National Missile Defense and Early Warning Radars: Background and Issues

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- My Background
  - Education
    - Undergraduate engineering at SMU
    - Graduate engineering at Stanford
  - Air Force
    - B-52 pilot in Viet Nam
    - Reserves: Systems Engineer at WPAFB
  - System Engineer for Texas Instruments/Raytheon
    - Radar for German Tornado Aircraft
    - GPS guided weapons for Navy/AF
  - 2nd (or 3rd) career as Management Professor
    - IEEE Congressional Fellow in 2000
    - Fulbright Fellow to Germany in 2006

- IEEE Congressional Fellow
  - 2 or 3 selected each year by IEEE USA
  - Part of AAAS program (~ 50 Fellows/year)
  - Provide technical expertise for Congress
  - AESS has had several recent fellows
  - I was selected in 2000
    - NMD research at Congressional Research Service
  - Russ Lefevre in 2001
    - Staff support for Sen Rockefeller

- Fulbright Fellowship to Germany
  - US leading program in international educational exchange – started in 1946
  - mutual understanding between US and other countries
  - each year more than 500 faculty to more than 100 countries – over 300 different universities
  - Germany is the largest – over 50 folks each year
  - I taught at Landshut University of Applied Sciences near Munich

Future Engineering Education

Keys to Success

Global Mega-Trends

- Globalization
- Energy
- Terrorism
- Environmental
- Disruptive Change
- Demographics
- Regulation
- Government Research
- Science & Technology
- The Workplace

What does this mean for future university students?

Guiding Principles for the Future

- Rapid Pace of Technological Innovation
- Globally Interconnected
- Increasing Diverse and Multi-Disciplinary
- Social, Cultural, Political and Economic Forces will continue to shape the success of technological innovation
- Presence of technology must be seamless and transparent

The Timeless Attributes of Engineers

- Strong analytical skills
- Practical ingenuity and creativity
- Strong communication
- Business and management skills
- Leadership
- Highest ethical standards
- Professionalism

More than ever, people's lives
will depend on the acts of engineers

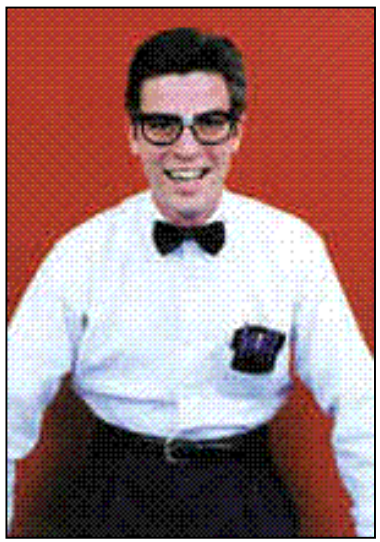
Preparation of Engineers for the Future

- **Adapt to flexible working conditions**
  - Work in multilingual, multicultural, multigenerational teams
  - Collaborate when not collocated and across time zones
  - Live with postponed retirement
- **Must be innovative and entrepreneurial**
  - Able to deal with dilemmas, risks and uncertainties
- **Broad knowledge of global issues & societal implications**
- **Able to combine diverse domains & disciplines**
  - Can adapt to rapid technology changes
  - Must be life-long learners

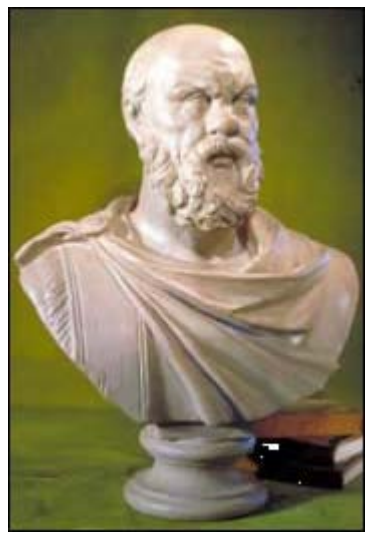
Engineers must be even more flexible, agile and resilient.

The Evolution of Engineering

- Engineer of 1960 (hero)
- Engineer of 1980 (nerd)
- Engineer of today (technologist)
- Engineer of 2020 (global citizen)



"Technology is cool"

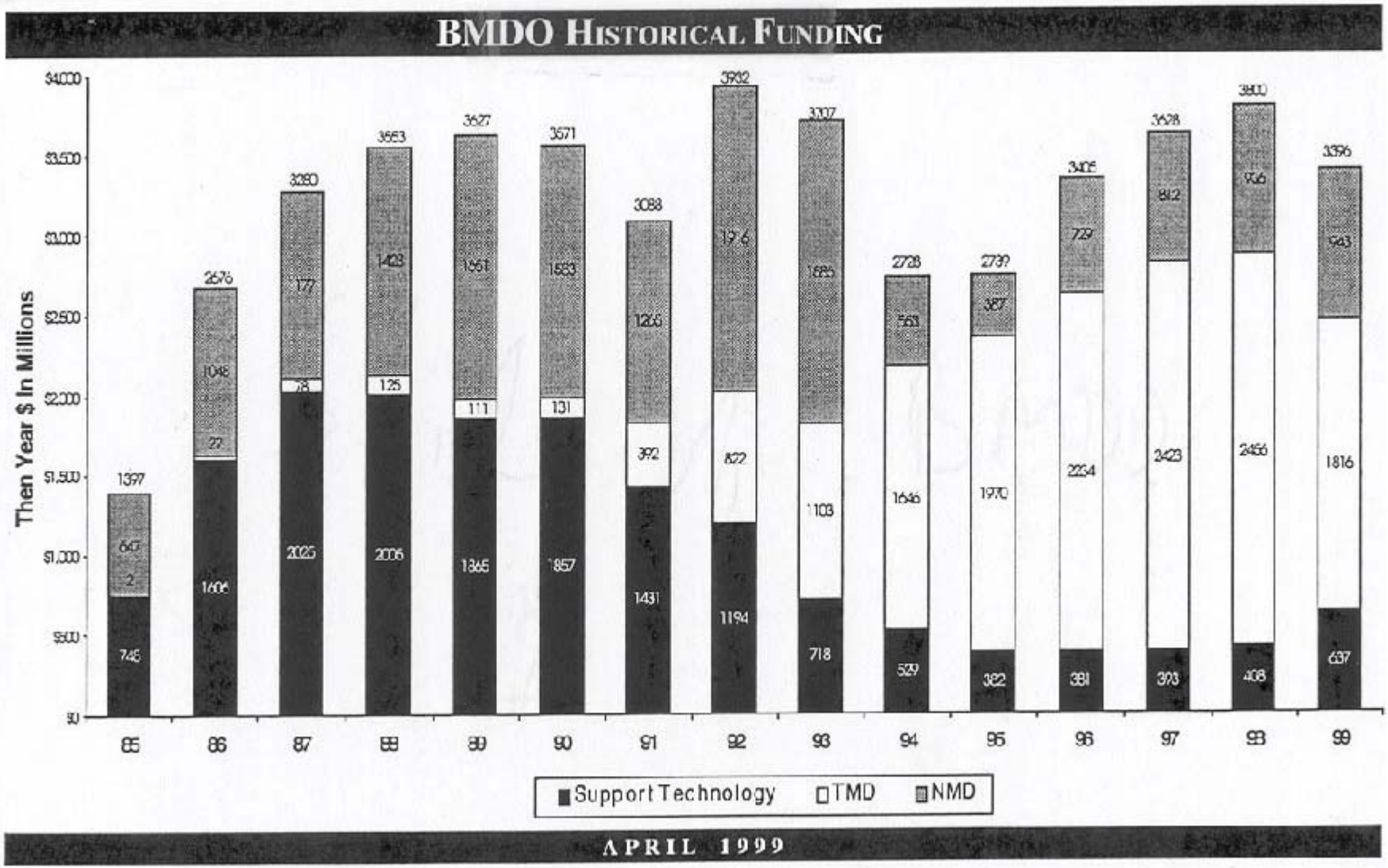


"I am a citizen of the world"
--Socrates

- Missile Defense History – 2 eras
  - Nuclear-tipped interceptors
    - Started in the 1950's
    - Ended with the closing of America's first missile defense system, Safeguard, in 1976
  - Non-nuclear missile defenses
    - Started with Reagan's SDI in the 1980's
    - Continued with TMD and NMD in 1990's
    - Combined as MDA in 2000's

- Missile Defense Agency Organization (MDA)
  - Director: LG Henry Obering (USAF)
  - Deputy: MG Peter Franklin (US Army)
- Former organization
  - National Missile Defense (NMD)
  - Theater Missile Defense (TMD)
  - Support Technologies
- New organization
  - Boost phase - Sensors
  - Midcourse phase - Command and Control
  - Terminal phase - Testing

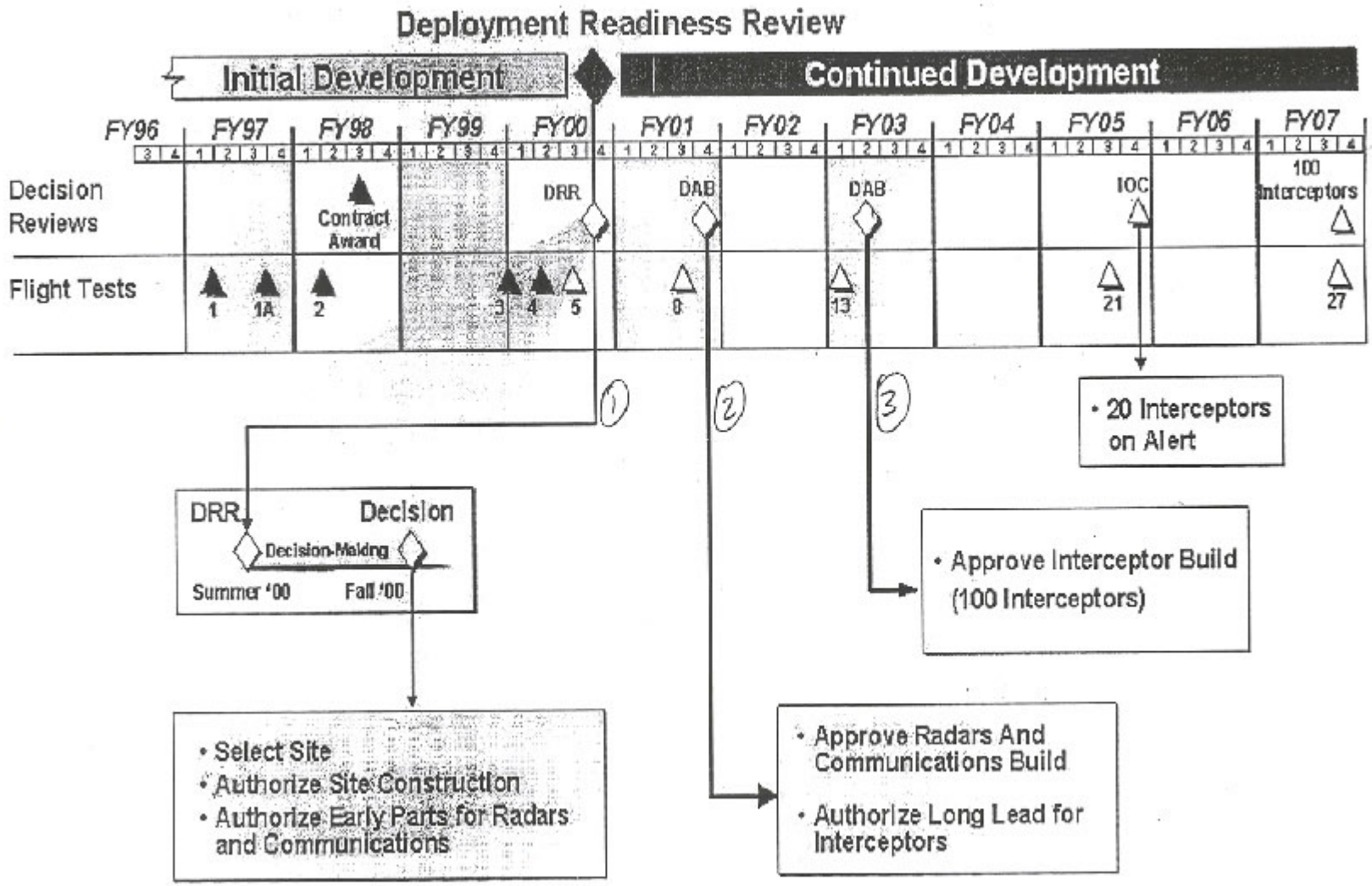
National Missile Defense and Early Warning Radars



- Clinton's Revised Limited NMD Program
  - Pressured by Congress (1996) to increase program
  - New threats – North Korean 3 stage rocket
- Clinton's plan
  - Upgrade existing early warning radars (EWR)
  - Develop ground based X-band radars (GBR)
  - Develop "hit-to-kill" interceptor (GBI)
- Series of flight tests to prove technical feasibility
  - Failure of key test on July 8, 2000
  - Clinton postponed production decision to Bush

- Bush's expanded NMD program
  - Bush expanded the scope of NMD and increased the funding
  - Added sea-based component (Aegis ship)
  - Investigating space based components
  - Added new testing capabilities
  - Summary – not define specific architecture or milestones but rather pursue a broad, flexible RDT&E program (spiral development)

National Missile Defense and Early Warning Radars



National Missile Defense and Early Warning Radars

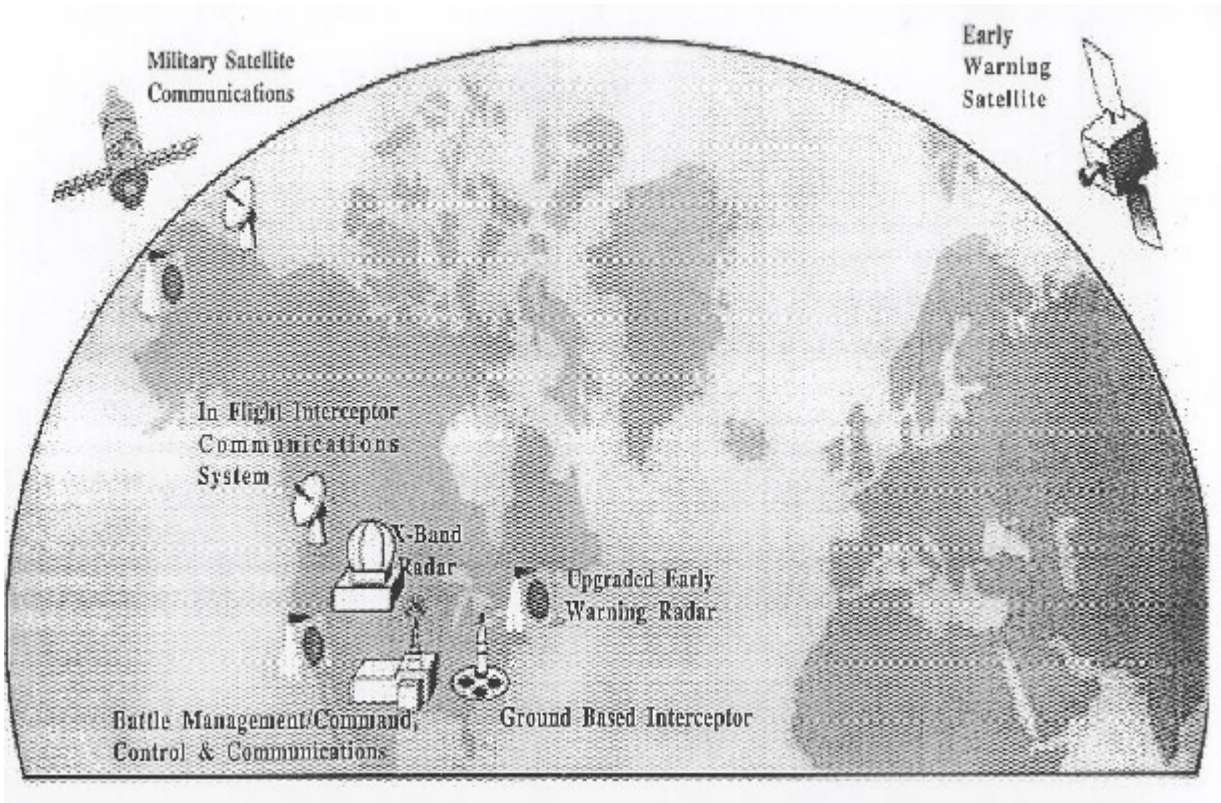
FY2001 vs. Amended FY2002 Request

(millions of dollars or percent)

Proposed Program Elements	FY2001 Estimated Funding	FY2002 Amended Budget Funding	FY2001 Share of total	FY2002 Share of total	FY2002 amended vs. FY2001 % change
Terminal	1,305.1	2,221.0	25%	27%	70%
Midcourse	2,411.3	3,940.5	47%	48%	63%
Boost	304.0	685.4	6%	8%	125%
Sensors	368.5	495.6	7%	6%	34%
BMD Technology	745.3	912.5	15%	11%	22%
Headquarters	4.7	34.3	0%	0%	626%
TOTAL	**5,139.0**	**8,289.3**	**100%**	**100%**	**61%**

National Missile Defense and Early Warning Radars

Surveillance & targeting is a combination of systems

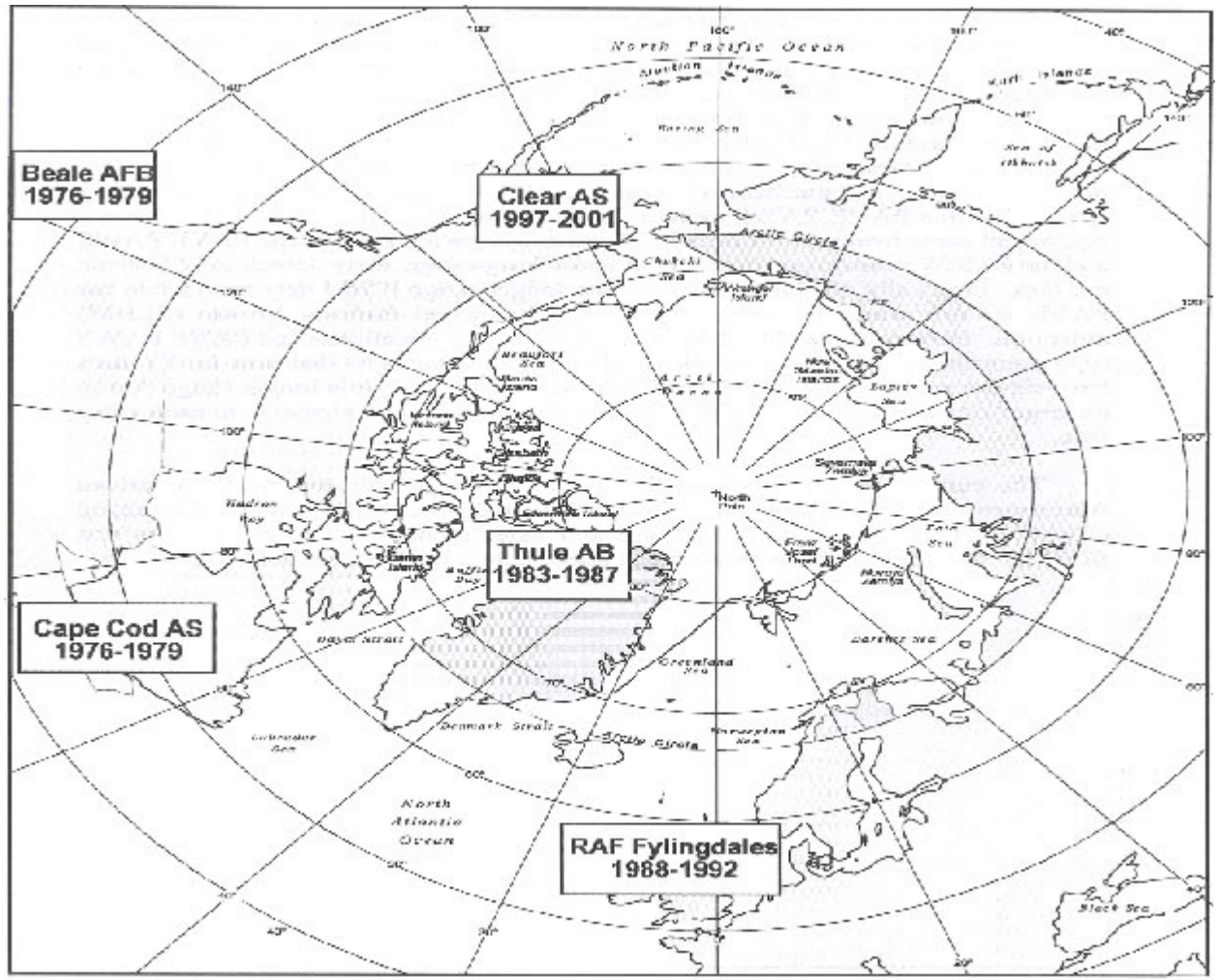


- Satellites notify of launch
- EWR's identifies as a threat and the potential target
- X Band radar finalizes target location/intercept
- Missile seeker allows the "hit-to-kill"

Current Surveillance Assets

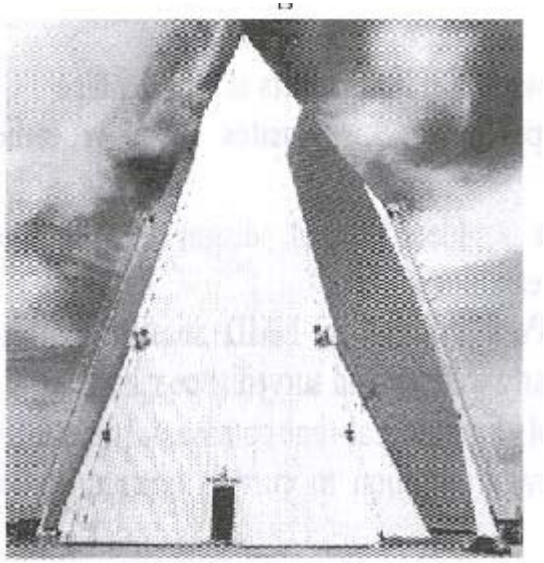
- Space Wing responsible for ballistic missile warning
- 3 Pave Paws
  - Beale AFB, CA
  - Cape Cod AFS, MA
  - Clear AFS, AK
- 2 BMEWS
  - Thule, Greenland - updated in 1987
  - Fylingdale, UK (Joint UK) - updated in1992
- 1 Cobra Dane
  - Shemya, AK

National Missile Defense and Early Warning Radars



Adapted by CRS from Magellan Geographix.

National Missile Defense and Early Warning Radars



3 currently at:

Beale AFB, CA

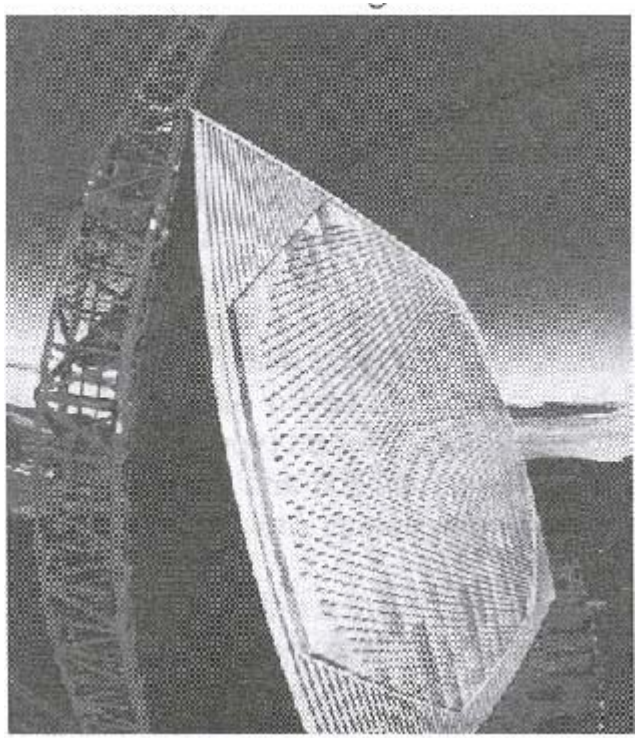
Cape Cod AS, MA

Clear AS, AK

PAVE PAWS (AN/FPS-115)

- UHF (420-450 MHz)
- Number of T/Rs/Face:1,792
- Elements/Face:2,677
- Number of Manifolds: 4
- Total T/R Modules manufactured >14,336
- Diameter: (72 feet/102 feet)
- Raytheon is prime contractor

National Missile Defense and Early Warning Radars



Located at:

Thule AFB (2 faces) and
Fylingdales AFS (3 faces)

BMEWS UPGRADE (AN/FPS-123(V)5)

- UHF
- Number T/Rs/Face: 2,560
- Elements/Face: 3,584
- Number manufactured: 2
- Total T/Rs manufactured: 12,800
- Diameter: 84 feet
- Raytheon is prime contractor

National Missile Defense and Early Warning Radars

The UEWRs performance will be improved in the following areas:

- Acquisition- Ability to acquire RV- sized objects at long range based upon satellite cues
- Tracking- Precision track estimates to allow interceptor commit and update with improved accuracy and extremely high probability of intercept
- Object Classification- Identify threatening (RV-like) versus non-threatening objects
- Command and Control - Provide real-time, low latency command and control interface in addition to current interfaces

National Missile Defense and Early Warning Radars

Characteristics and Measurement Capabilities of Current and Planned Radars

Parameter	**Current PAVE PAWS** (in CA and MA)	**Current BMEWS** (in AK, Greenland and UK)	**Upgraded Early-waring Radars**
Frequency (f)	420-450 MHz	420-450 MHz	unchanged
Wavelength (λ)	0.67-0.71 m	0.67-0.71 m	unchanged
Antenna Diameter (D)	22.1 m	25.6 m	unchanged
Average Power (per face)	150 W	255 W	unchanged
Detection Range (R_D)**	5,000 km in search mode (for object with σ =10 m^2	5,000+ km in search mode (for object with σ =10 m^2	5,000+ km in search mode (for object with σ =10 m^2
Bandwidth (β)	100 kHz (search mode); 1 MHz (track mode)	300-600 kHz (search mode); 5-10 MHz (track mode)	$\leq$ 30 MHz
Range Resolution (ΔR)	1,500 m (search mode); 150m (track mode)	250-500 m (search mode); 15-30 m (track mode)	$\geq$ 5 m
Angular Beamwidth (θ_{BW})	0.038 radians = 2.2 °	$\cong$ 2.0 °	unchanged
Cross-Range Resolution (ΔX) (for objects at a range of 2,000 kilometers)	75 km*	70 km*	unchanged

EWR ISSUES

- Software complexity, hardware risks, cost, schedule
- Per 1972 ABM treaty, surveillance radars can't tie directly to NMD C&C to give tracking information or to direct launch of GBI.
- 1972 ABM treaty required radars that provide early warning be located on edges of the nation and face outward.
- Would Denmark and UK allow upgrades to the EWR's in their countries?
- The US withdrew from the ABM treaty in June 2002 so could continue upgrading the EWR's.

- NMD Issues
  - Cost, complexity, technical risks
    - can US afford NMD, War on Terrorism, and Iraq?
  - 1972 ABM treaty
    - allowed only one NMD site
    - did not allow the development testing proposed by Bush
  - The US withdrew from the ABM treaty in June 2002 so could continue developing the NMD program

- Impact of countermeasures on the system
  - One of major concerns
  - Testing thus far has not included realistic countermeasures
  - Video

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