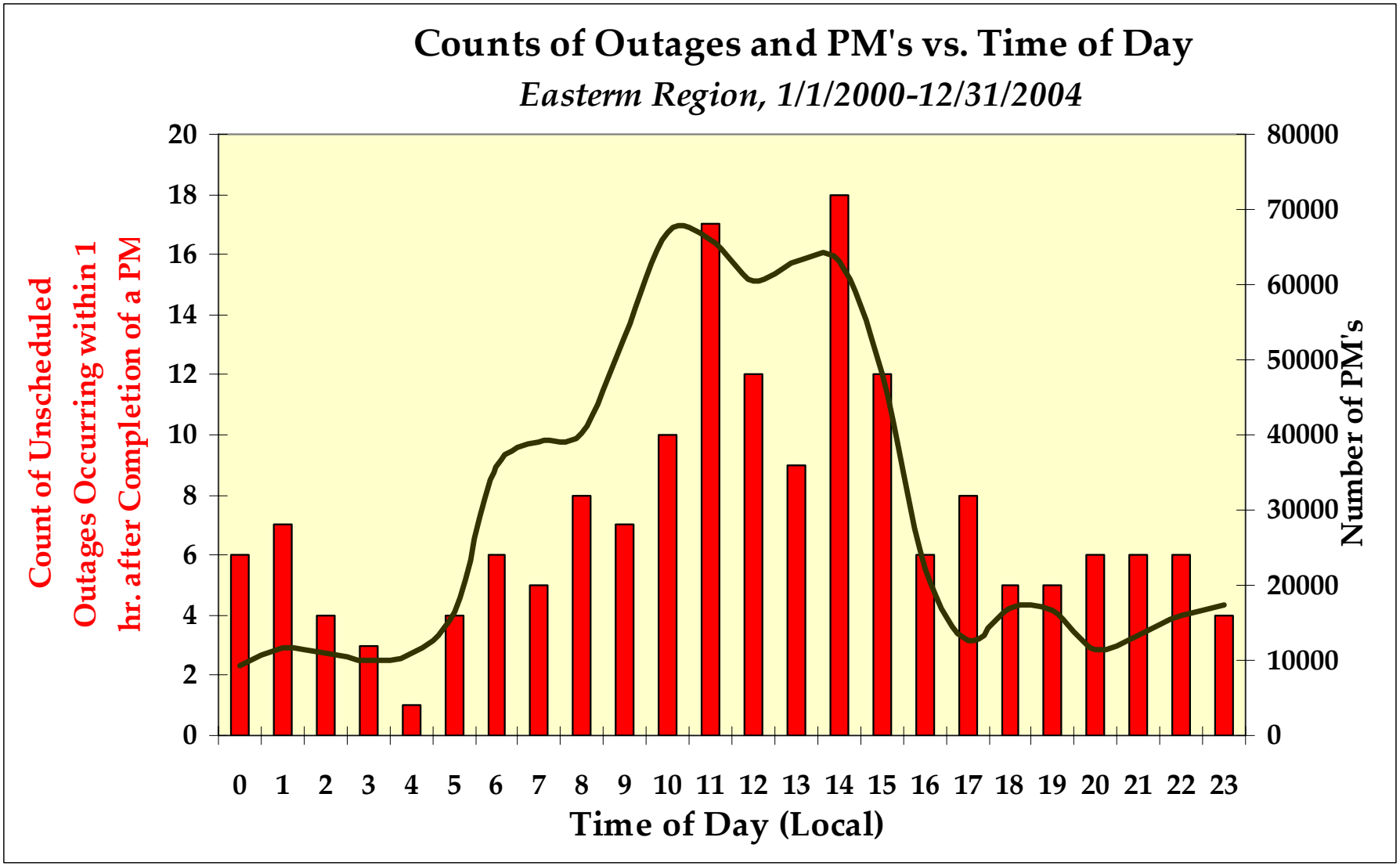
Findings

- Correlation coefficient of 0.73 between PMs and outages
- Mean time between PM and outage is 840 hrs.
- If outage is “caused” by PM, would expect to see it in first few hours after PM
- If outages are random, would expect 17 outages in the first hour

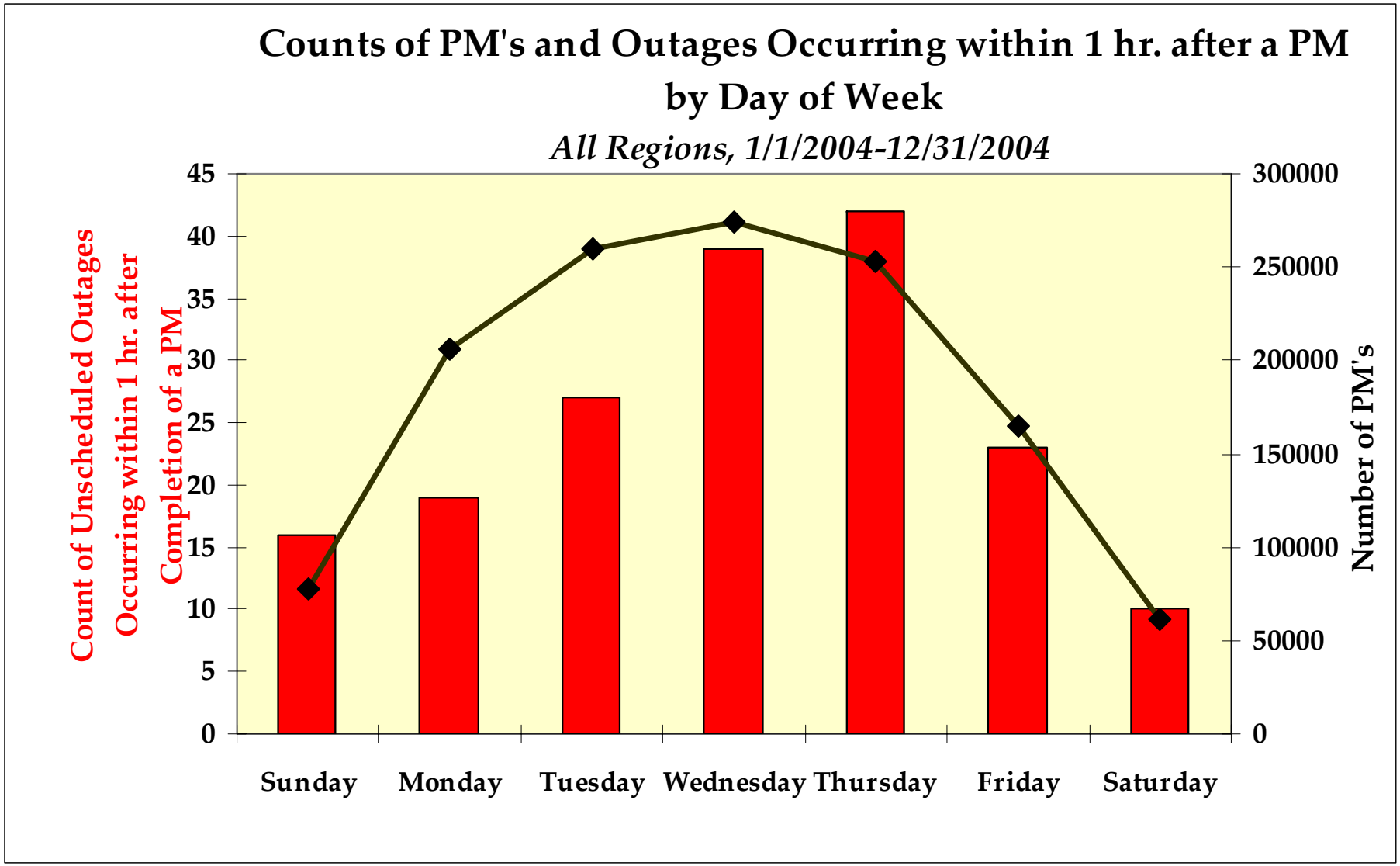
Findings


Number of Unscheduled Equipment Outages Occurring after Periodic Maintenance
All Regions, 1/1/2004-12/31/2004
Counts of Unscheduled Equipment Outages
180
160
140
120
100
80
60
40
20
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47
Hours after Completion of PM Activity

Findings—Time of Day



Findings—Day of Week



Periodic Maintenance and Unscheduled Outages

- Maintenance-induced maintenance or secondary maintenance occurs, which is also common in industrial facilities.

- PM's should be performed during time periods when the consequence of an outage is low, i.e., when there are low numbers of air traffic controllers, pilots, and aircraft relying on the equipment.

- The fact that some PM's do cause unscheduled outages does not mean, however, that reducing the number of PM's will necessarily decrease the number of unscheduled outages.

Future Work

- Differences across equipment types/locations
- Delay-causing outages
  - Outages “of consequence”
- Balance between too many PMs and too few

Facility Assessments

Facility Condition Index (FCI)

$$FCI = \frac{\text{Dollar value of backlog (Maintenance \& repair)}}{\text{Current replacement value}}$$

Surveillance

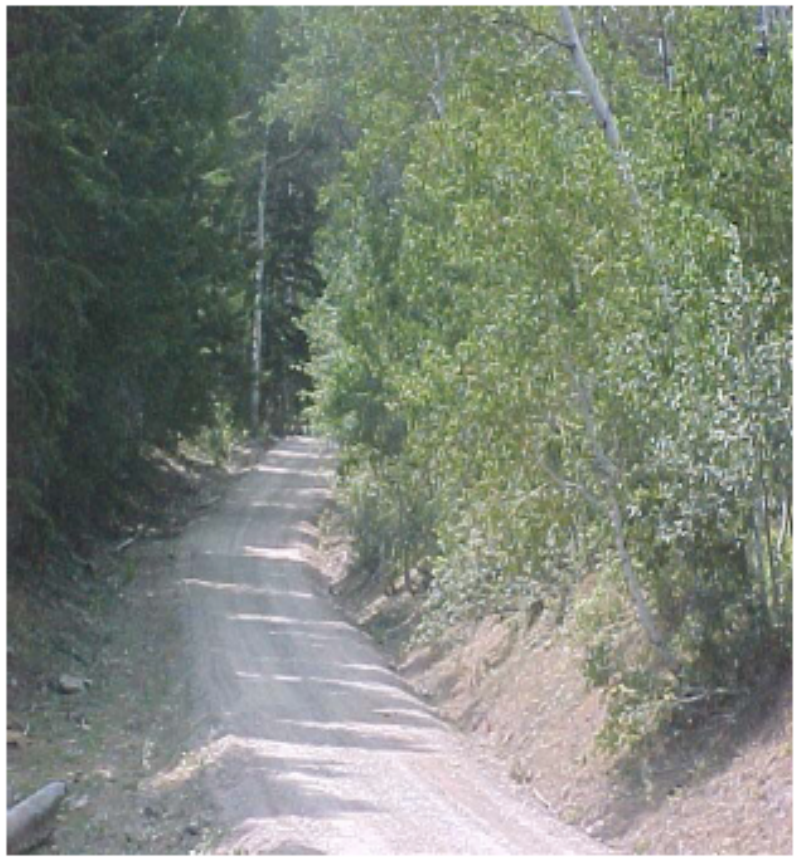
Navigation Aids

Communications

Shelter Replacement

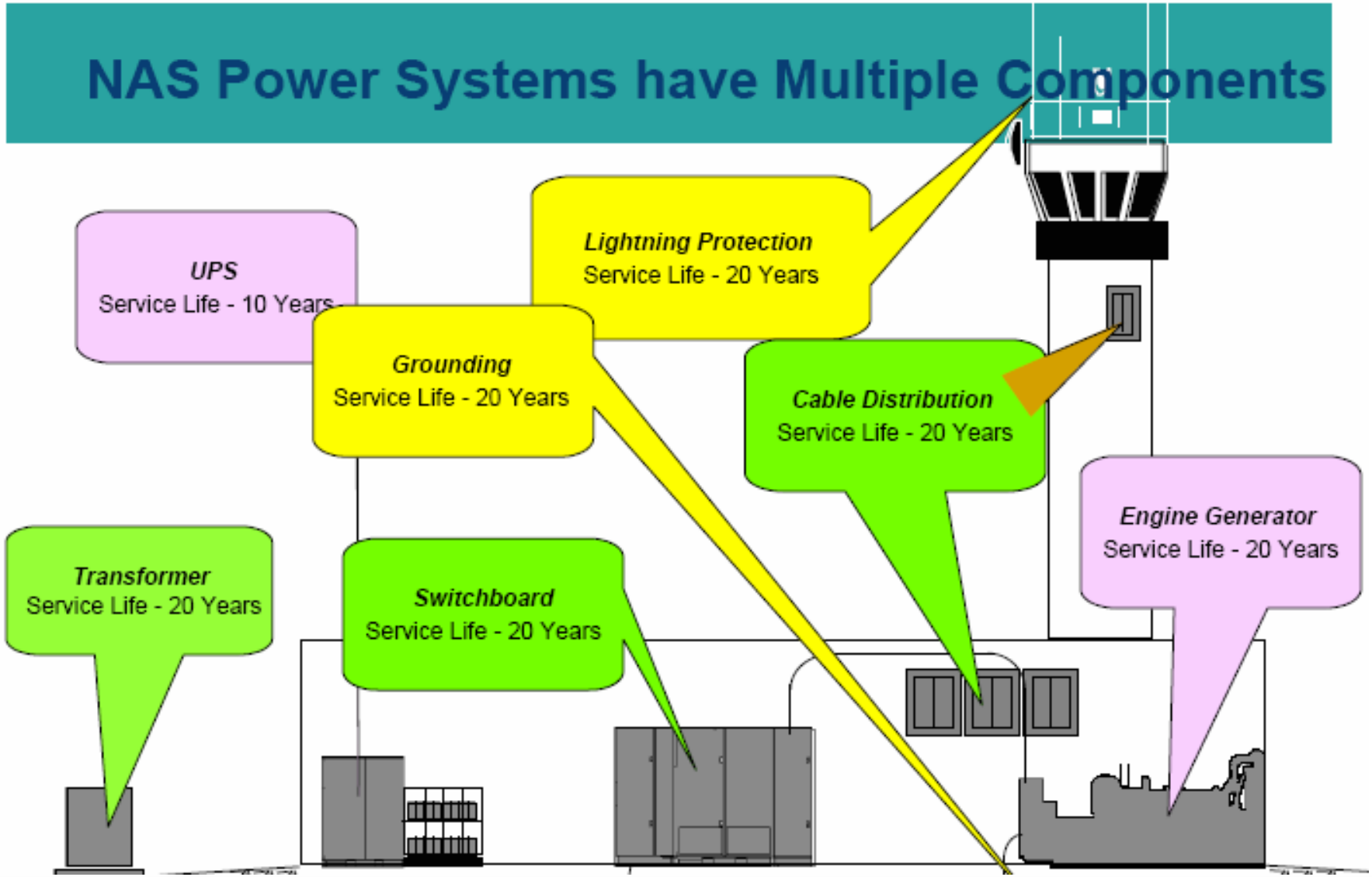
Structural Towers

Access Roads

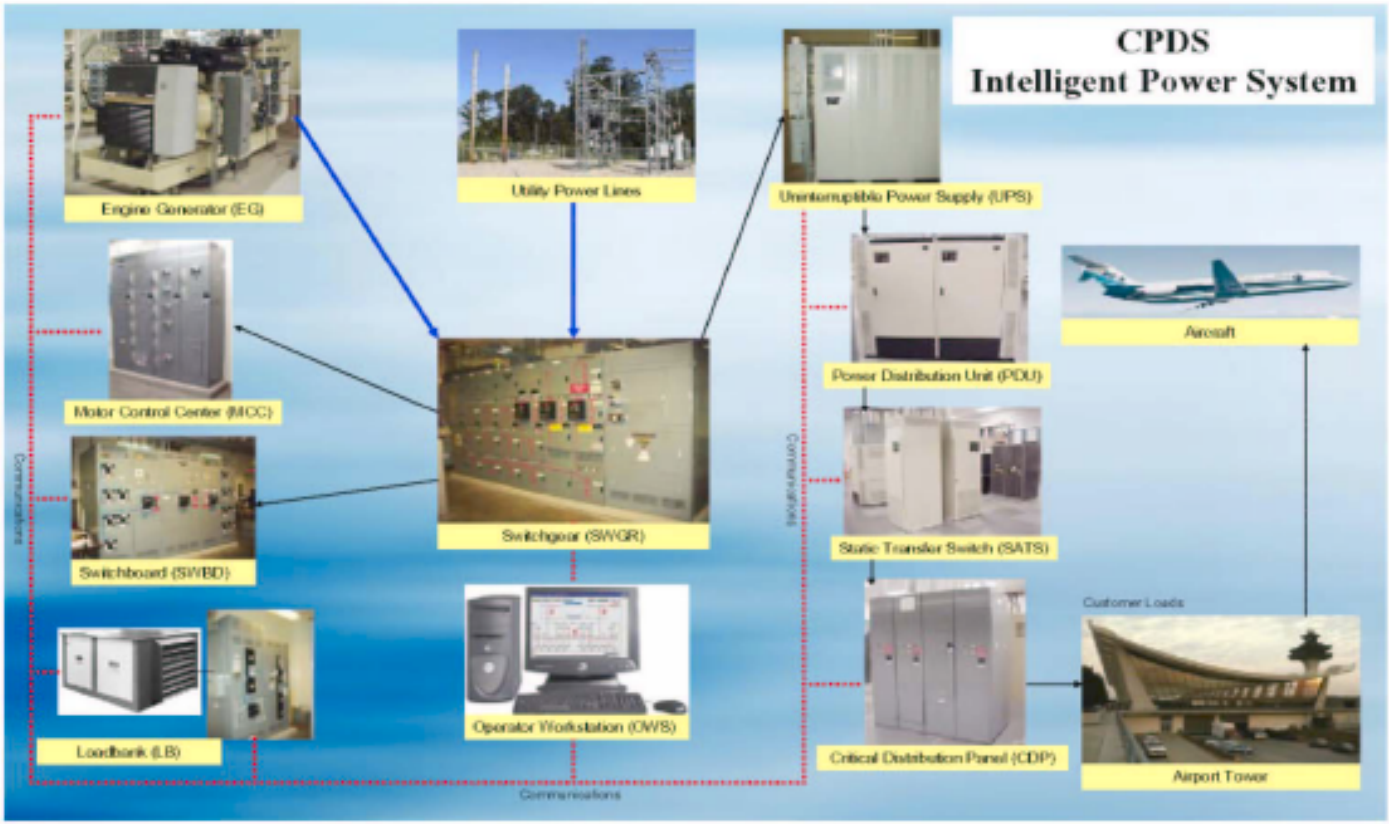


Roofing

NAS Power Systems have Multiple Components



Critical Power Distribution System (CPDS) Have Multiple Complex Subsystems



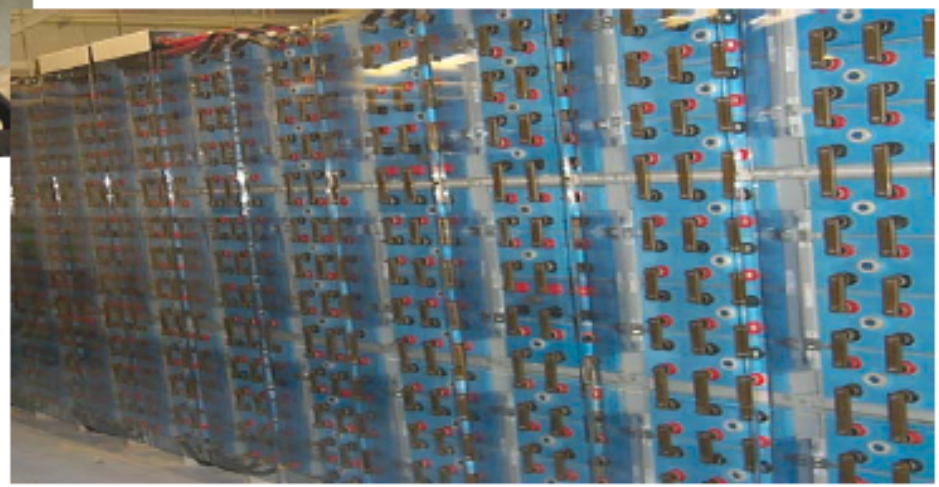
Both GNAS and ARTCC Batteries Must Be Replaced before They Fail

GNAS Battery Bank

"Wet Cells"

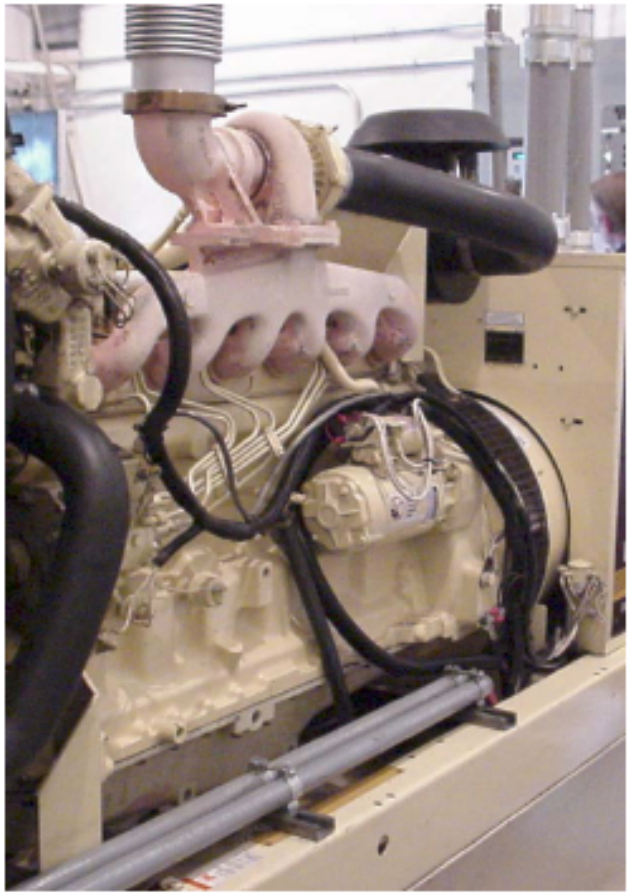
ARTCC UPS Batteries

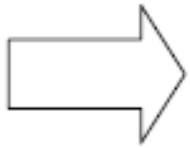
"VRLA Cells"



DC Systems Replace Standby Generators

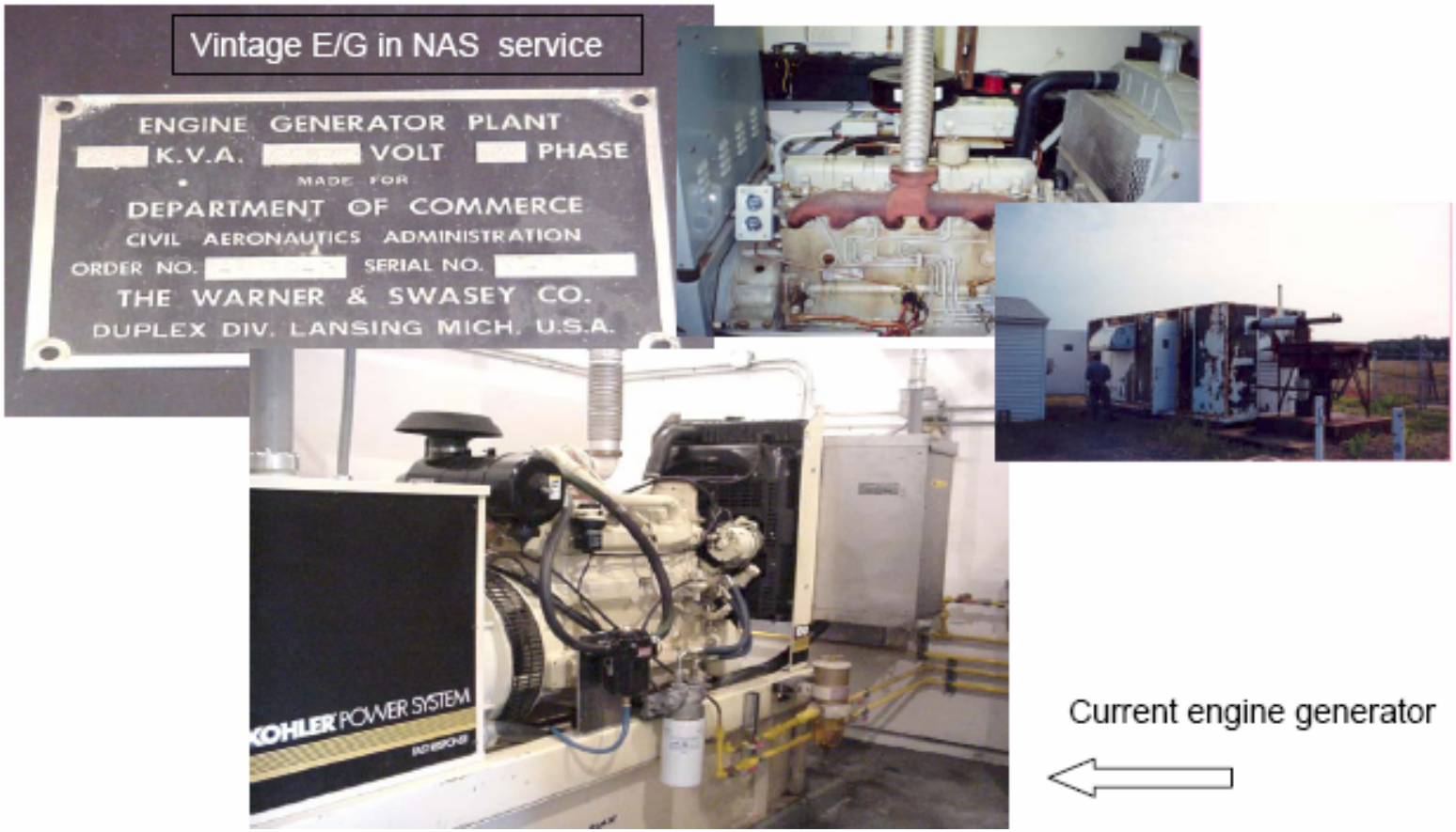
Before





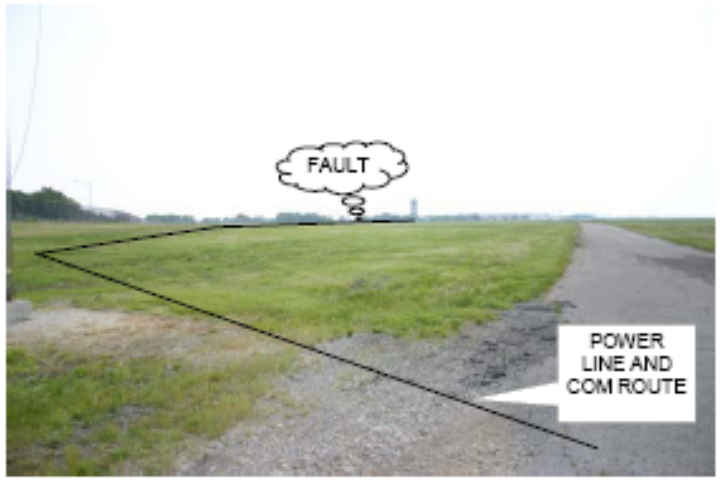
After

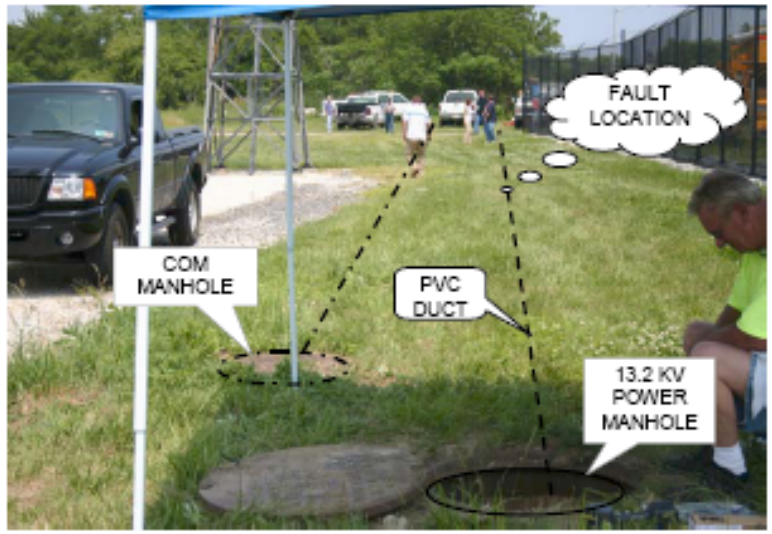
Legacy Engine Generators: Overdue To Be Replaced



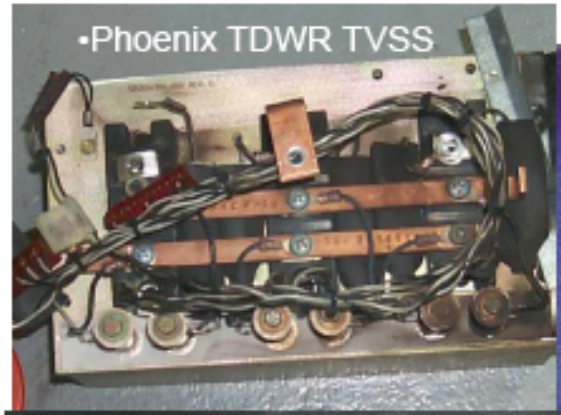
Airport Buried Power Cable: Failure Causes Delays

Philadelphia Airport Power and Data Cable Outage, July 2005

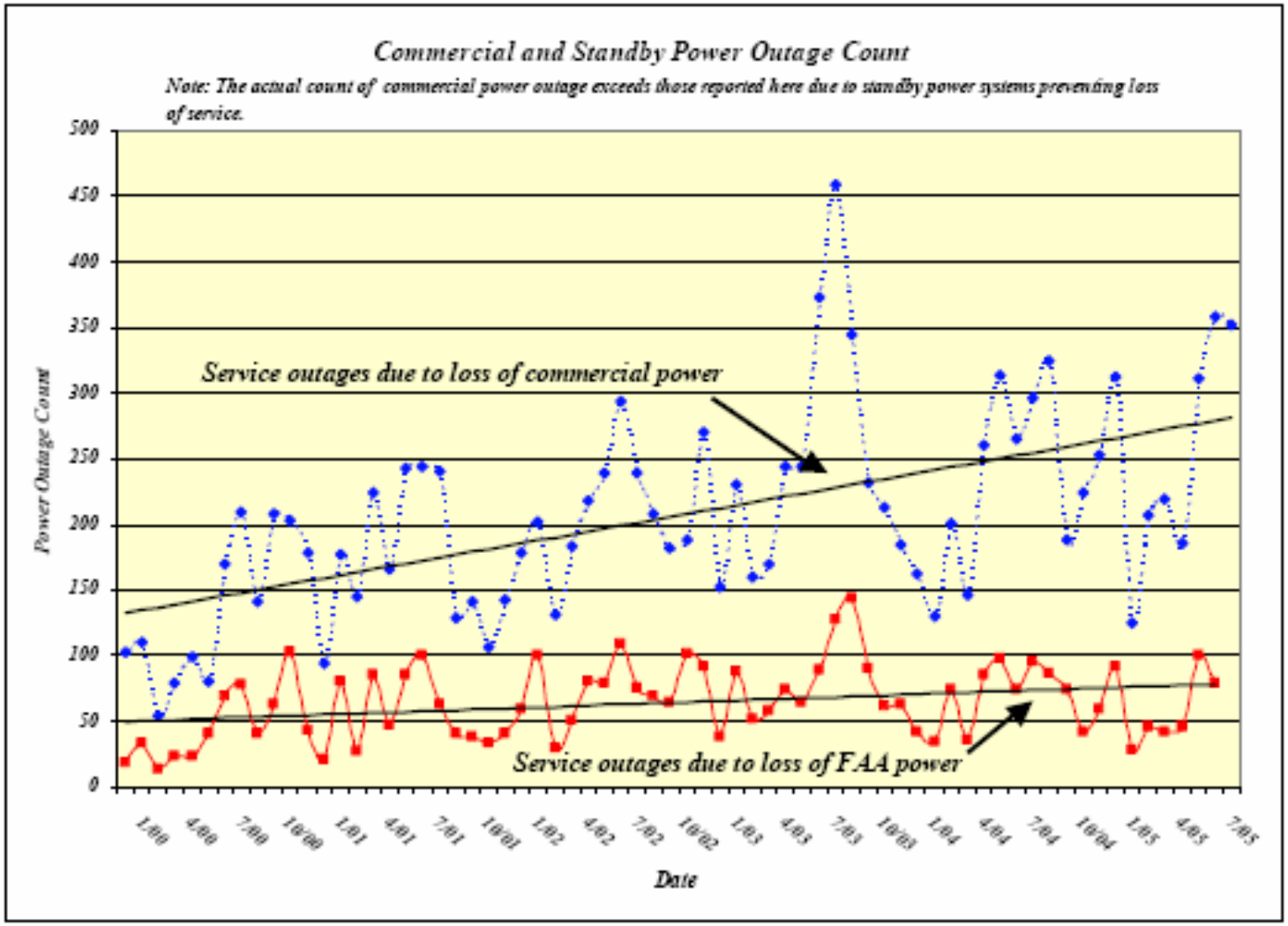




Proper Grounding Is Critical



Commercial and Standby power outages are increasing



Summary

- Infrastructure is critical to running the NAS
- Infrastructure does not get a lot of publicity
- Introduce maintenance optimization models that also consider the airport/airline side of the problem
- Introduce reliability-centered maintenance.