# Surveillance Implications of 9/11

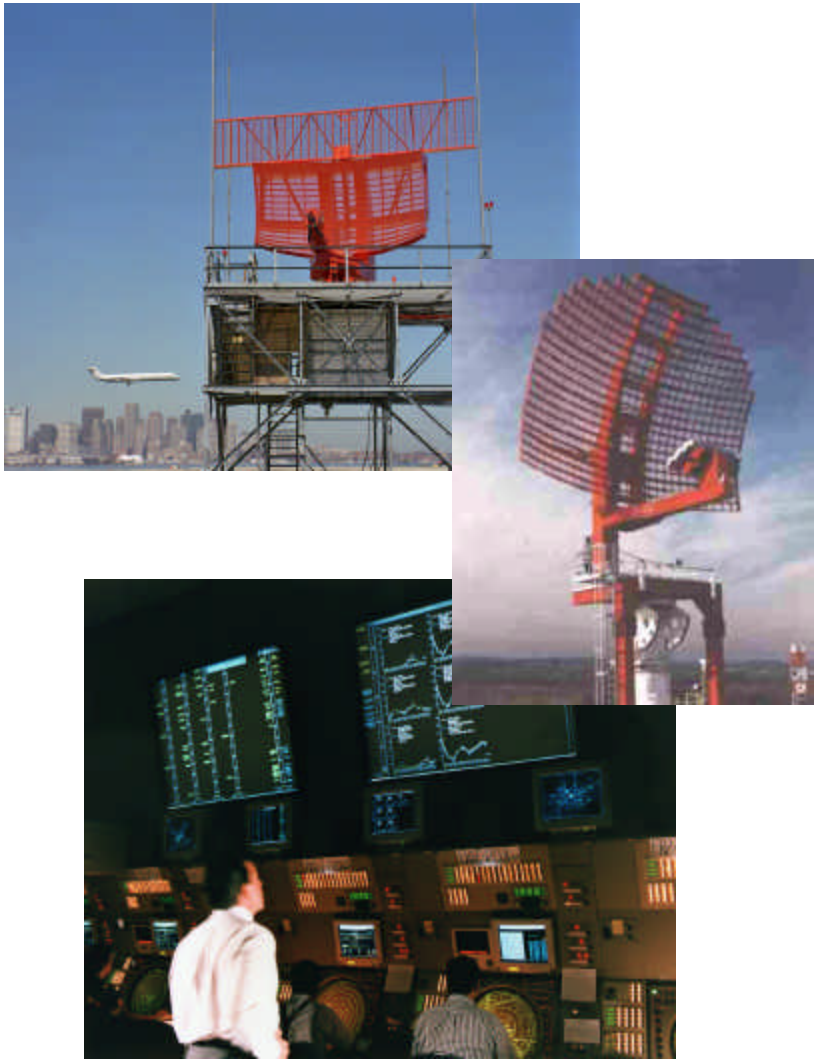
**Dr. Steven R. Bussolari**
**MIT Lincoln Laboratory**
**2 May 2002**

**<bussolari@ll.mit.edu>**

This work is sponsored by the Federal Aviation Administration under Air Force Contract #F19628-00-C-0002. Opinions, interpretations, conclusions, and recommendations are those of the author and are not necessarily endorsed by the U.S. Government.

# Outline

- New operational needs
  - Resulting from 9/11/01
  - DoD operational concerns
  - Implications of operational needs
- Existing surveillance capabilities
- Looking ahead
- Summary



# FAA Air Traffic Operational Needs

## Post September 11, 2001

- **Surveillance**
  - **Continuous primary radar track while cooperative surveillance is lost**
  - **All available surveillance for a given airspace volume made available to controller responsible for airspace**
- **Automatic alerting of controller**
  - **Loss of transponder capability**
  - **Unexplained deviations from planned route of flight**
  - **Unexplained deviation from assigned altitude**

# DoD Operational Concerns
## Civil Aviation Threat Spectrum

Remotely
Piloted Aircraft

Small Jet Aircraft

Commercial Airliner

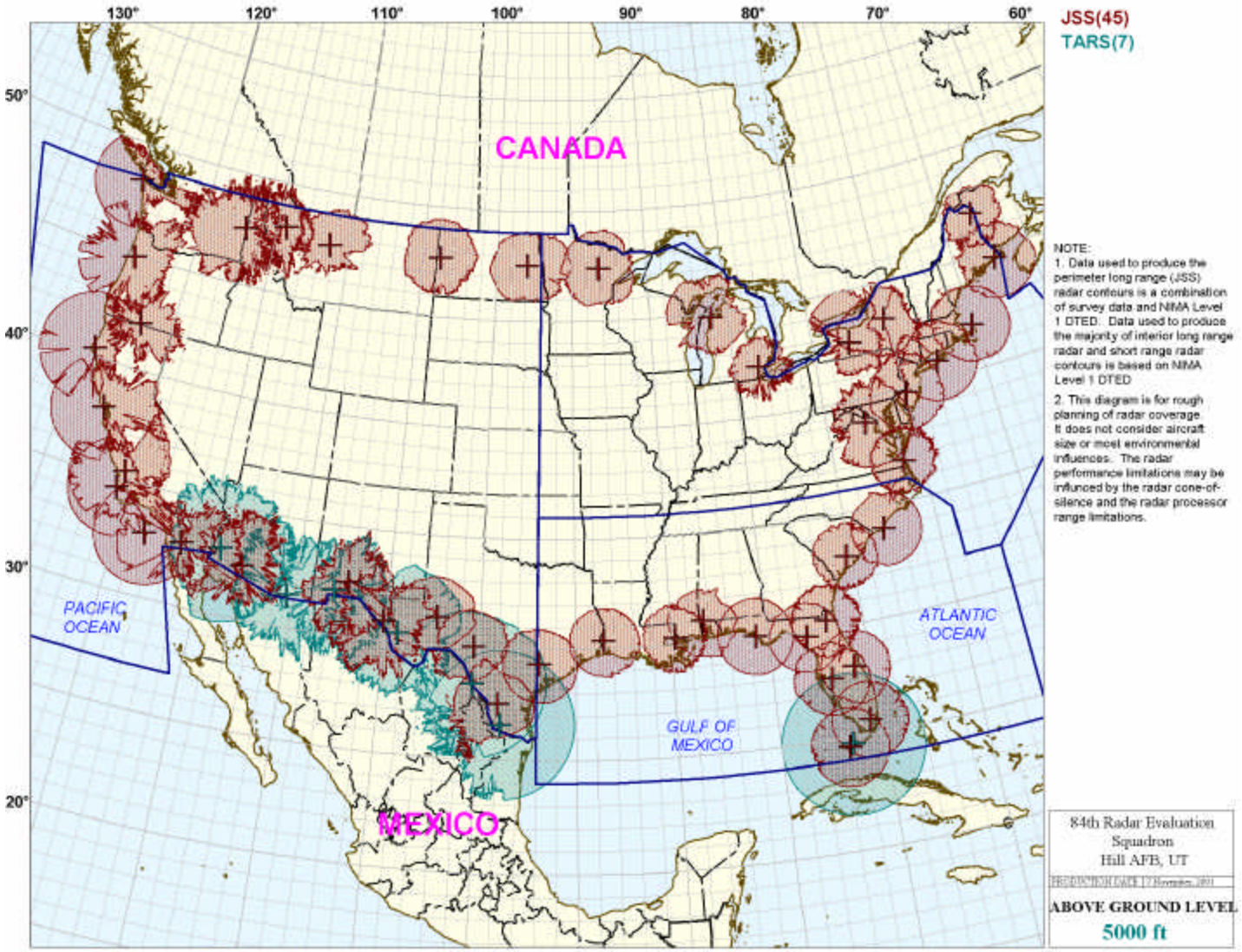
Sailplane

Ultralight

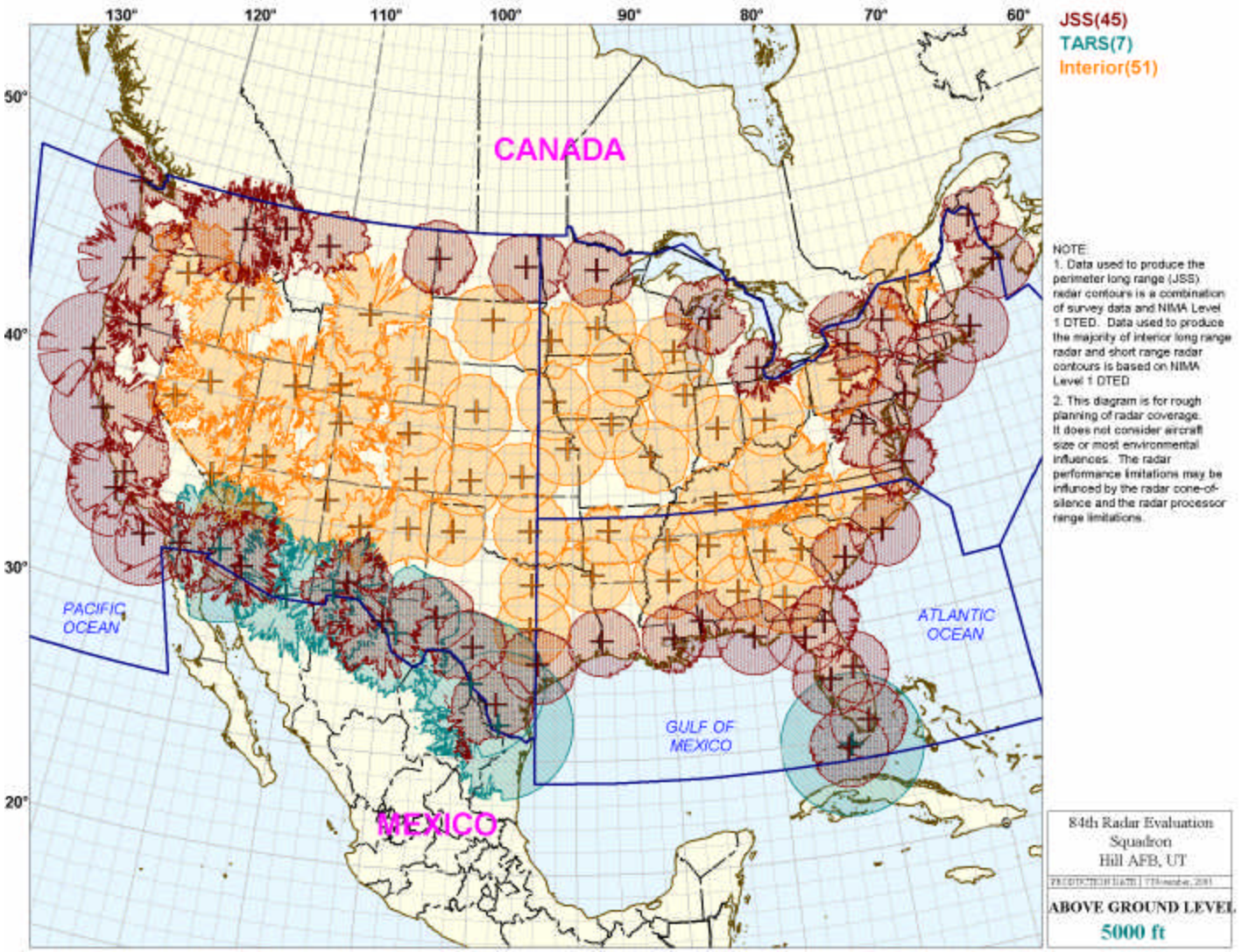
Helicopter

Single Engine Propeller

# NORAD Radar Network (CONUS)
# 9/11/01

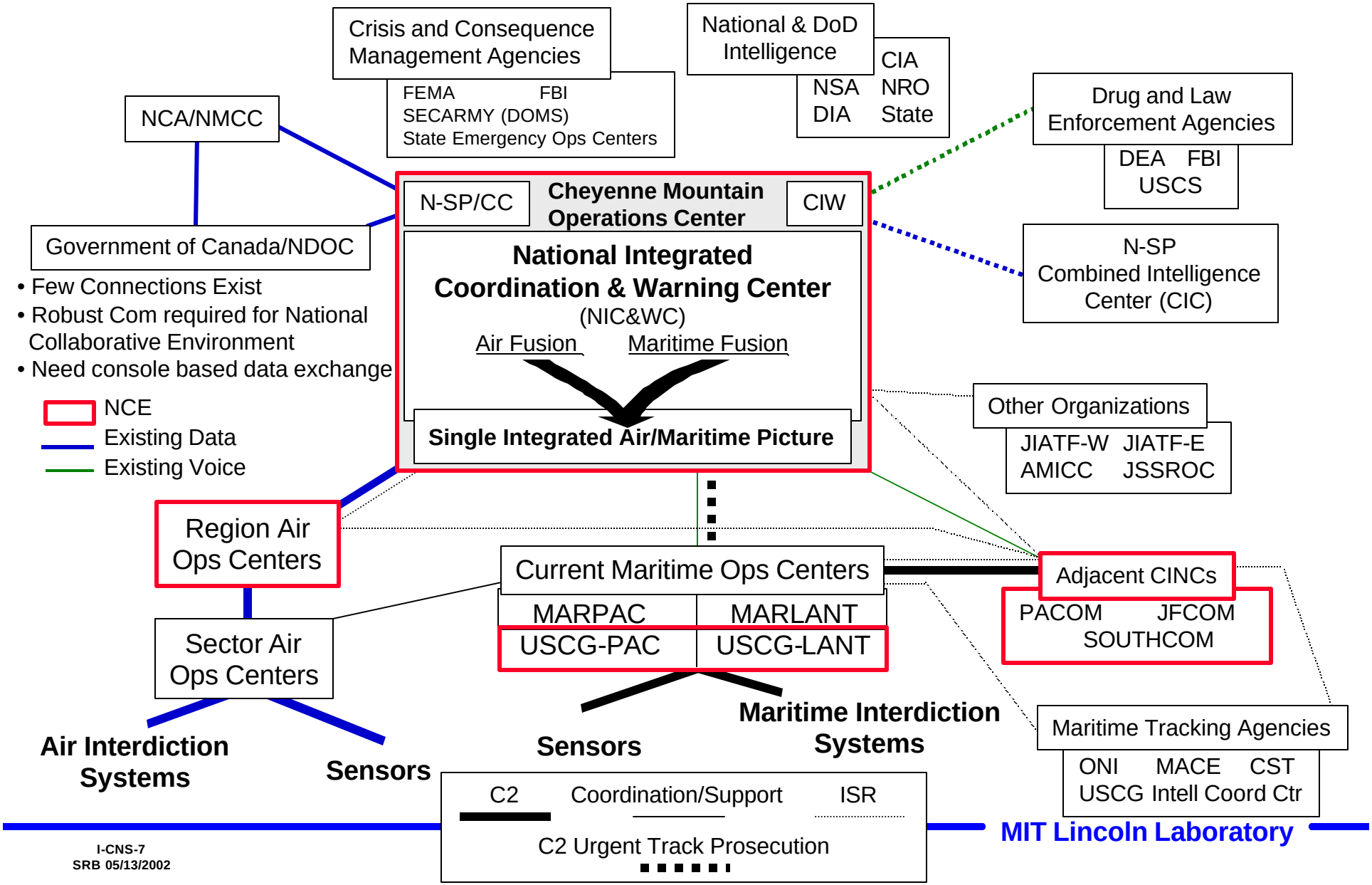


# NORAD Radar Network
## With Additional 51 Interior ATC Radars



# Proposed National Integration Infrastructure

## Source: National Cruise Missile Defense 2000 Study

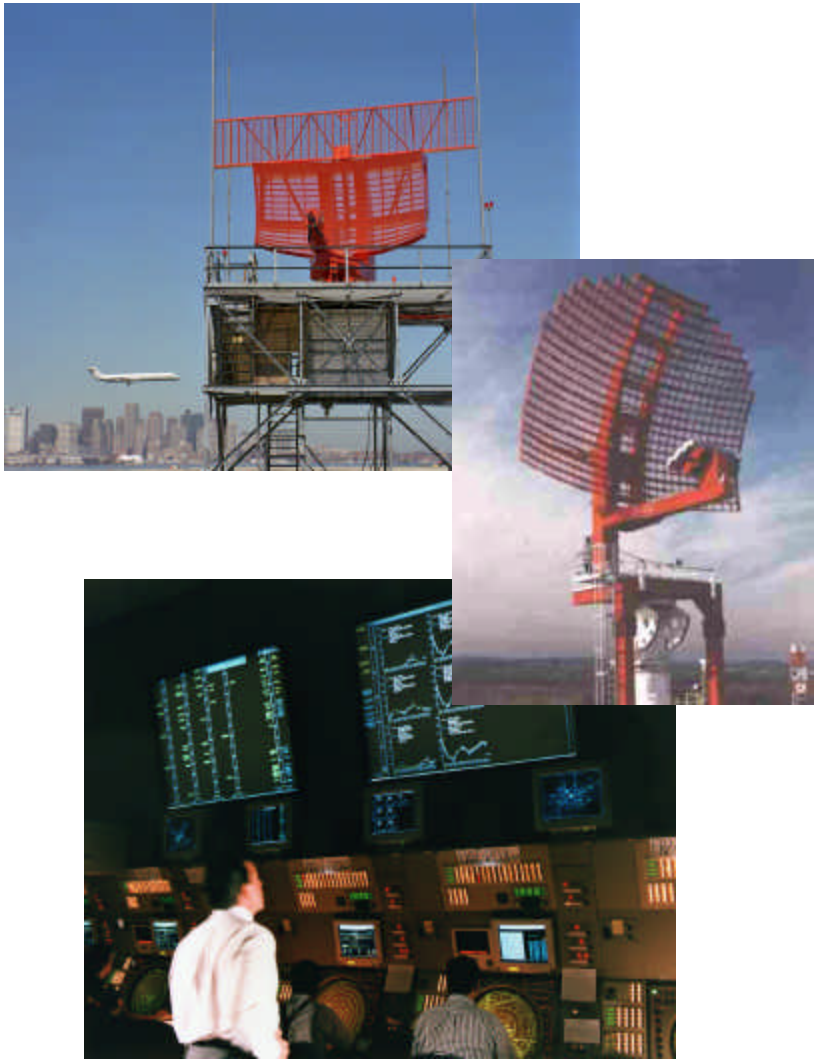


# Implications of FAA Operational Needs
## Immediately Post 9/11

- **Aircraft tracking**
  - **Track continuity in case of loss of cooperative surveillance**
- **Surveillance data distribution**
  - **Must not continue to scale as (# sensors) x (# users)**
- **Surveillance data integration**
  - **Need seamless integration of data from multiple sensors**
- **Conformance monitoring**
  - **Requires significant reduction in false alarms**

# Outline

- New operational needs
- **Existing surveillance capabilities**
  - **FAA**
  - **DoD / Law Enforcement**
- Looking ahead
- Summary



# FAA Surveillance System

- Two types of radar data
  - Primary (skin paint)
  - Secondary (beacon)
- Terminal RAdar Approach Control (TRACON)
  - 155 facilities in US
  - Uses surveillance data from Airport Surveillance Radar (ASR)
- Air Route Traffic Control Center (ARTCC)
  - 21 facilities in US
  - Uses data from Air Route Surveillance Radar (ARSR) and selected ASR (as gap filler)

# FAA Airport Surveillance Radars (ASR)

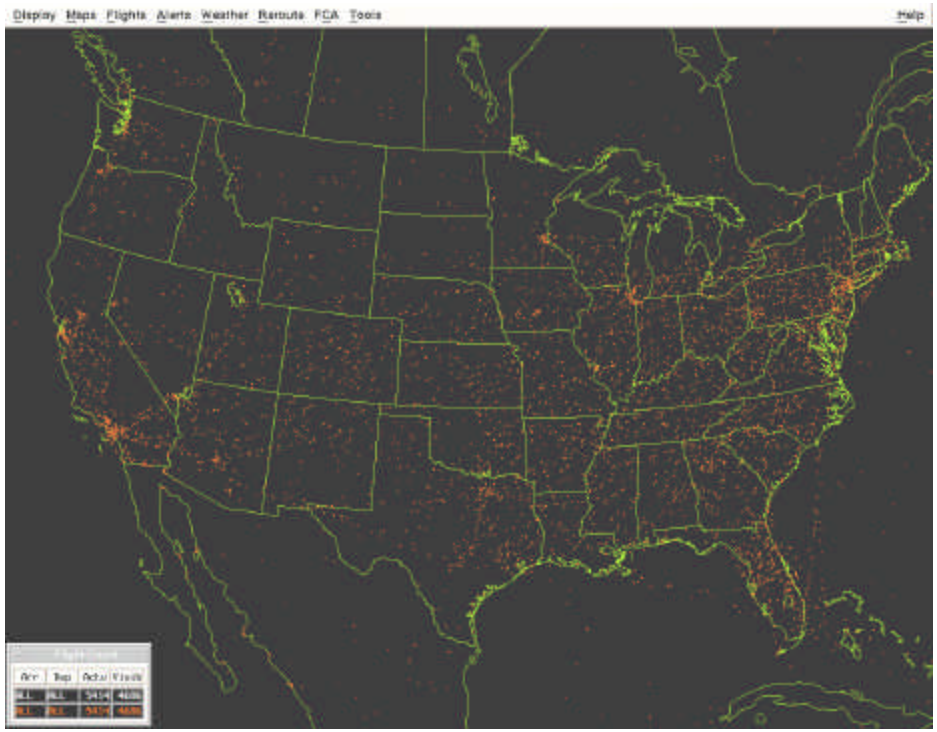
| | Location | Number of Sites | Range | Update Period | Height Finding | Status |
|---|---|---|---|---|---|---|
|  ASR-7 | Airports | 30 | 5-60 nmi | 4.8 sec | No | To be replaced by ASR-11 |
|  ASR-8 | Airports | 65 | 5-60 nmi | 4.8 sec | No | To be replaced by ASR-11 |
|  ASR-9 | Principal Airports | 134 | 0.25-60 nmi | 4.8 sec | No | Service Life Extension Program Underway |
|  ASR-11 | Airports | 104 | 0.25-60 nmi | 4.8 sec | No | FAA / USAF new acquisition |

# FAA Air Route Surveillance Radars (ARSR)

| | Location | Number of Sites | Range | Update Period | Height Finding | Status |
|---|---|---|---|---|---|---|
|  ARSR-1/2 | Internal CONUS | 45 | 200 nmi | 10 sec | No | Near end of service life |
|  ARSR-3 | Internal CONUS | 13 | 5-200 nmi | 12 sec | No | Near end of service life |
|  ARSR-4 | Perimeter CONUS | 42 | 5-200 nmi | 12 sec | Yes | FAA / DoD Dual use radar |

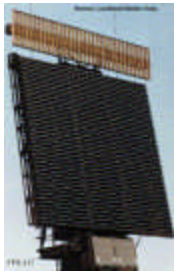
# Enhanced Traffic Management System (ETMS)

- Designed as a strategic traffic flow management tool
- Receives flight plan and aircraft position data from FAA TRACON and ARTCC facilities
  - Update period ~ 1 min
- Operated by DoT VNTSC
  - Data assembled in Cambridge, MA
  - Data disseminated to FAA, airlines, and other users



# Military Ground-Based Surveillance Radars

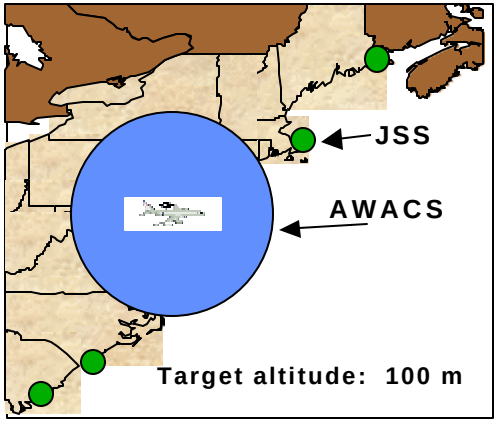
## Selected Examples

| | LOCATION | NUMBER OF SITES | RANGE | UPDATE PERIOD | ALTITUDE CAPABILITY | MISCELLANEOUS |
|---|---|---|---|---|---|---|
|  AN/FPS-117 | North Warning System, Alaska, Foreign Countries | ~100 | 250 nmi | 10-12 secs (360°) | Yes, ~1100 ft @ 100 nmi | IFF included, fixed site or transportable |
|  AN/TPS-59 | U.S., Egypt | ~15 | 300 nmi | 5, 10 secs (360°) | Yes, ~1000 ft @ 100 nmi | IFF included, transportable |
|  AN/MPQ-64 Sentinel | Mobile system (U.S. Army) | >100 (as of 1998) | 20 nmi | 2 secs (360°) | Yes, ~200 ft @ 10 nmi | IFF included, mobile, gap filler |

# AWACS E-3 Sentry

- The E-3 Airborne Warning and Control System (AWACS) provides Airborne Early Warning (AEW) and C2 in support of air defense
  - 34 E-3s in U.S. inventory, additional AWACS are deployed with NATO and with foreign nations
  - Air surveillance of small civil aircraft to radar horizon
    - 360° coverage
    - 10 sec update period
    - IFF capability included
  - Maritime surveillance capability also available

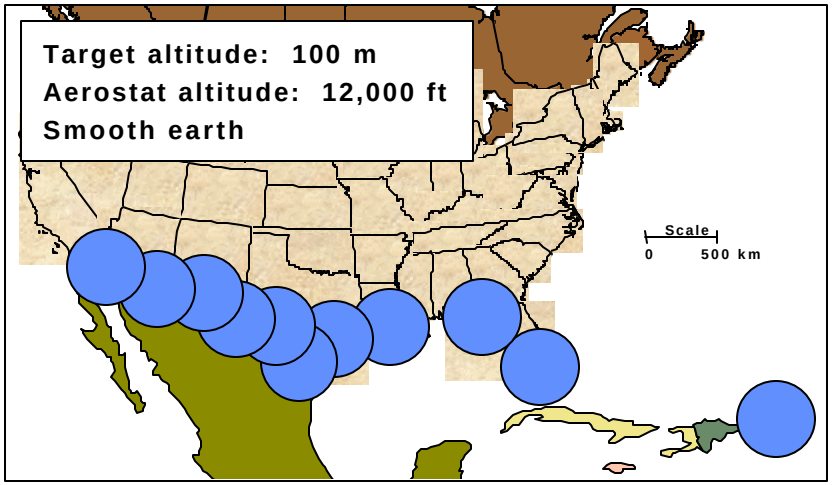
AWACS E-3




Radar Line-of-Sight Coverage

# Tethered Aerostat Radar System (TARS)

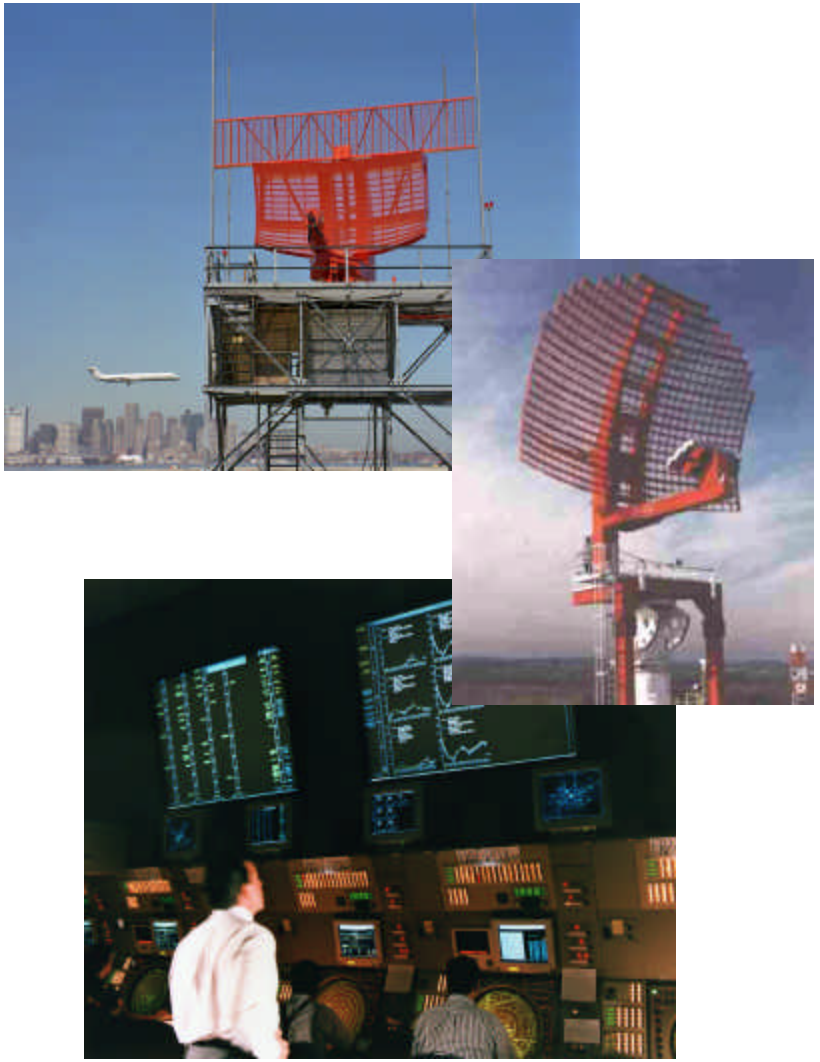
- TARS provides air surveillance coverage along the southern border of the U.S. and Puerto Rico
  - Primary mission: detection of drug smuggling aircraft
  - Established by U.S Customs Service, currently operated by DoD
  - 10 CONUS sites from Arizona to Florida
  - Operating altitude: 10-15 kft
  - Radar horizon: 250-300 km




Radar Line-of-Sight Coverage

# Outline

- New operational needs
- Existing surveillance capabilities
- **Looking ahead**
  - **Surveillance Data Network**
  - **Sensor enhancements**
- Summary

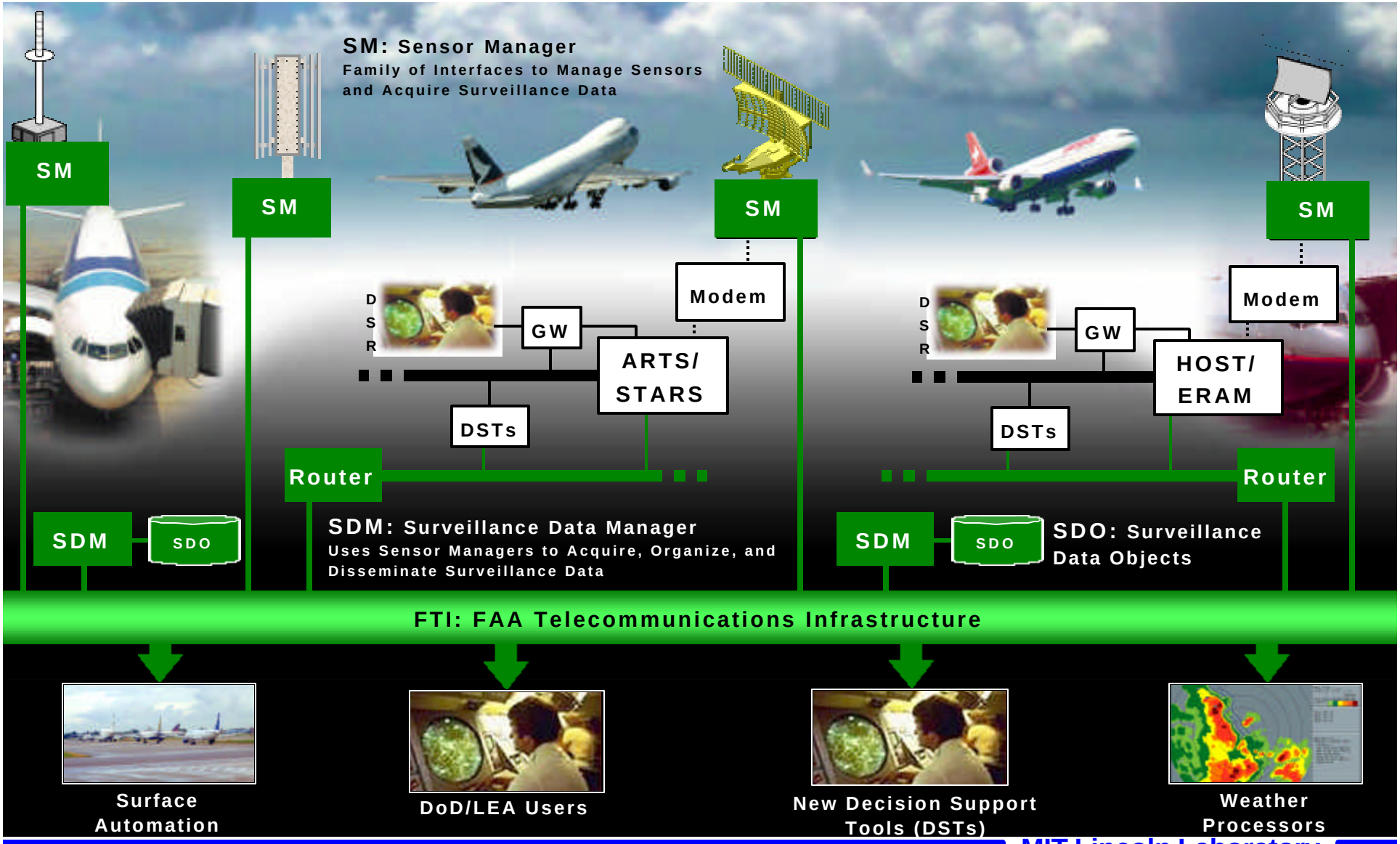


# Motivation for Surveillance Data Network

- **Existing NAS surveillance data distribution**
  - **Costly to build and maintain**
  - **Not robust in the presence of sensor failures**

- **Existing surveillance data formats (e.g., CD-2)**
  - **Do not support the gains in surveillance accuracy achieved over past 40 years**
  - **As a consequence, the NAS cannot exploit the existing and future capability of its surveillance sensors**

# Proposed Surveillance Data Network (SDN)

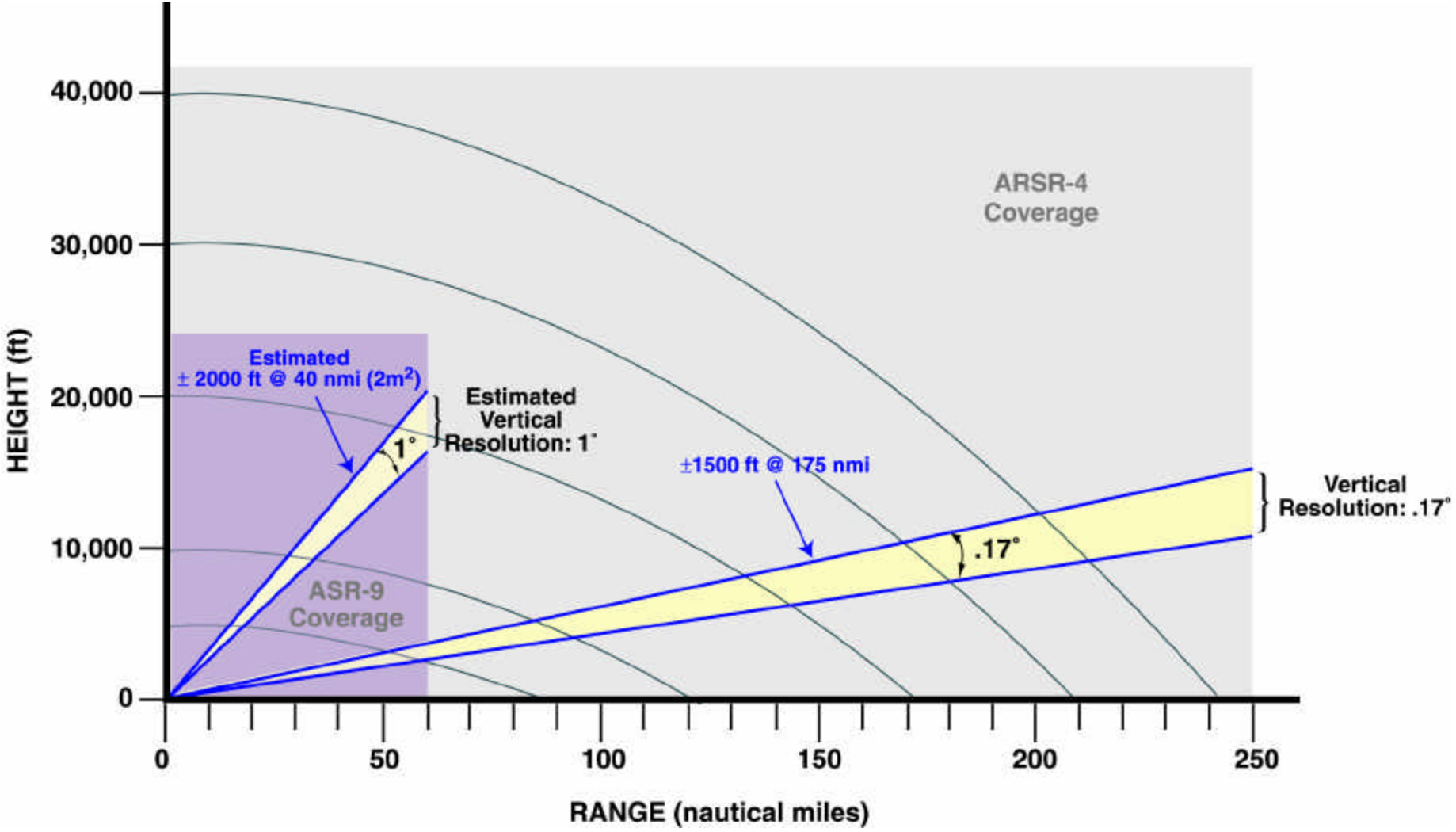


# Sensor Enhancement Example

## Height Finding Capability of Existing ATC Primary Radars

| | LOCATION | RANGE | ELEVATION ANTENNA | ACCURACY (ELEVATION) | STATUS |
|---|---|---|---|---|---|
|  ARSR-4 | Perimeter CONUS | 5-200 nmi | Multiple Stacked Beam | ±1500 ft @ 175 nmi ($2m^2$) | Operational |
|  ARSR-3 | Internal CONUS | 5-200 nmi | High/Low Beams | TBD | TBD |
|  ASR-9 | Principal Airports | 0.25-60 nmi | High/Low Beams | ±2000 ft @ 40 nmi ($2m^2$) (estimated) | Concept Demonstrated |
|  ASR-11 | Airports | 0.25-60 nmi | High/Low Beams | TBD | TBD |

# Potential Height Finding Accuracy with Existing ATC Radars



# Near Term Actions

- **Provide DoD with FAA radar data to cover interior CONUS**
  - **Already underway with numerous FAA sensors**
- **Develop integrated national air picture**
  - **Integrate surveillance data from multiple sensors in CONUS with flight data from FAA to form a seamless and common air picture**
- **Develop anomalous event reporting system**
  - **Provide automated or semi-automated means for ATC to send anomaly information to DoD and Law Enforcement**
- **Improve quality of integrated national air picture**
  - **Increase sensor and automated tracking performance**

# Summary

- Many sensors, no common integrated air picture
  - FAA, DoD, Law Enforcement operate separate sensor networks
  - Wide spectrum of sensor capabilities
  - Very little integration of sensor data
- Recommended first step is to create common air picture with existing sensors
  - Connectivity, integration, and data dissemination
  - Architecture should permit addition of sensors as well as increase in sensor capability as required