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Center for Strategic and Budgetary Assessments

What It Takes to Win

Succeeding in 21st Century Battle Network Competitions

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Battle Network Competition in Perspective

- **Battle Network (BN) definition:**
  - A combination of distributed target acquisition sensors (finders and damage assessors), command and control (deciders), weapons (shooters), and the electronic communications linking them together.
- **Essential BN attributes:**
  - Enable *shooters* to engage targets they cannot "see" far more effectively than would otherwise be possible
  - Enable *finders* to achieve much higher levels of effectiveness as a group than they possess organically
  - Enable *deciders* to coordinate and prioritize tactical engagements at a much higher level of efficiency to achieve the desired operational effects
  - Enable those assessing the results of these operations (*damage assessors*) to determine their relative success with far greater accuracy than would otherwise be possible
- **BNs first emerged about 100 years ago but were relatively rare until recently due in part to the high cost of transmitting and processing information**
  - This limited the number of BNs and the instances of BN competition
- **Declining cost and increasing power of information transmission and processing systems will likely spur BN proliferation, and with it BN competition**

Insights from historical analysis

- **Network attributes depend heavily on operational metrics**
- **Tempo of operations influences decision to exploit or disrupt opposing network**
- **“Virtual Attrition” is often more cost-effective than platform destruction**
- **Competitions accelerate and culminate, then jump to new mode**
- **In some cases one side or the other is “saved by the bell” when a conflict ends just before a competition jumps to a new mode**

Battle Network Competition cases

- **Submarines vs. ASW**
  - Examine competition with focus on BMC2, multi-domain elements, success of networked vs. autonomous attackers

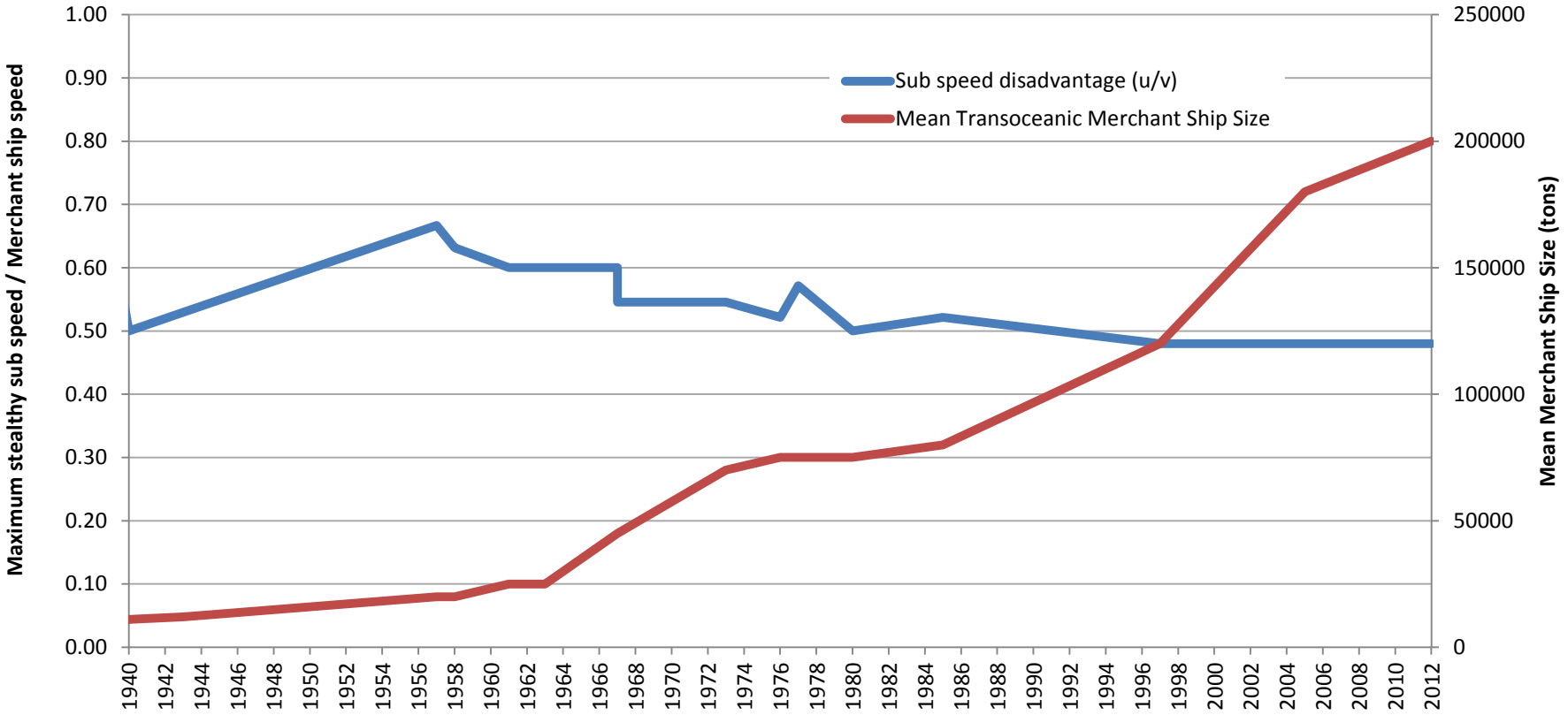
- **IADS vs. Air Attack**
  - Explore how "cutting-edge" technologies advantage first one side, then the other in Battle Network Competitions

World War II / Cold War ASW relevant

- Submarines and commercial/escort ships are relatively slow
  - Dependent on cueing to get in position
  - Difficult to evade attack
  - Results in “slow-motion” operations (better to exploit comms)
- Submarines have limited situational awareness
  - EM sensor range <10 nm; sonar ranges <30 nm normally
  - Difficult to determine if incoming weapon will be successful
- Submarines lack self defense
  - Some decoys, but little else to defeat torpedoes and depth charges

Fundamentals of ASW-sub competition remain largely unchanged.

Sub gains paced ship improvements



Subs maintain speed disadvantage & larger ships less vulnerable.

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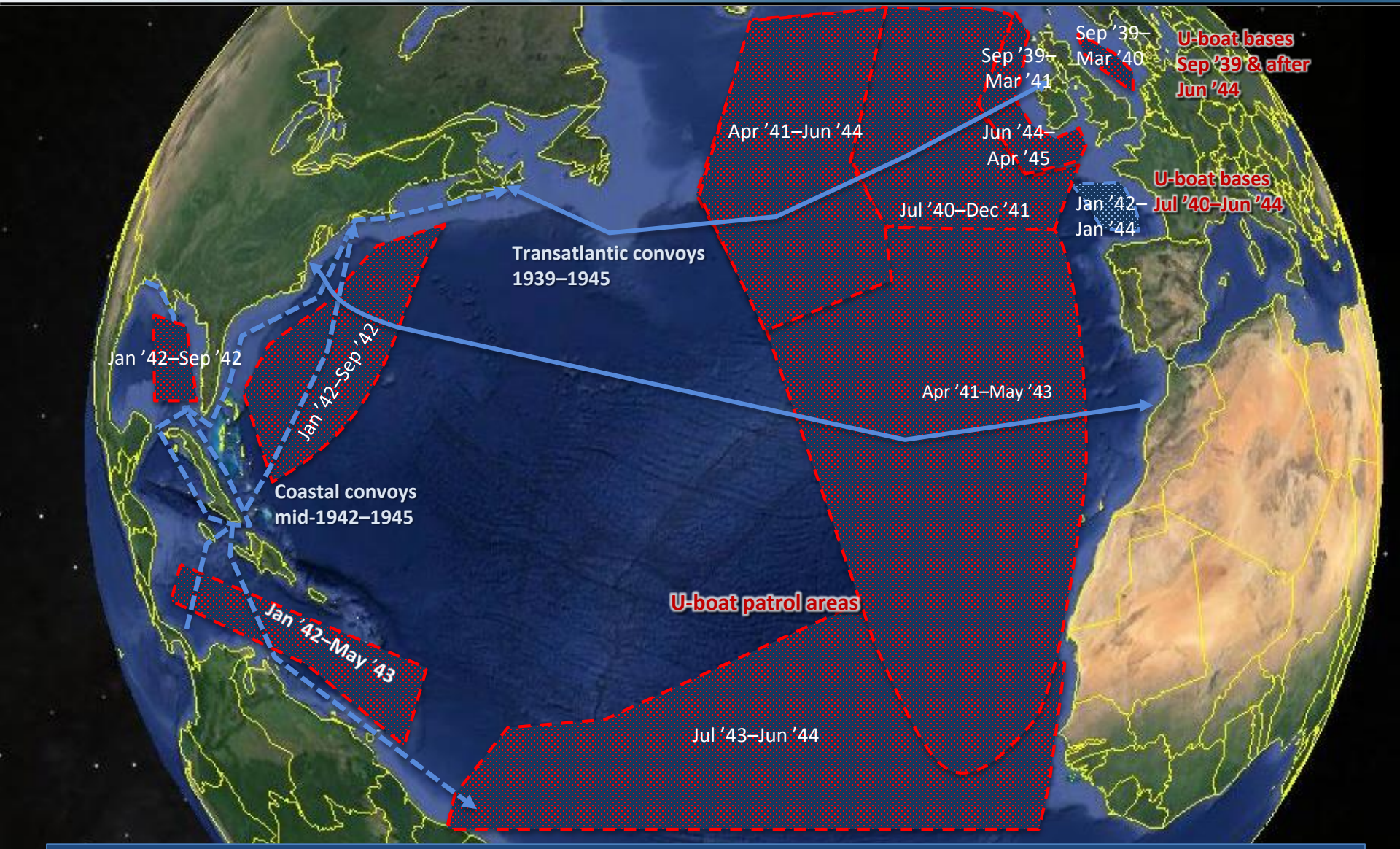
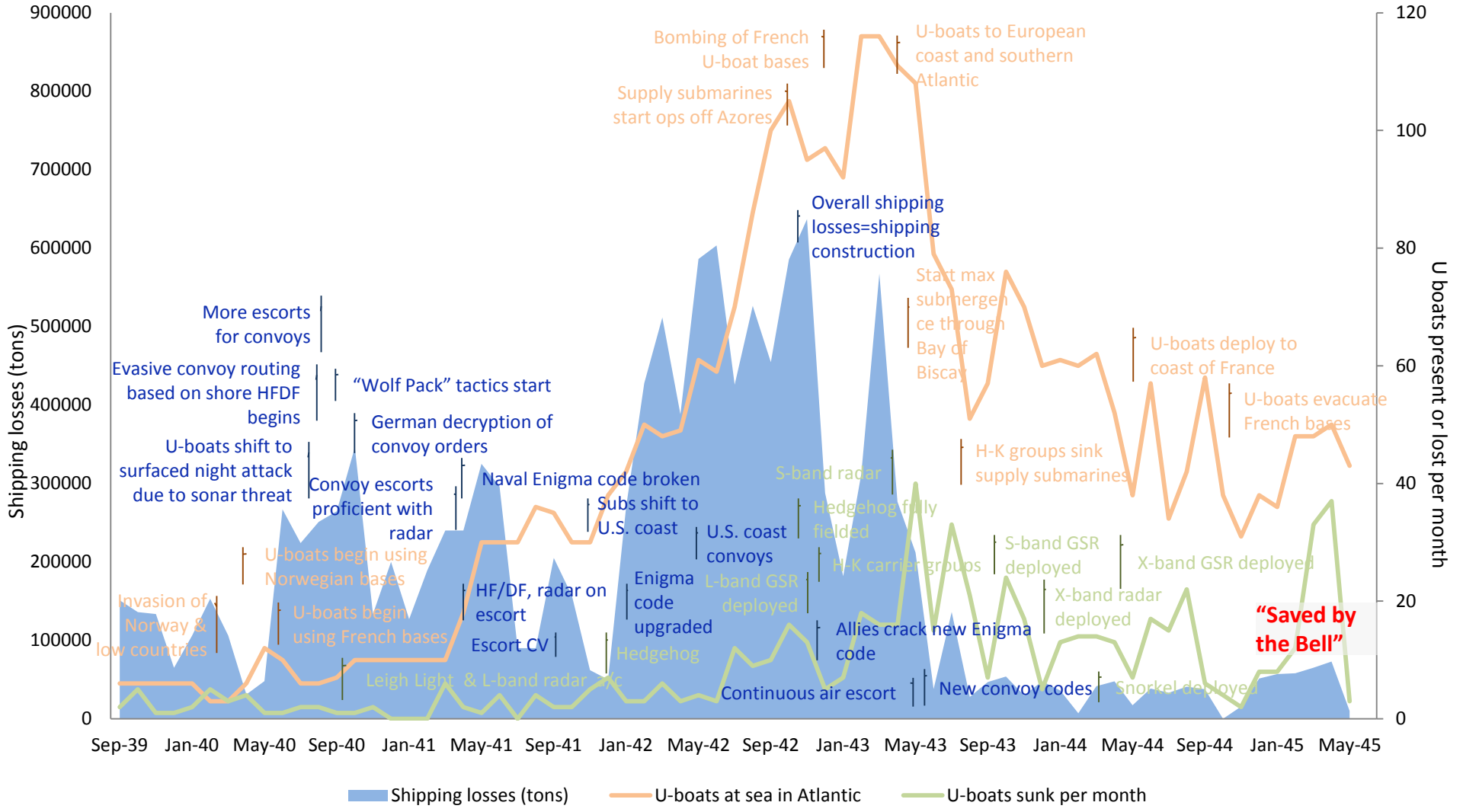
Battle of the Atlantic a useful case



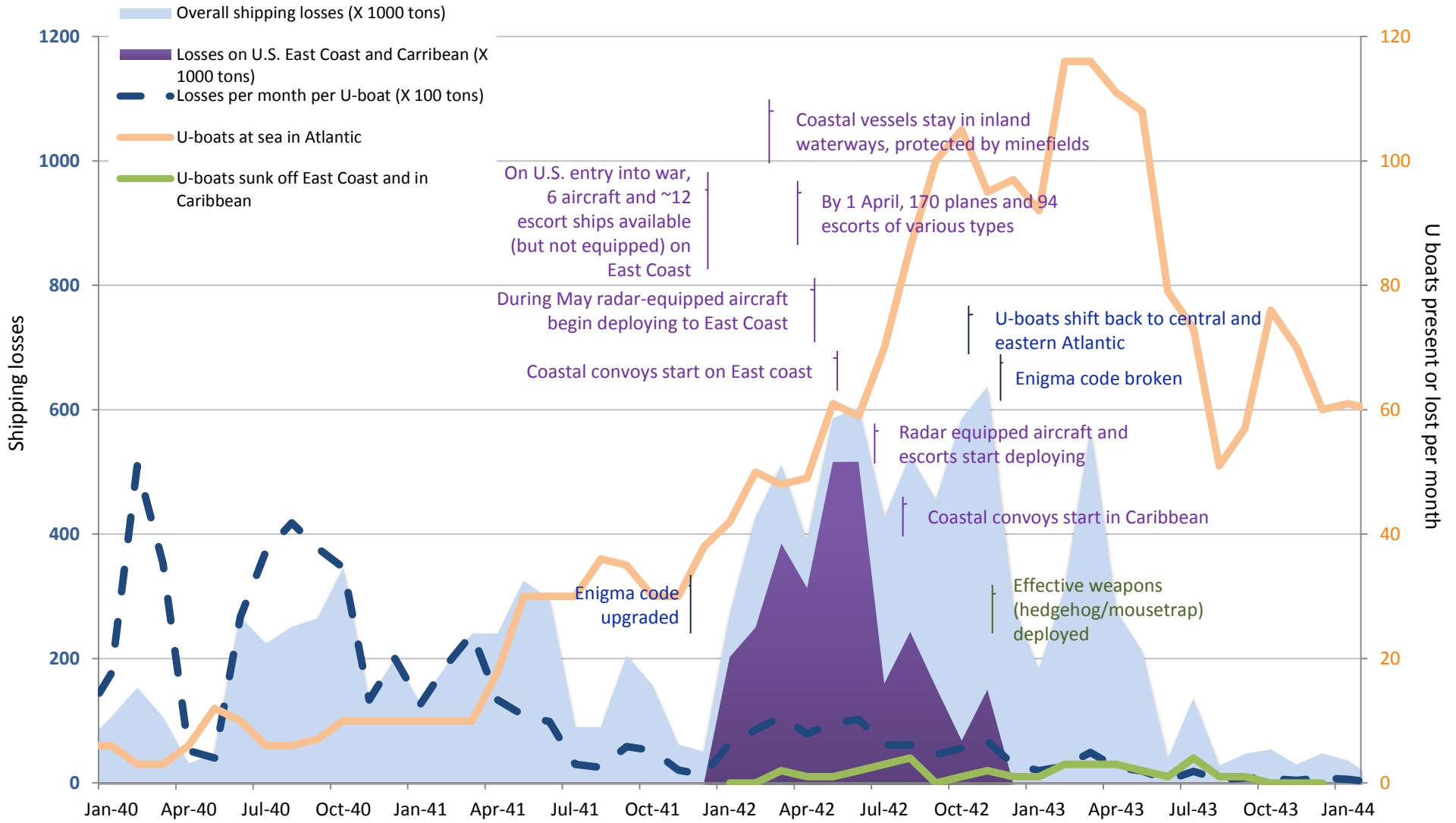
Long range & slow speed of adversaries shaped competition.

Battle of the Atlantic—Allies' view



Key metric for allies: overall shipping losses.

CSBA Only part of ASW "kill chain" needed



1942 spike around U.S.; stopped by convoys w/out sinking subs.

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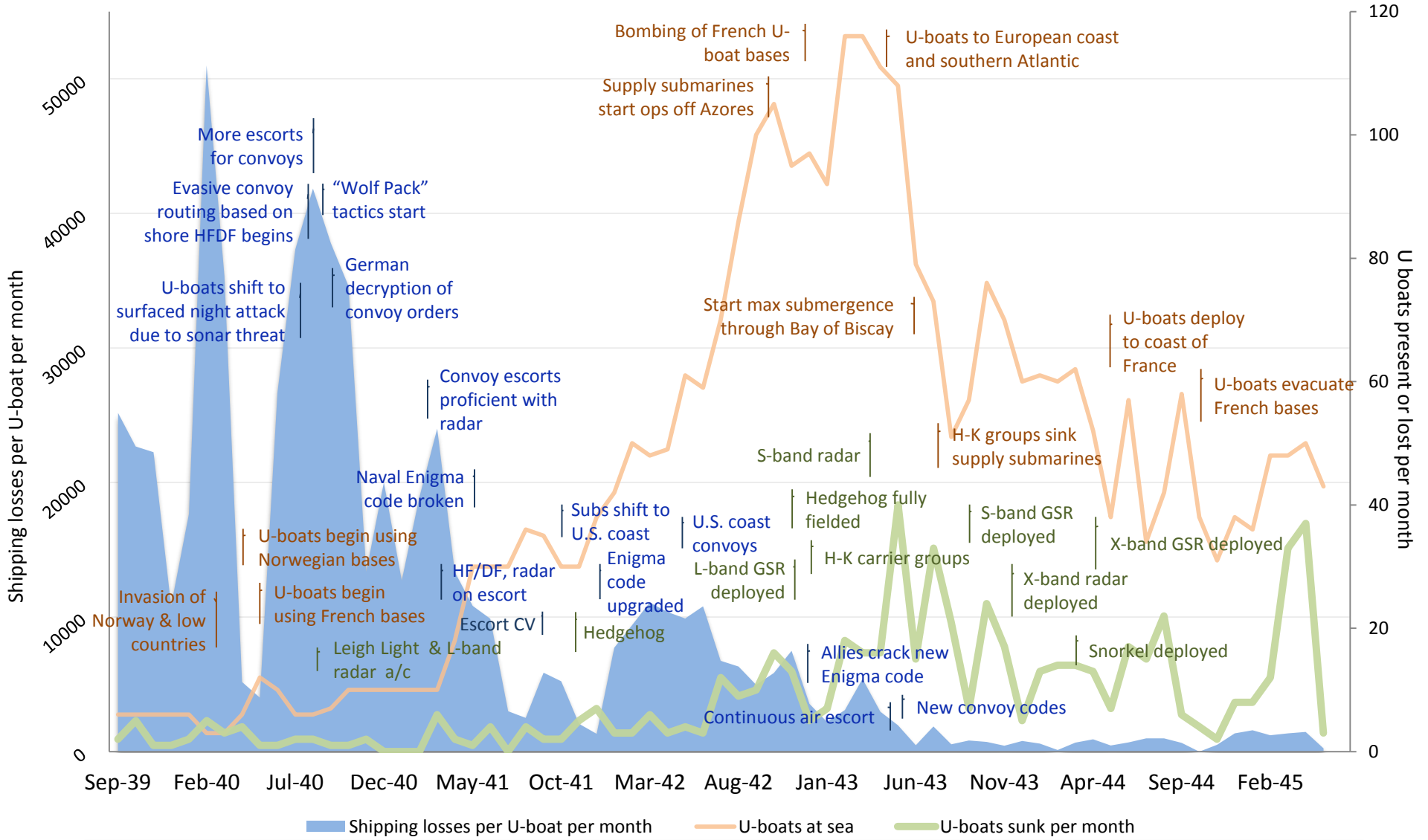
Battle of the Atlantic—Axis' view



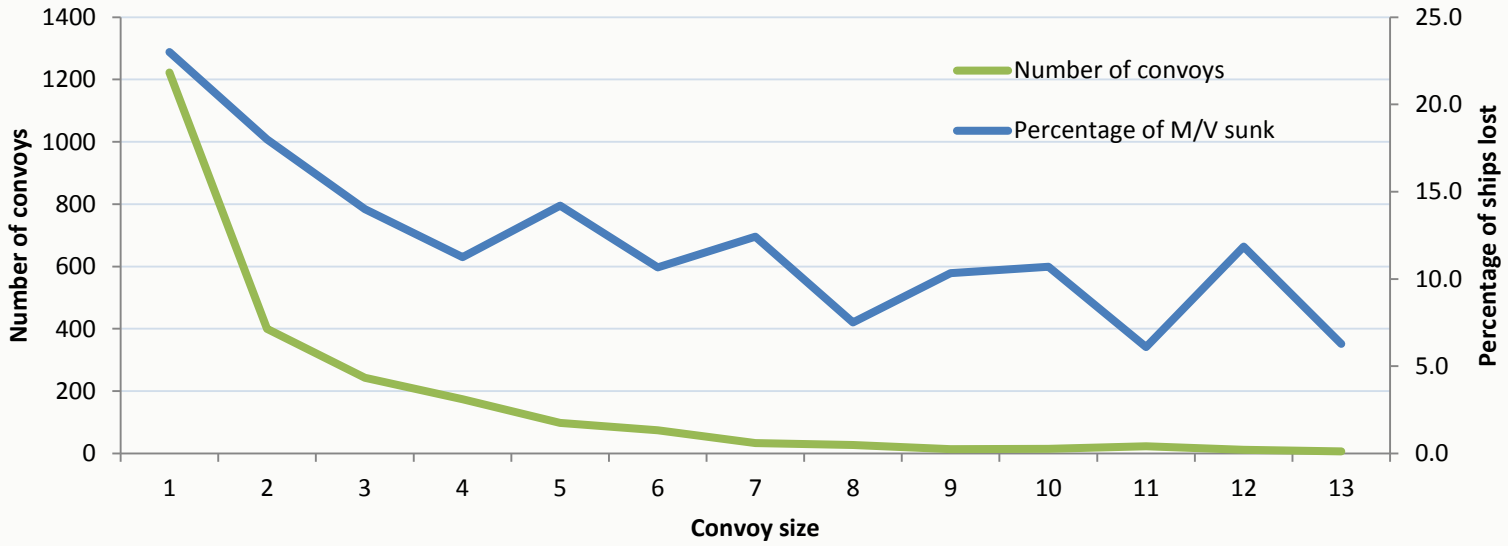
Key metric for Axis: U-boat productivity.

U-boats had an excess of targets

North Atlantic convoy results

	Convoys	Ships	Convoys Sighted	Ships Sunk	% Convoys Sighted	% Ships Sunk
HX (9 kts)	23	923	8	12	35	1.3
SC (7 kts)	24	991	14	45	58	4.6
ON (9.5 kts)	24	897	11	29	36	3.2
ONS (7 kts)	23	836	11	31	48	3.7

Japanese convoy results



But convoys alone reduced submarine effectiveness.

ASW kill chain requires a network

Location of attacks	Independent	Coordinated
U.S. attacks, Atlantic and Mediterranean; Jan 1943–Feb 1944		
Number of incidents	176	18
Number assessed as sunk or probably sunk	9	3
Percent successful	5	17
U.S. attacks, Atlantic and Mediterranean; March 1944–May 1945		
Number of incidents	41	38
Number assessed as sunk or probably sunk	5	21
Percent successful	12	55

Probability of regaining contact		
	Single Ship	Coordinated
Jan 1943–July 1943	0.54	0.8
Aug 1943–Feb 1944	0.68	0.9

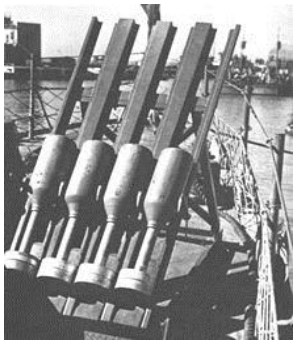
Engagement platform sensors not able to gain & maintain contact.

Precision essential to kill chain

Weapon	Lethal radius (ft)	# of charges / barrage	Weapons effectiveness per barrage				
			1st half '43	2nd half '43	1st half '44	2nd half '44	1st qtr '45
Depth Charge	21	9	5.4	4	6.4	5.1	7
Mousetrap	0	24		7.5	15.4	28.1	23
Squid	0	16				33.3	62

Depth Charge (1939)

Hedgehog (1941)

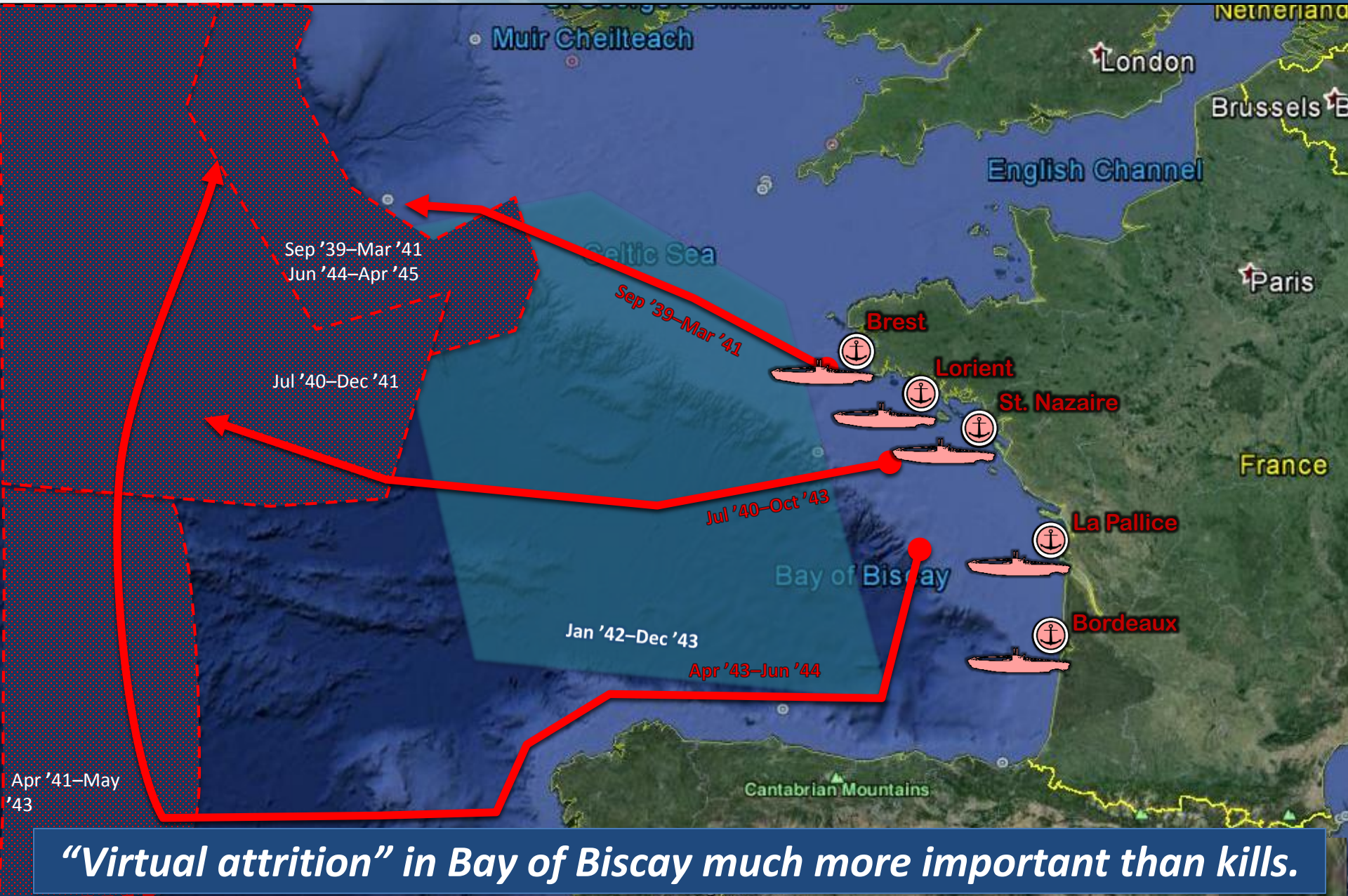


Mousetrap (1942)

Squid (1943)

Smaller, aimed contact weapons more effective.

CSBA Offensive ASW to attrite U-boat fleet



"Virtual attrition" in Bay of Biscay much more important than kills.

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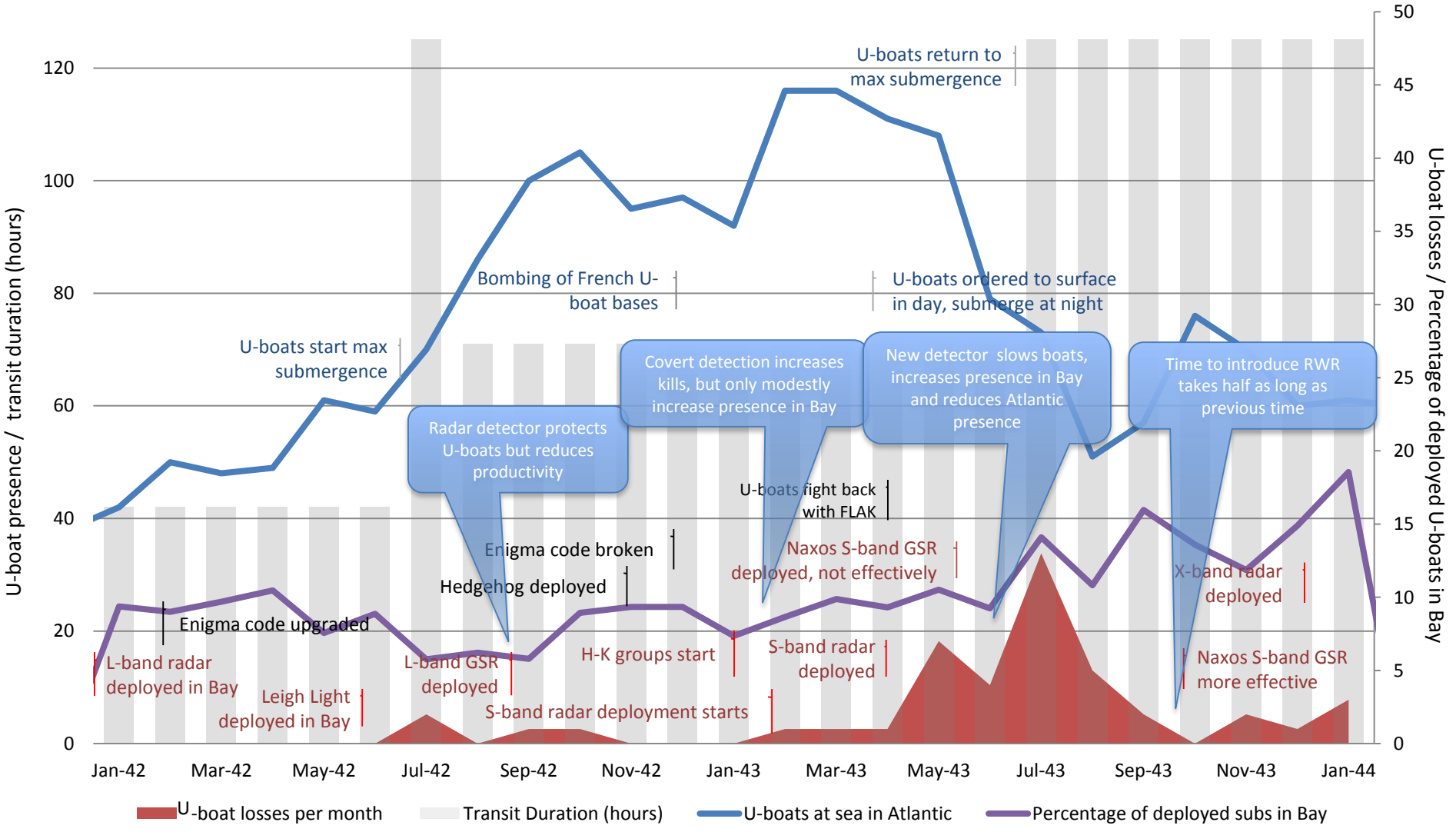
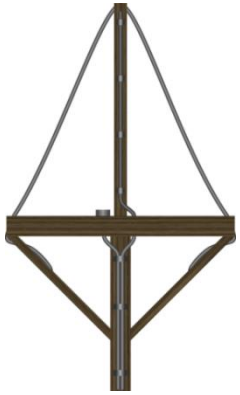
Killing vs. slowing submarines



Metric was kills; should be "virtual attrition" of U-boat presence.

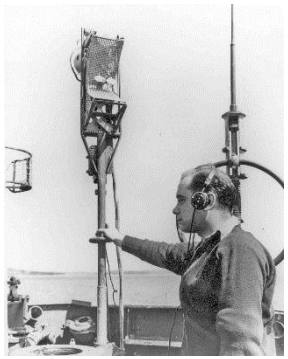
WWII ASW was an EM competition



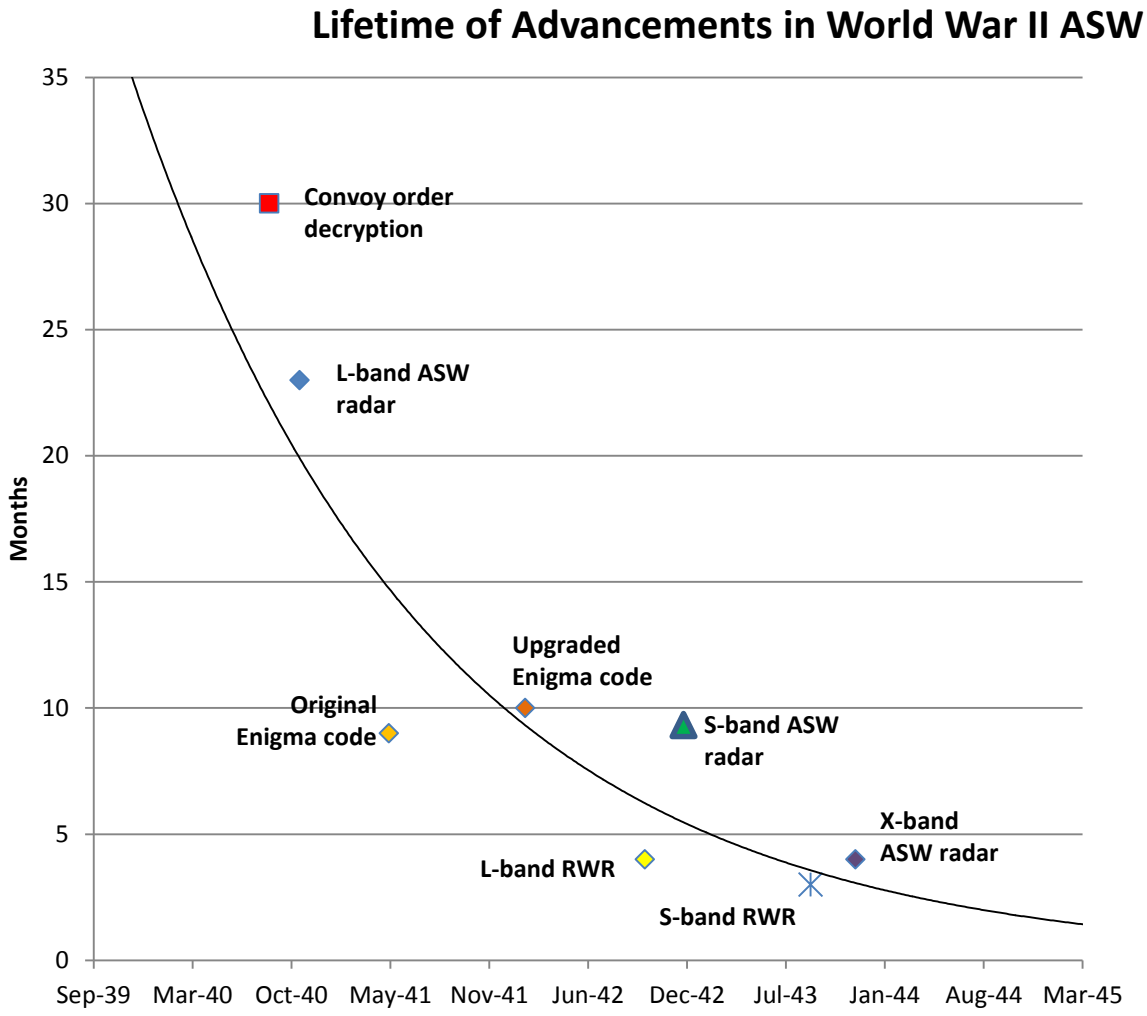
Metox L-band GSR

H2S S-band radar

Naxos S-band GSR

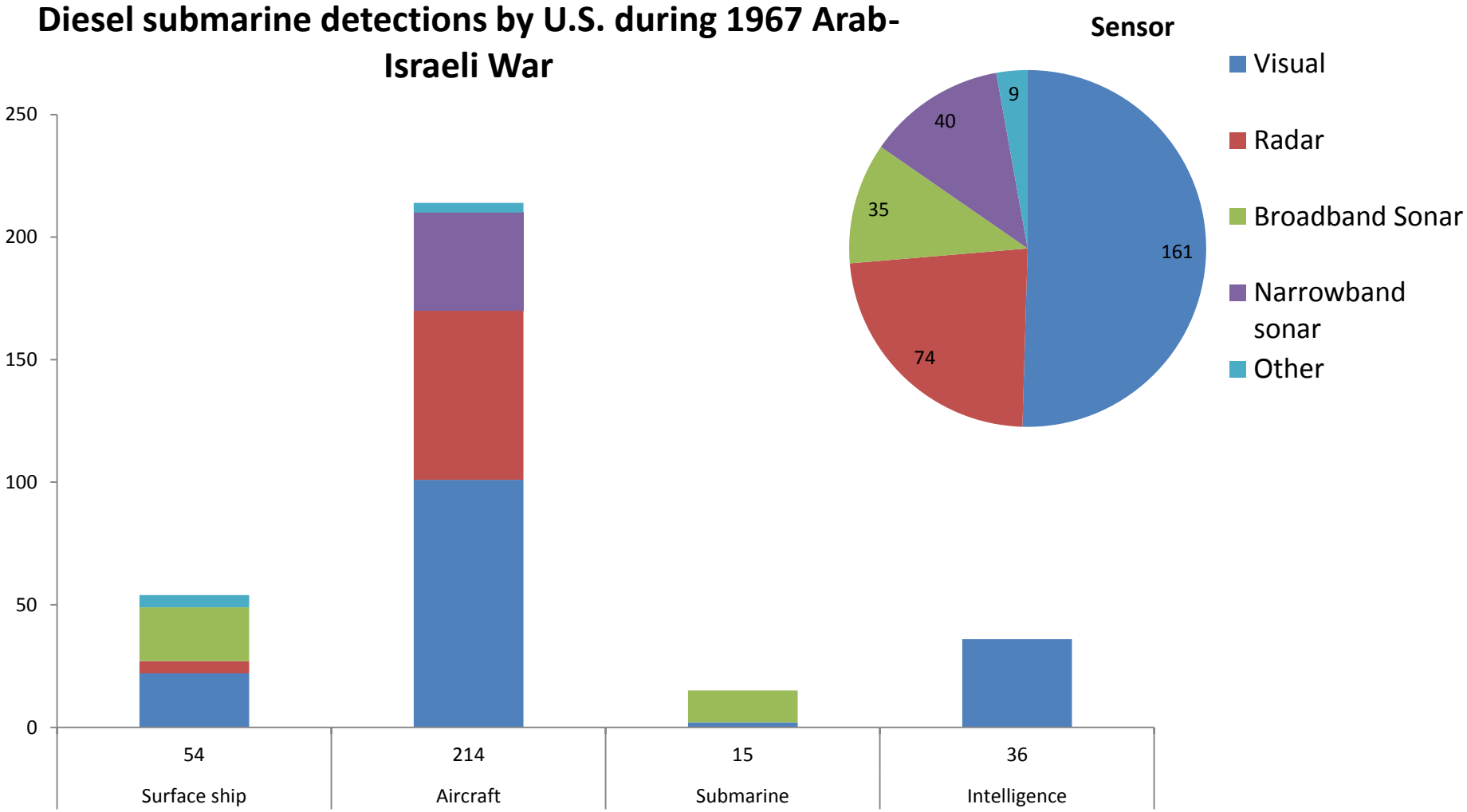


Tunis X-band GSR



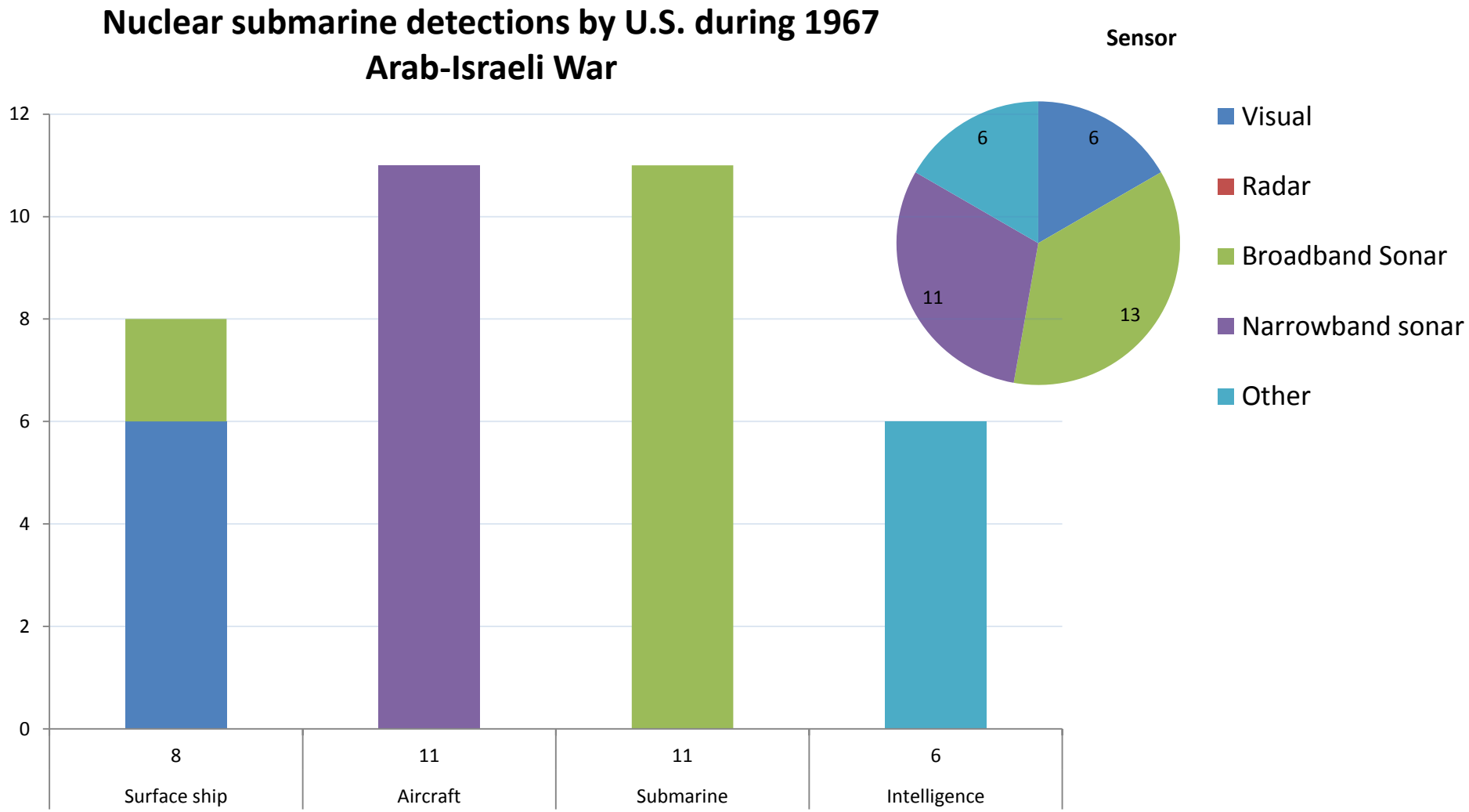
Counters take less time until competition "jumps" to a new band.

Cold War diesel ASW still in EMS



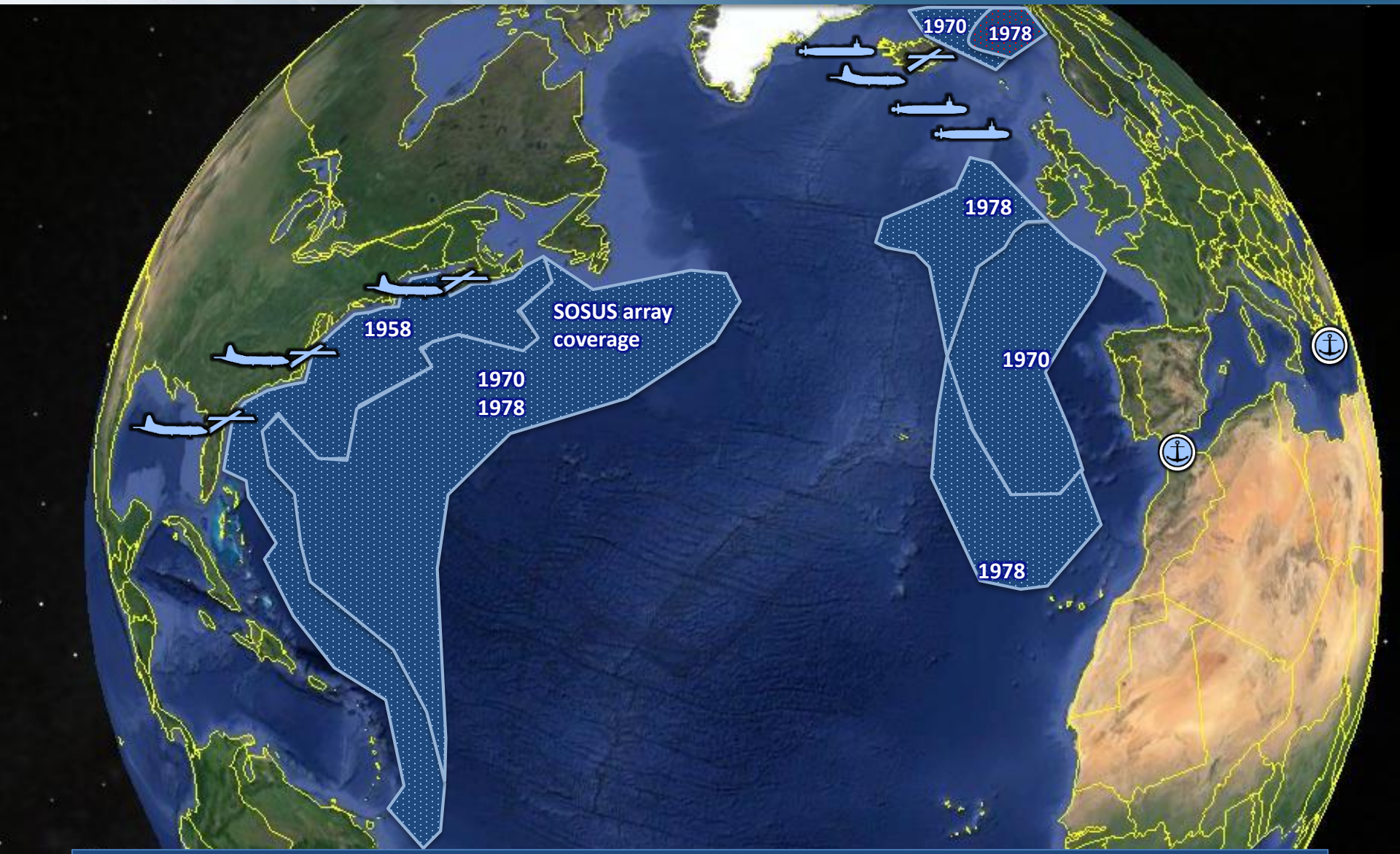
Diesel subs in 1967 Arab-Israeli War tracked as in WWII.

Nuclear subs shift ASW to acoustic



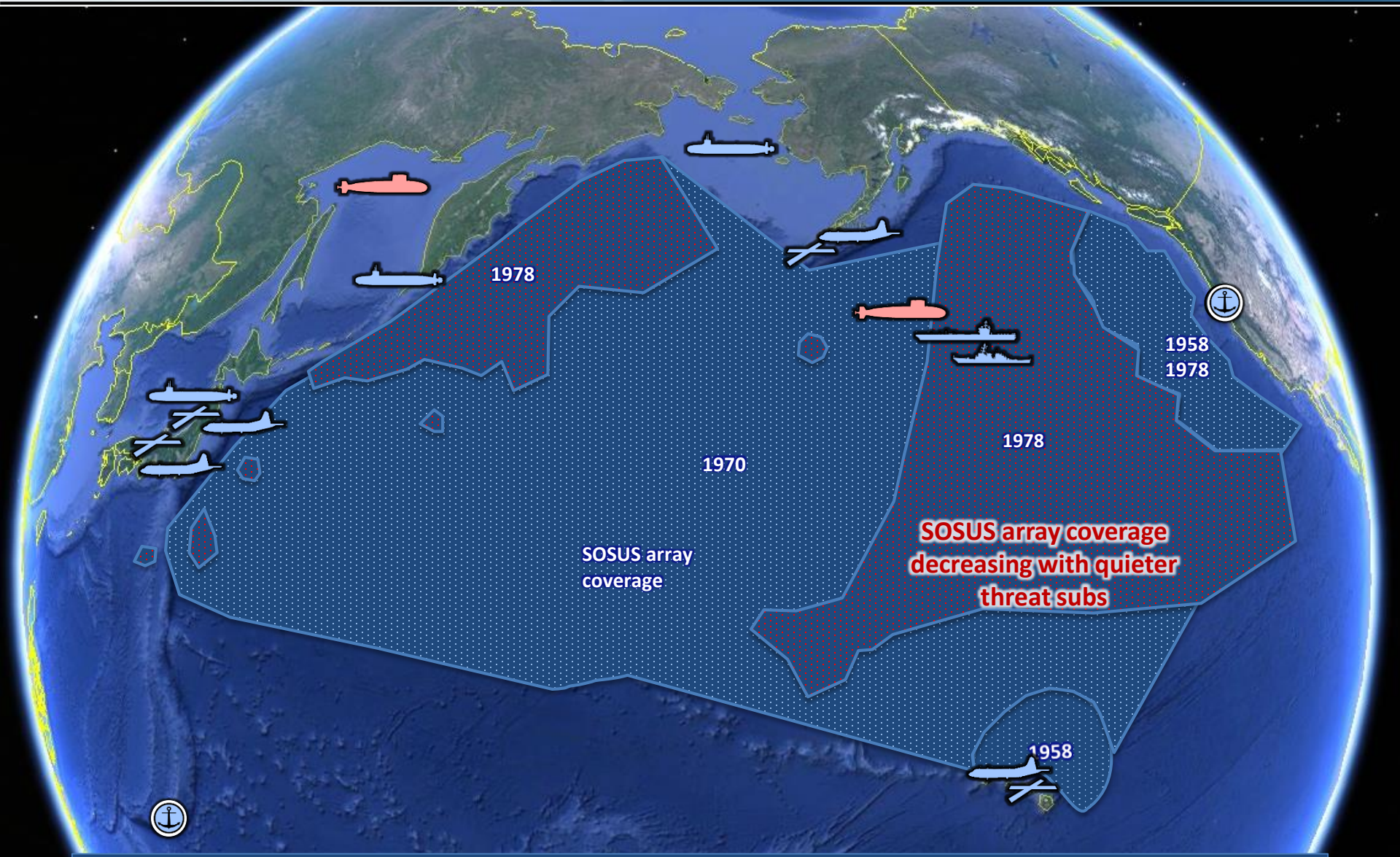
Nuclear subs tracked during 1967 war by passive sonar.

CSBA U.S. exploited lead in passive sonar



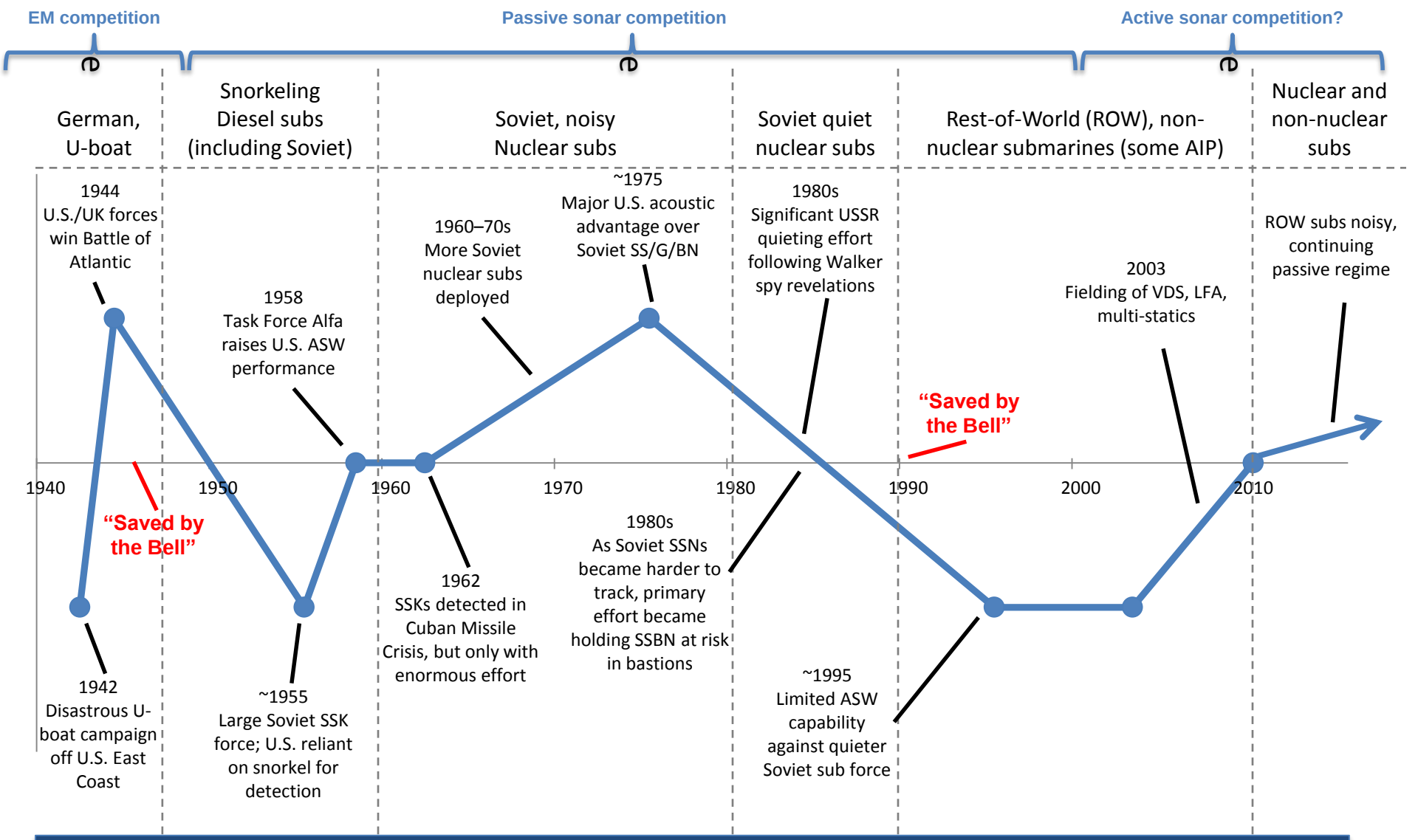
SOSUS and submarine arrays enabled near-continuous track.

CSBA Passive sonar gives sub more control



Passive sonar competition nears "culmination" in 1980s.

Undersea competitive regimes



U.S. was lucky in last two shifts; how to prepare for next one?

Where is ASW competition going?

- Competition will shift away from detection of noise from sub
  - Culminated in 1990s, but U.S. got a reprieve
  - Quieting techniques known and achievable by key competitors
- Competition will shift toward:
  - Active sonar: Low-frequency (100–300 hz) ranges in 10s–100s of miles
  - Non-acoustic phenomena: Wakes, chemicals, radiation, etc.
  - Background noise
- Shift enabled by improved processing and modeling
  - Increasingly can fit onto mobile platforms, co-locating sensor and shooter
- Effective competitors will exploit fundamentals, “virtual attrition”
  - Active sonar impacts sub operation and behavior, even if inaccurate
  - Smaller, “mission-kill” weapons can be longer range, effective vs. subs

Battle Network Competition cases

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- **IADS vs. Air Attack**
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Enduring aircraft attributes shape the IADS vs. air attack competition

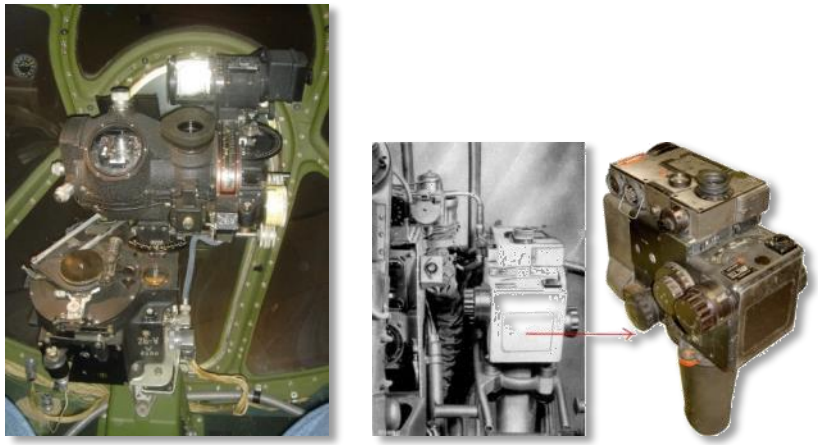
- **Speed**
- **Access**
- **Fragility**

- **Relatively low payload**
- **Relatively low combat persistence**

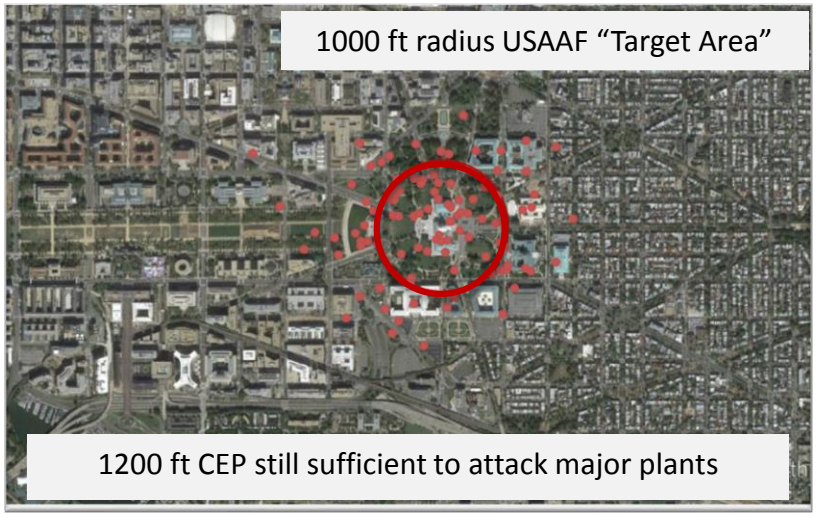
- **Combination makes air forces extremely sensitive to attrition**

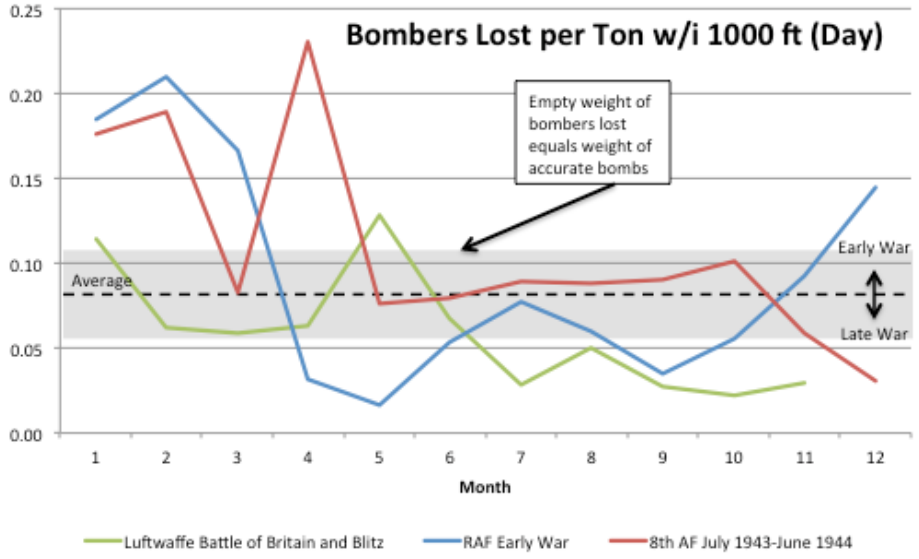
Combat Sorties per Month	
US AAF vs. Germany March 1944	26,411
Rolling Thunder (1965–86)	9,468
IAF 1973	18,131
Desert Storm	51,840
Allied Force	10,231

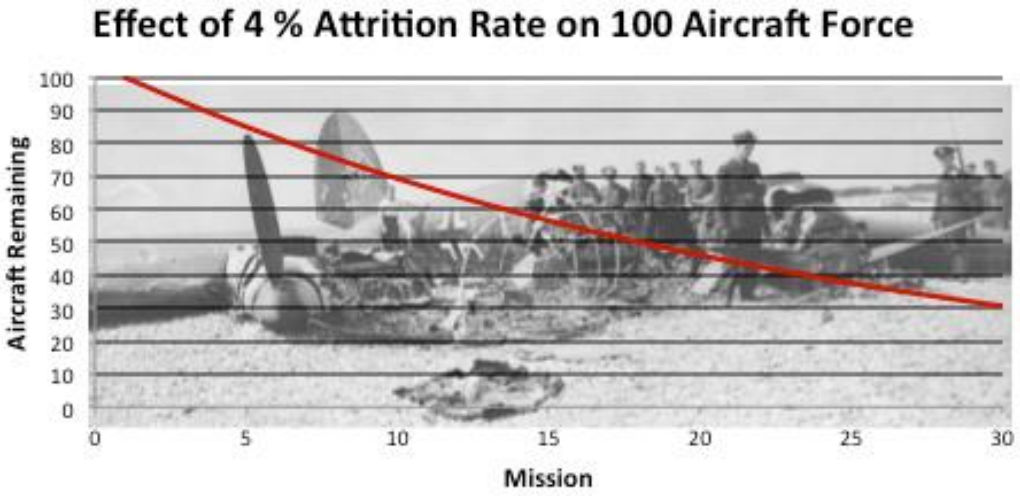
Daylight precision bombing in the 1940s



Analog computing bombsights

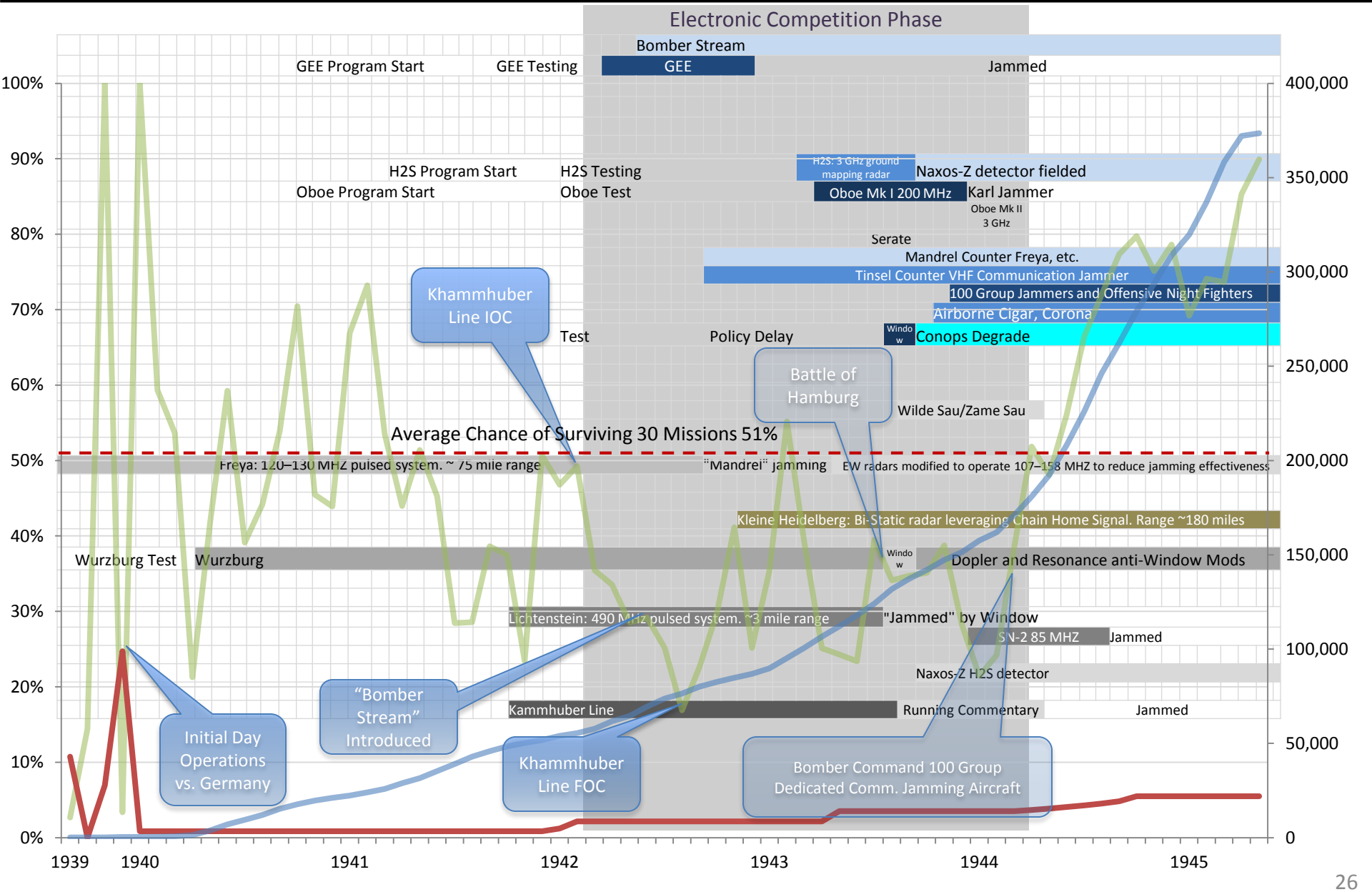




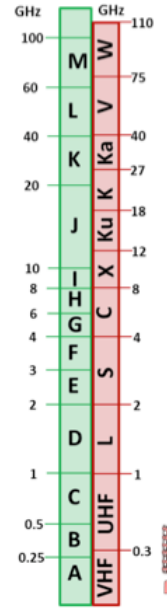


Early losses drove both the Luftwaffe and RAF to adopt night bombing.

RAF Bomber Command

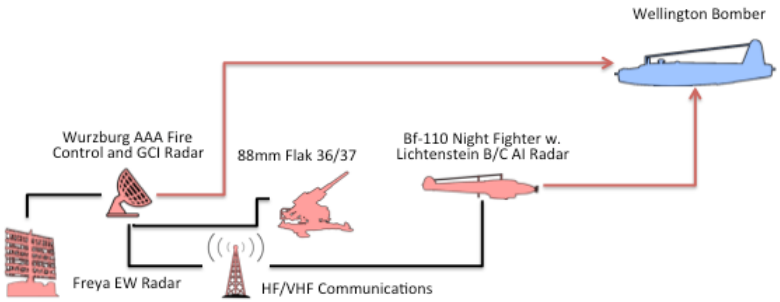


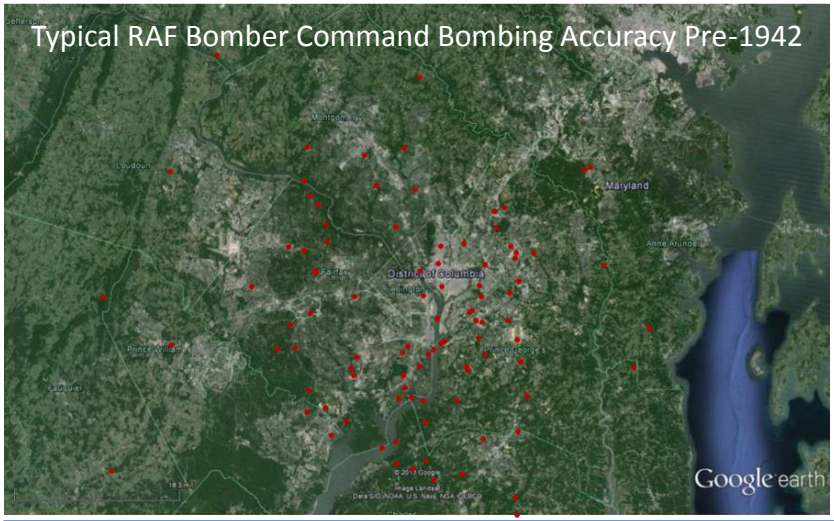
Night bombing IADS competition (Sept 1939–Feb 1942)

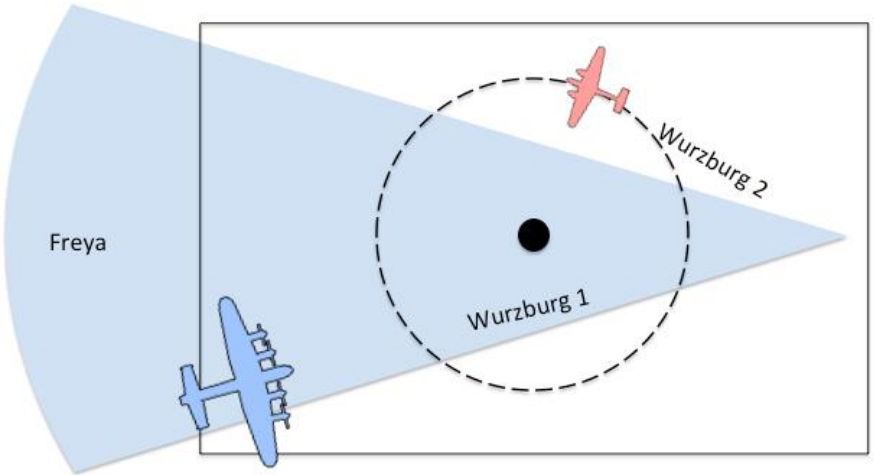


Bomber Command operations through early 1942 relied on crews independently finding targets with aircraft widely separated in space and time

- Navigation and bombing highly inaccurate
- German defenses develop slowly but grow increasingly effective







"Himmelbett" Engagement Chain

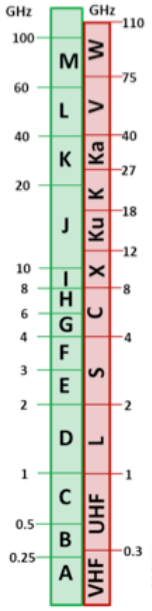
Freya EW
125 MHz / 20 kw / 65 nm range

Wurzburg TTR
560 MHz / 8 kw / 38 nm range

Lichtenstein AI
490 MHz / 1.5kw / 1.8 nm range

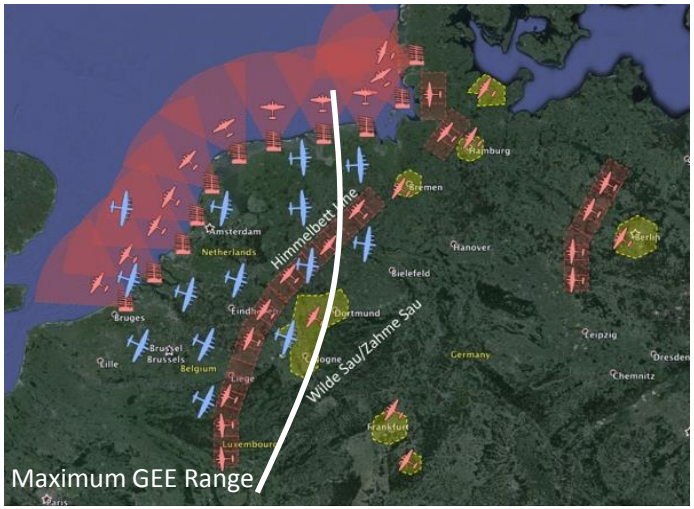
RAF bombing pre-1942 largely ineffective.

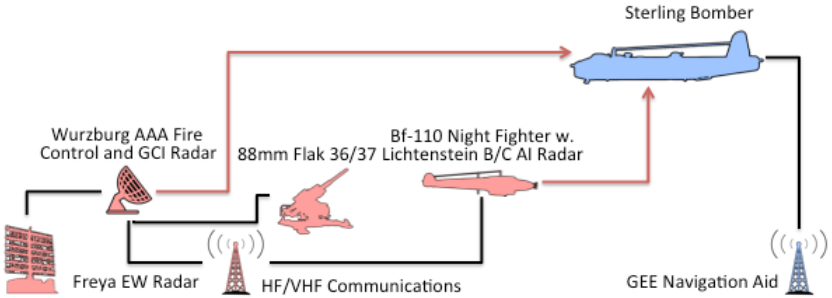
Night bombing IADS competition (Mar 1942-Jan 1943)

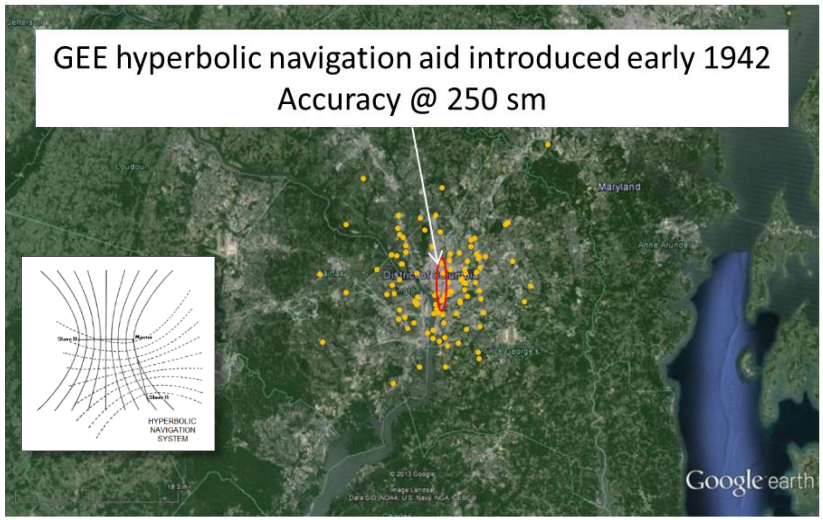


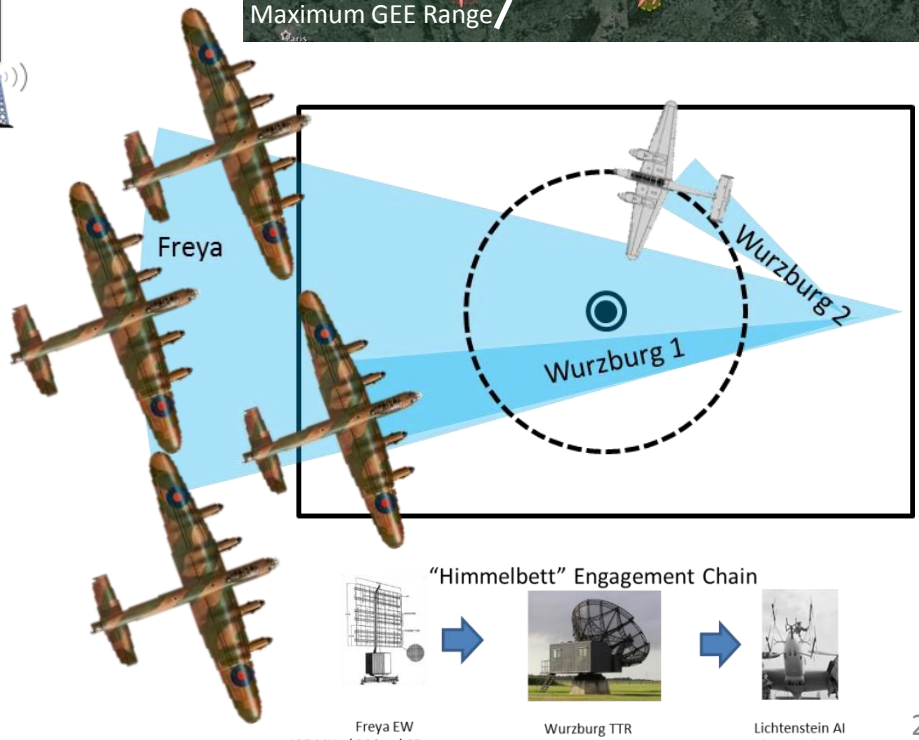
March 1942 British field GEE navigation aid after 21-month development period

- Accurate to about 5 nm at maximum range of 250 sm
- Enabled concentration of attackers in time and space to overwhelm linear Himmlebett defenses
- Germans identified its use and purpose on May 29 (82 days)
- "Henrich" jammers developed and fielded by August 4, 1942 (67 days)
- By December 1, 1942 GEE useless over Germany (267 day operational life)

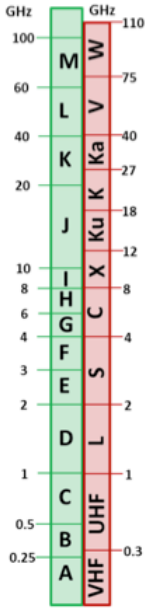






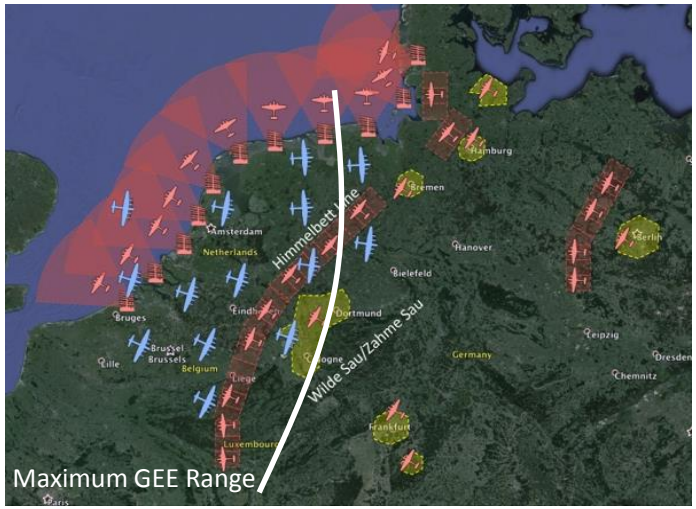


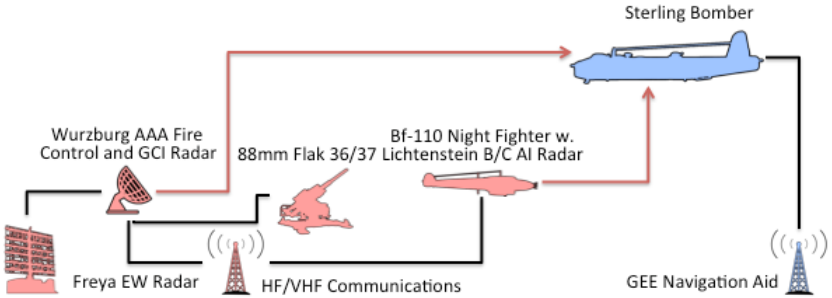
Night bombing IADS competition (Jan 1943–July 1943)

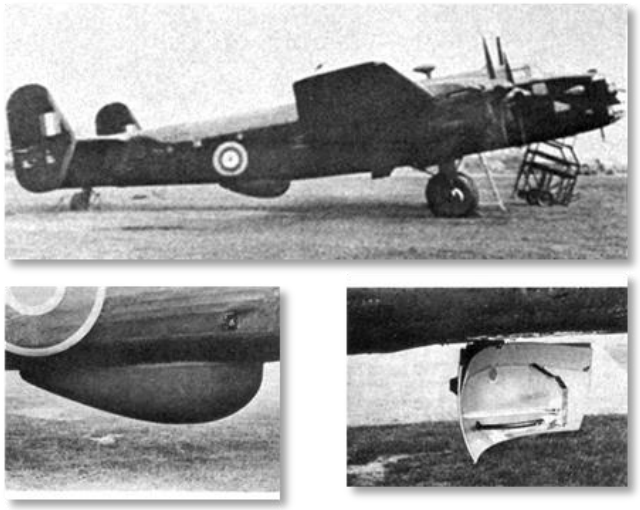


H2S required 15 months from program start to first combat use on January 30, 1943

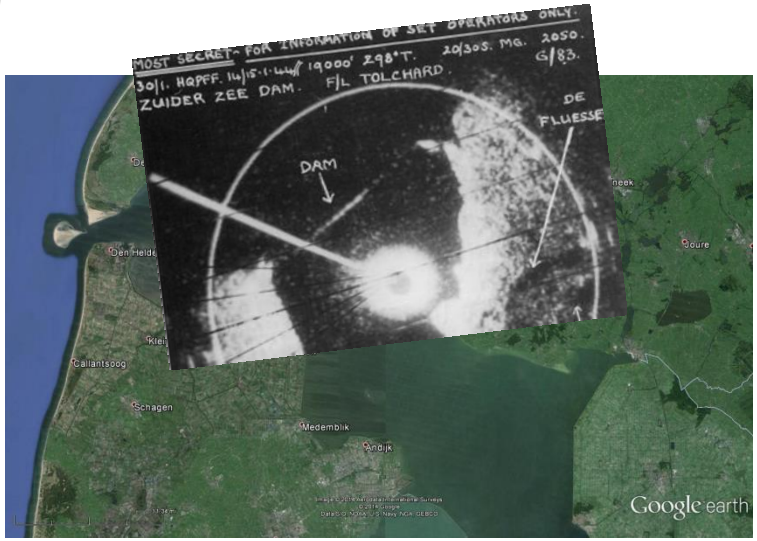
- Provided navigation and bombing accuracy independent of range from UK
- About twice as accurate as GEE
- Germans reconstructed set from aircraft downed on February 2, 1943 (second combat use—3 days!)
- Countermeasures team formed February 22, 1943 (24 days)
- Naxos airborne homing device fitted to German night fighters from September 11, 1943 (222 Days)





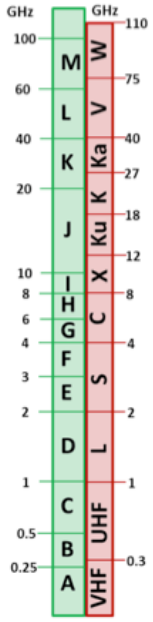


H2S S-Band Navigation Radar



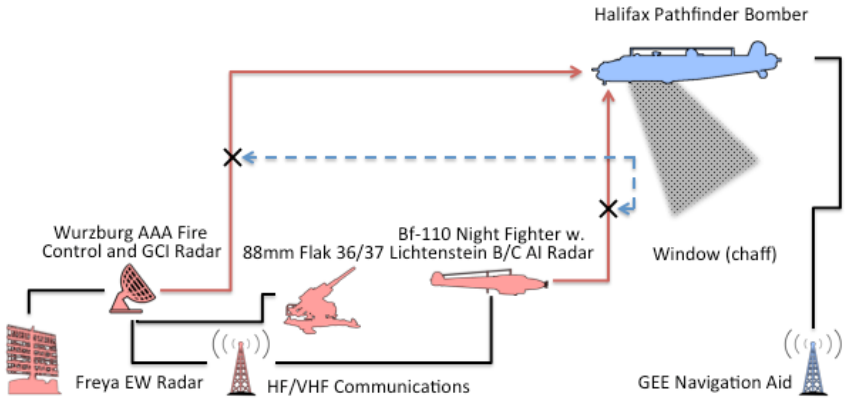
H2S Scope Presentation of Zuider Zee

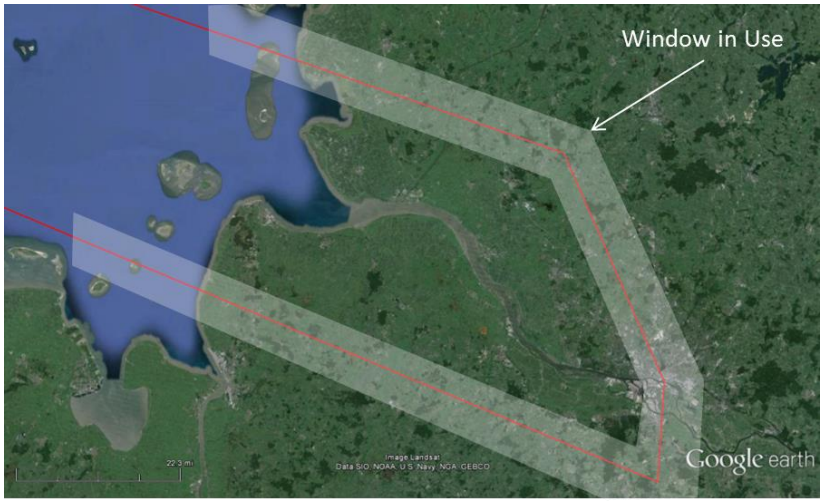
Night bombing IADS competition (July 1943–Jan 1944)



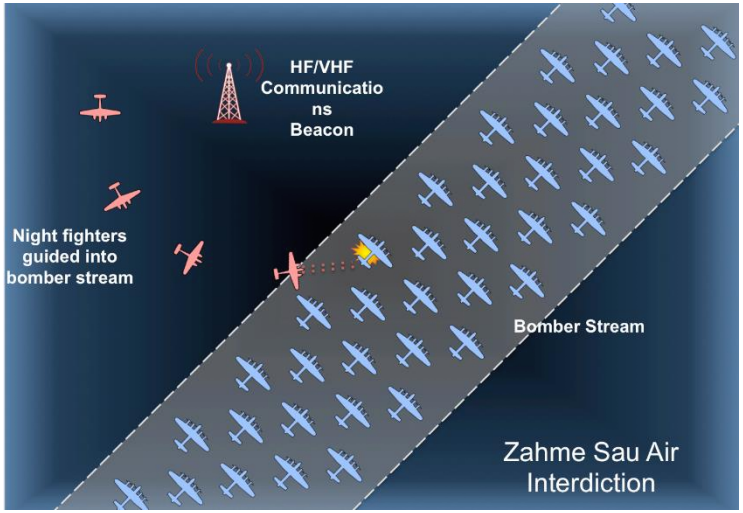
July 1943 RAF introduces "Window" in "Battle of Hamburg"

- 746 attacking bombers dispensed one 2-pound packet of Window every minute
  - Average time of fall was 15 minutes
  - Produced about 11,000 "bomber-like" returns
- German radars "clustered" near 500 MHz
- Foiled GCI, gunlaying and AI radars (all used similar frequencies)
  - Reduced effectiveness of defenses by about 75 percent





German Low-Tech Response Restores Defense Effectiveness Rapidly

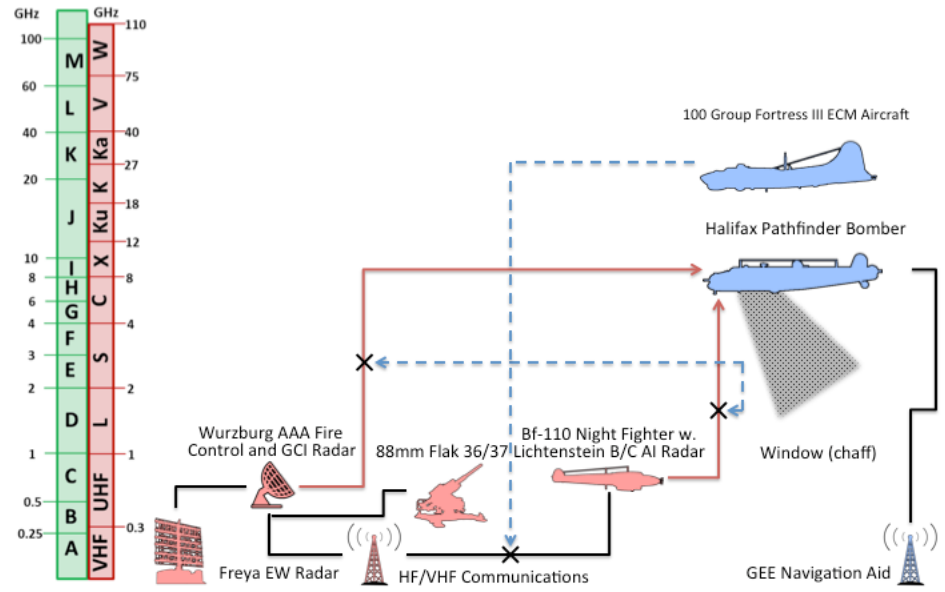


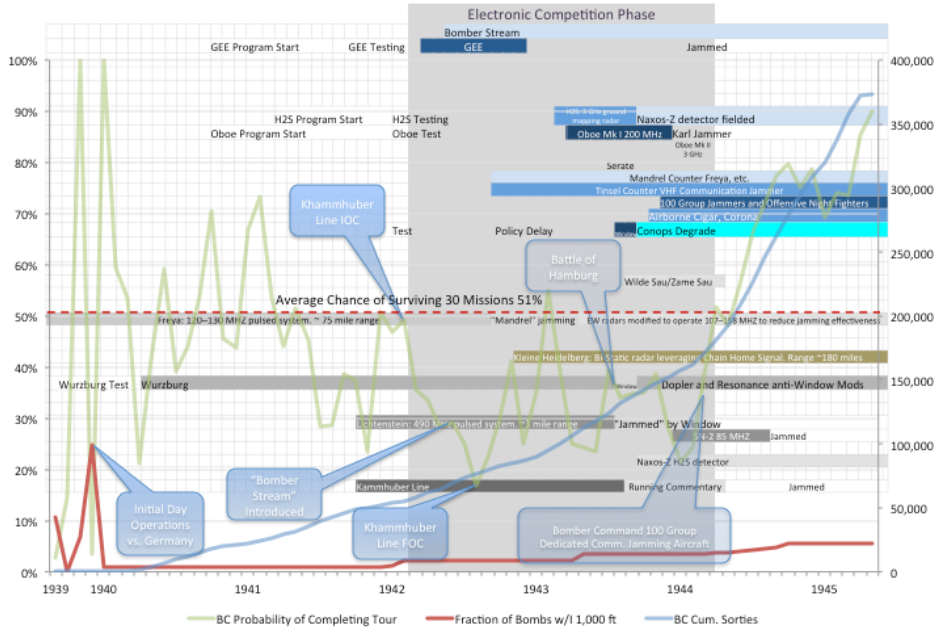
"Zahme Sau" (Tame Boar) night fighter tactics: Ground controllers provided general running commentary on the course, speed, height, and location of the bomber stream rather than single bombers.

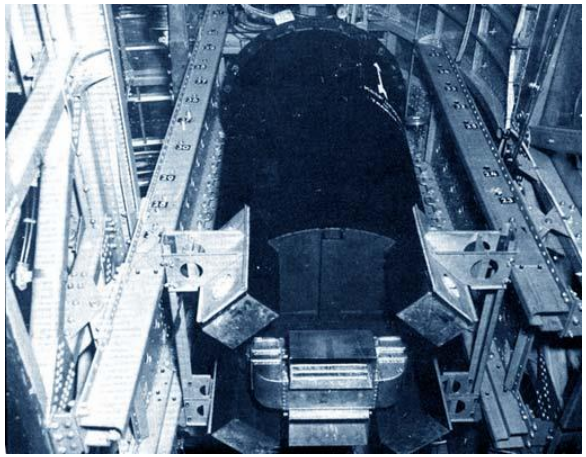
"Wilde Sau" tactics: Single seat day fighters converged on target city and engaged bombers visually in the target area under a 'freelance" system

Window defeats Himmelbett system, but Germans rapidly adopt new tactics.

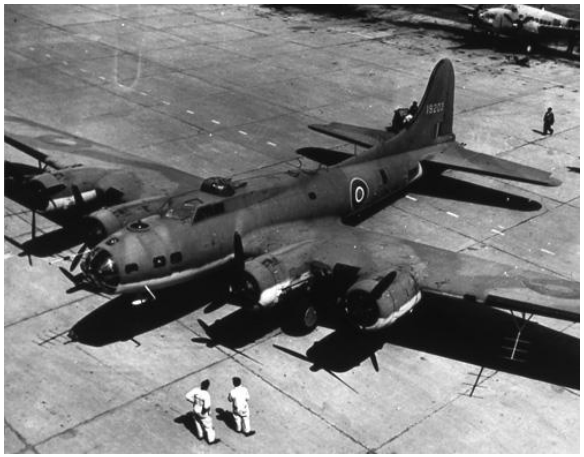
Night bombing IADS competition (Jan 1944–May 1945)







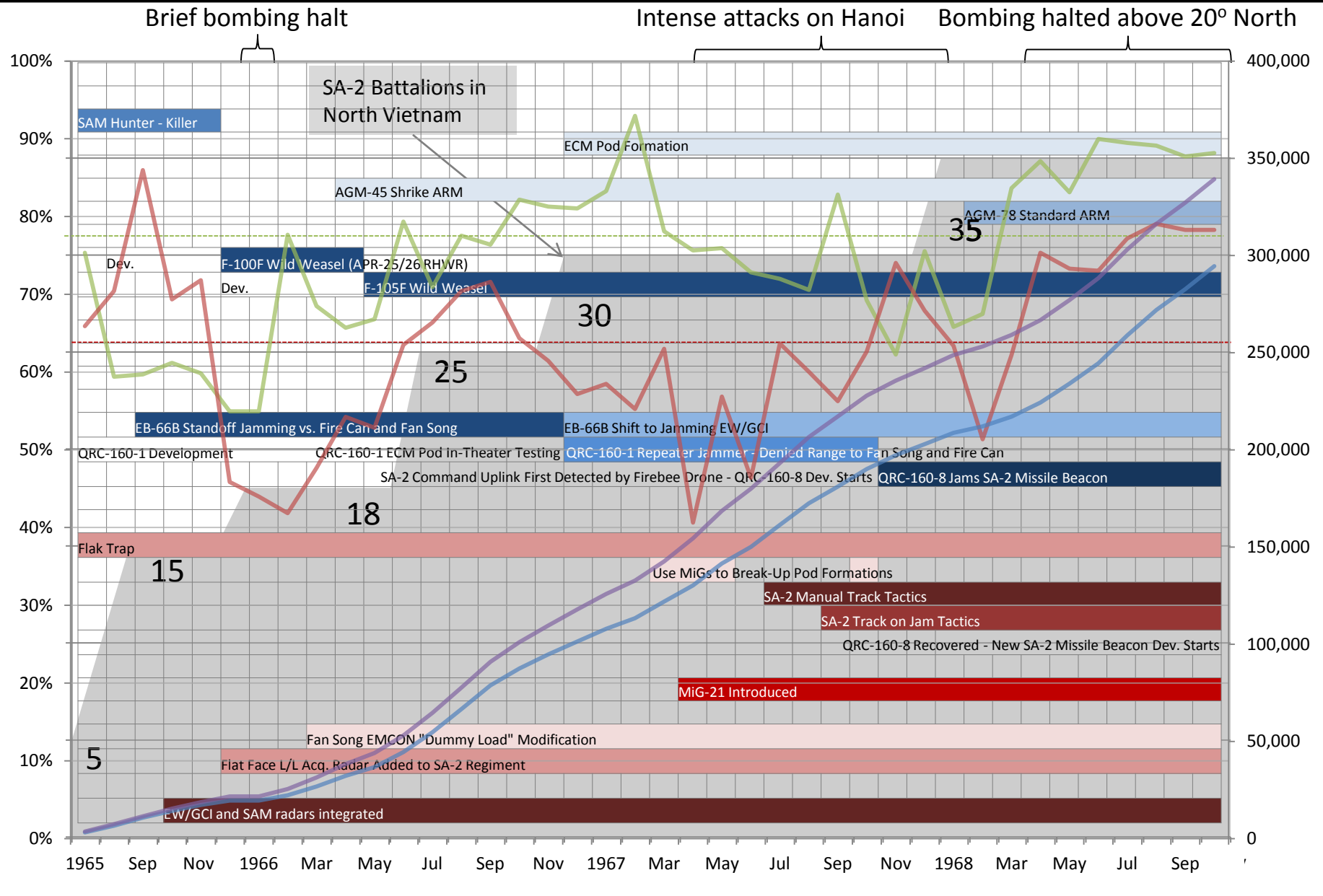
One of four 2.5 kW/650lb. Jostle VHF communications jammers in bomb bay of 100 Group B-17



100 Group B-17 Fortress III ECM Aircraft

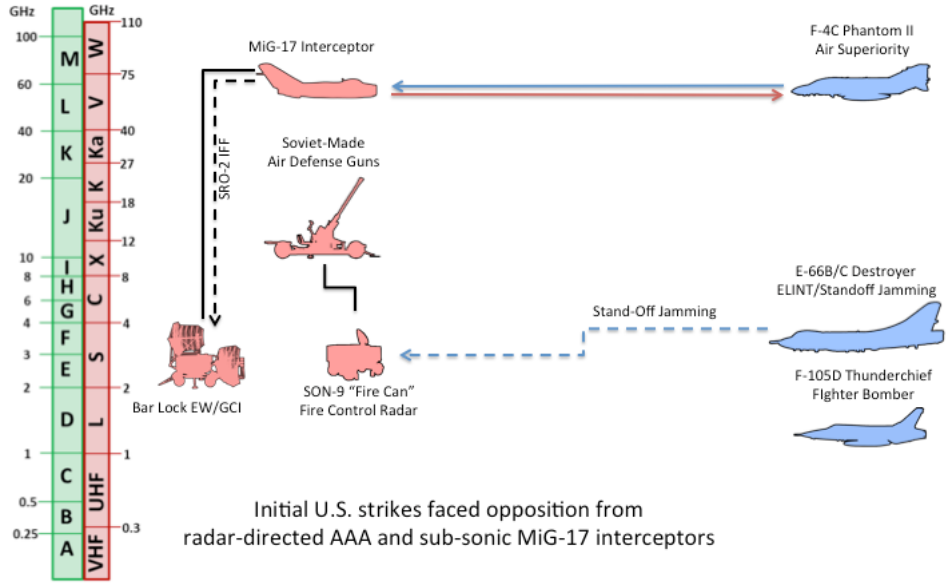
Fielding 250+ dedicated ECM aircraft defeats new German tactics by denying communications.

CSBA Rolling Thunder competition

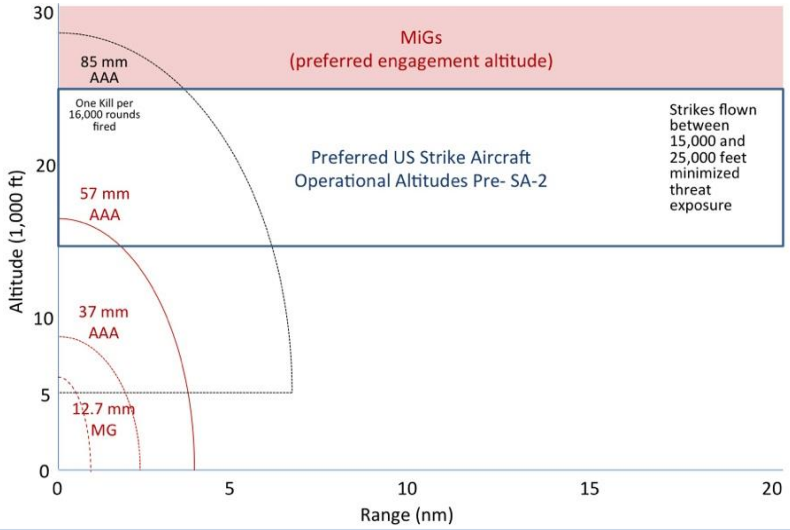


Rolling Thunder IADS competition

Mid-1965

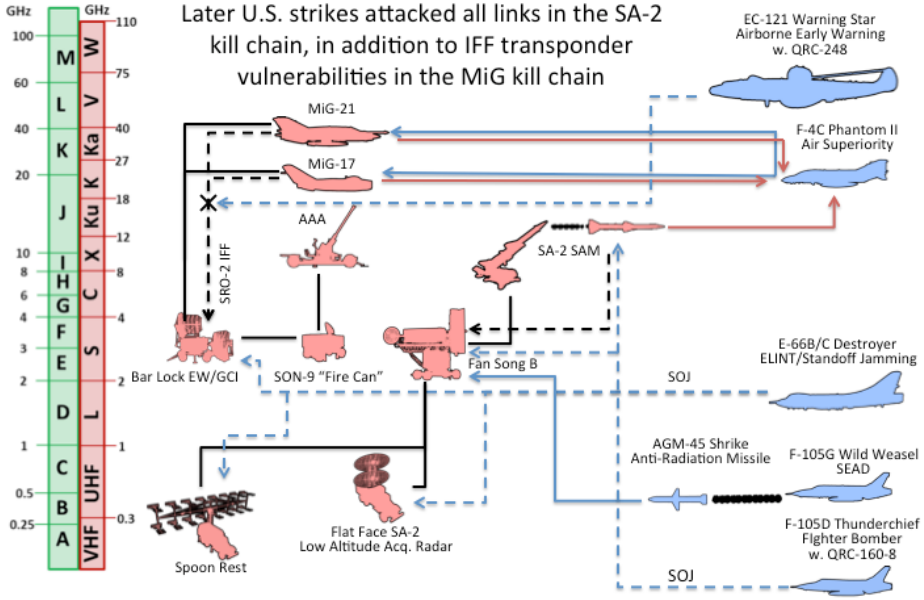


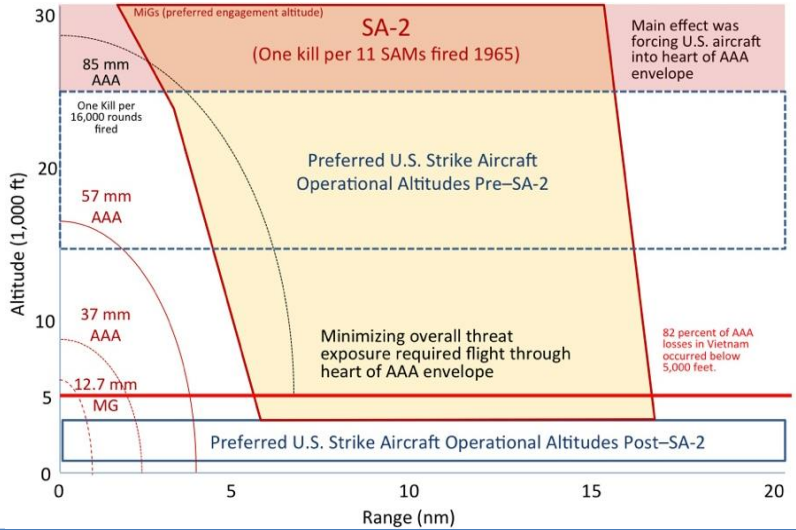
Initial U.S. strikes faced opposition from radar-directed AAA and sub-sonic MiG-17 interceptors



Early 1968

Later U.S. strikes attacked all links in the SA-2 kill chain, in addition to IFF transponder vulnerabilities in the MiG kill chain





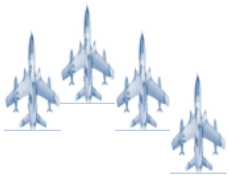
SA-2 drives U.S. to introduce extensive dedicated ECM support.

Typical Rolling Thunder strike force circa 1968

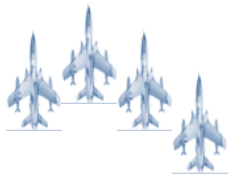
SA-2 Site

Target

SA-2 Site



"Iron Hand"
SEAD



"Iron Hand"
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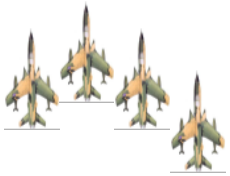
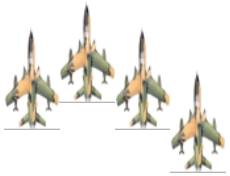
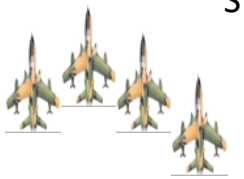
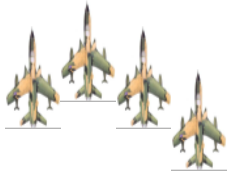




Strike Force





"MiG CAP"
Fighter Escorts

"MiG CAP"
Fighter Escorts

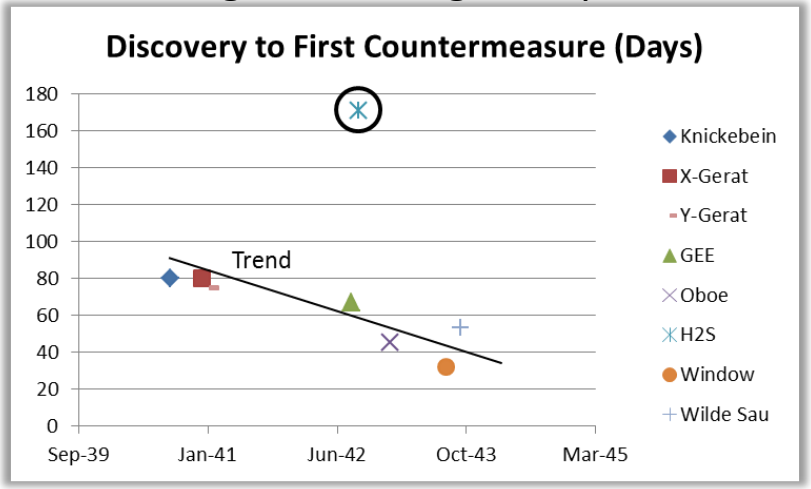
EB-66
Standoff Jammer
EC-121 AEW

By 1968 support aircraft often outnumber strike aircraft resulting in "virtual attrition."

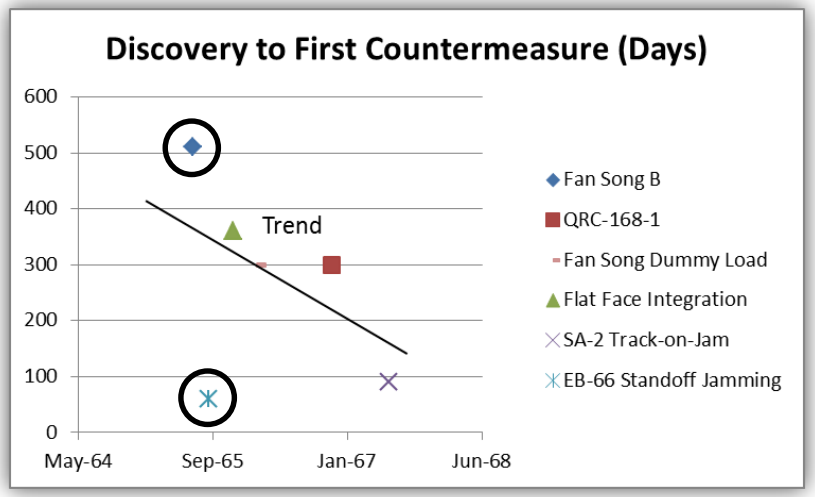
Important systems had relatively brief lives once discovered by opponent

- **Time from introduction of an innovative system to fielding of a countermeasure generally shorter than development time of the innovation**
- **Cycle time decreases as conflict duration increases**
- **Systems working in new ways (H2S, SA-2) take longer to counter**
- **Anticipated measures (EB-66 Jamming) take less time**

WWII Night Bombing Competition



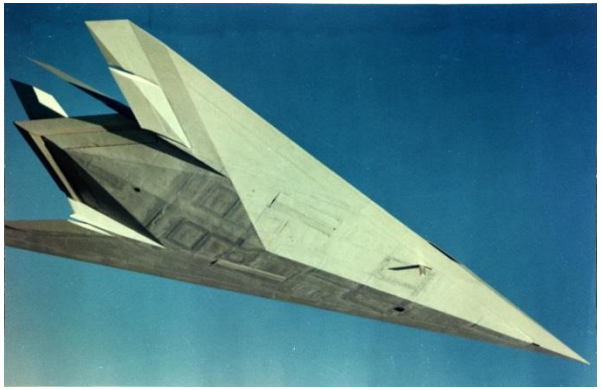
Rolling Thunder Competition



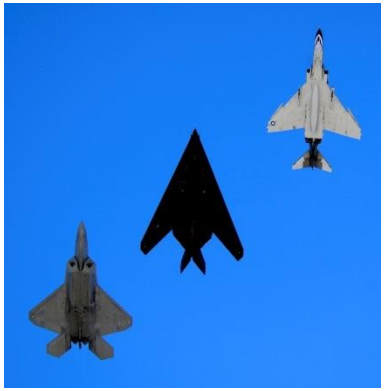
The U.S. seeks a new approach

- **U.S. experience in Vietnam and IAF experience in October War showed:**
  - **Even with massive support packages and advanced ECM attrition is still a concern**
  - **Introduction of new systems (e.g. SA-2) can dramatically change combat outcomes in short period of time**
  - **Big 'last mover' advantage in ECM/ECCM competition**
- **U.S. begins serious search for a "new approach" to aircraft survivability**
  - **Eventually invests in stealth to change the nature of the competition from active vs. active to active vs. passive in the EM realm**
- **What is next?**
  - **Increasing reliance on active ECM as counter-LO EM sensors proliferate**
  - **Increasing centrality of IR sensors and weapon seekers as LO aircraft proliferate on both sides**
    - Calls into question utility of supercruise and afterburners

Have Blue
(DARPA Initiative 1974)



Combat Aircraft
Design Transformed



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IADS vs. air attack insights

- **Aircraft get shot down over enemy territory providing adversary *physical access* to innovative systems—this often aids in fielding countermeasures**
  - **Corollary: It is better to wait until innovative systems can be fielded "en mass" to achieve significant results than to introduce them piecemeal and risk early compromise**
- **IADS goal is to minimize damage to important assets, not (necessarily) to shoot down aircraft**
- **Great sensitivity to "actual attrition" makes air attackers very susceptible to "virtual attrition"**
  - **Rising support : strike sortie ratios likely indication that a "jump" is required**

Major insights from past battle network competitions

- **Network attributes depend heavily on operational metrics**
  - **Avoiding subs or night fighters is "good enough"—don't have to kill them all**
- **Tempo of operations influences decision to exploit or disrupt opposing network**
  - **Short duration of air operations makes disruption more attractive**
  - **Slower pace of submarine warfare makes exploitation more attractive**
- **"Virtual Attrition" is often more important and cost-effective than platform destruction**
  - **Forcing opponent to operate less effectively or efficiently**
- **Competitions accelerate and culminate, then jump to new mode**
  - **Competitions "jump" when one side fields systems that defeat the opposing network (usually wide area and/or localization sensors) at the *physics level***
  - **Signs a competition may be nearing culmination include:**
    - Increasing support requirements to enable operations (Rolling Thunder)
    - Useful life of innovations measured in weeks
    - In peacetime, inability to significantly improve KPPs at affordable cost and/or in a reasonable time
- **In some cases one side or the other is "saved by the bell" when a conflict ends just before a competition jumps to a new mode**
  - **Identifying and preparing for new basis of competition important for future success**

CSBA

Center for Strategic and Budgetary Assessments

Questions?