Six Decades of Guided Munitions

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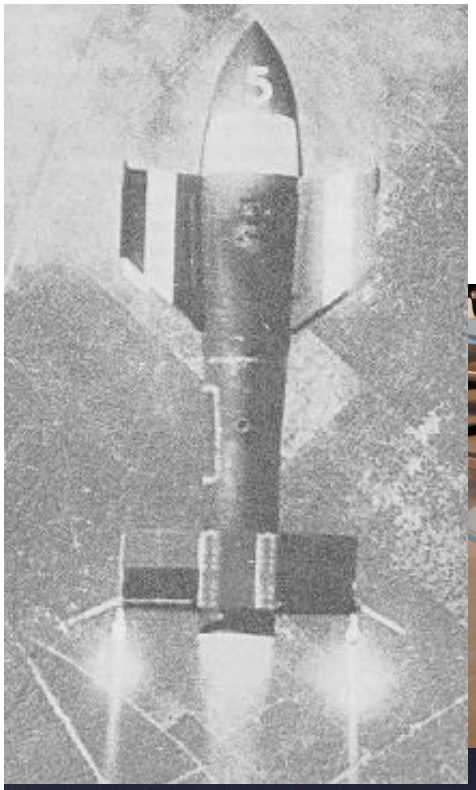
Precision Strike Association
25 January 2006

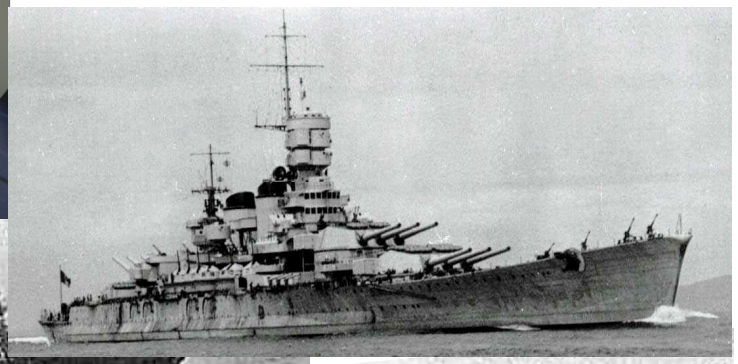
Fritz X (PC 1400 FX)

Radio/wire-controlled German glide bomb

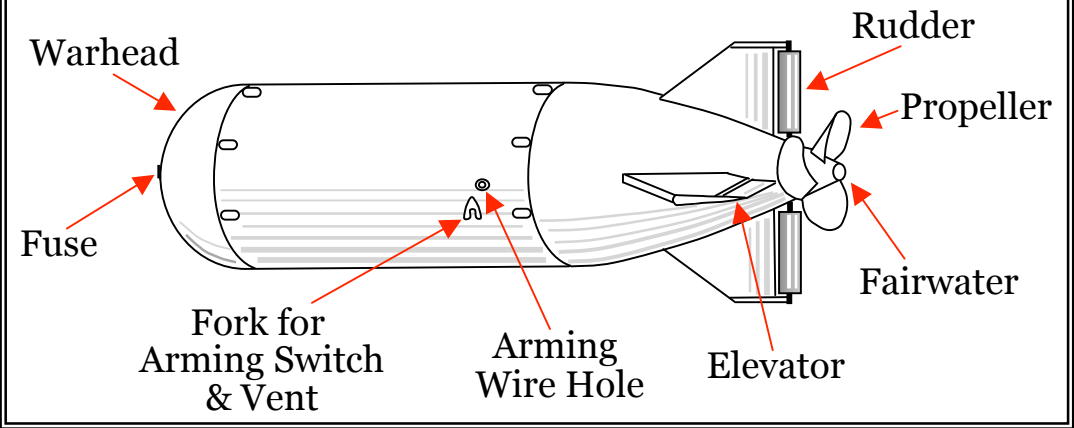
Length: 11.2 feet
Weight Loaded: 3,454 lbs
Warhead Weight: 705 lbs

In September 1943, Do 217 aircraft sunk the Italian battleship *Roma* with 2 Fritz Xs.





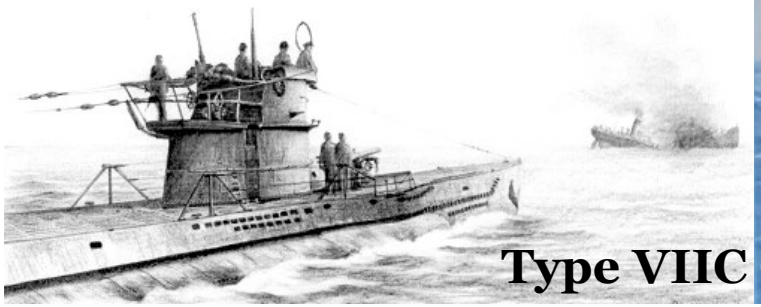
FIDO MARK 24 "MINE"



A PBY-5A sunk *U-640* on 14 May 1943—believed to be the first sinking by a Mark-24 torpedo

Credited with sinking 37 enemy submarines & damaging 18 others

Length: 7 ft
Weight: 680 lbs
Warhead: 92 lbs Torpex
Guidance: Acoustic
Range: 4,000 yards
Speed: 12 knots

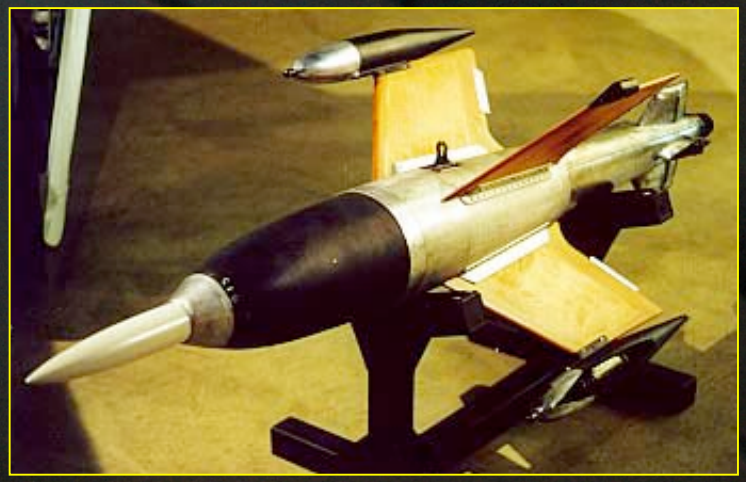


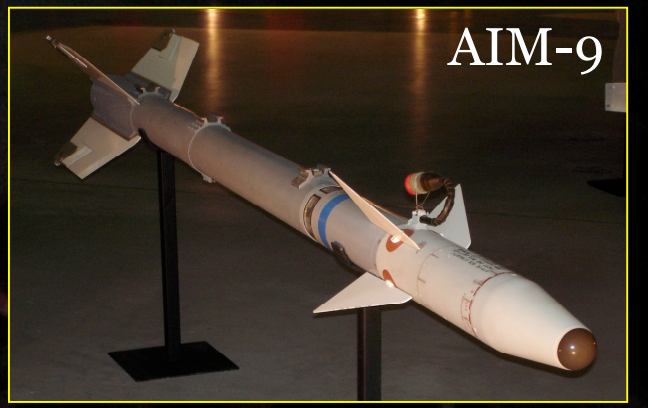
Type VIIC German U-boat

Ruhrstahl X-4

German air-to-air missile

Wire-guided via joystick with acoustic fuse (B-17 engines)





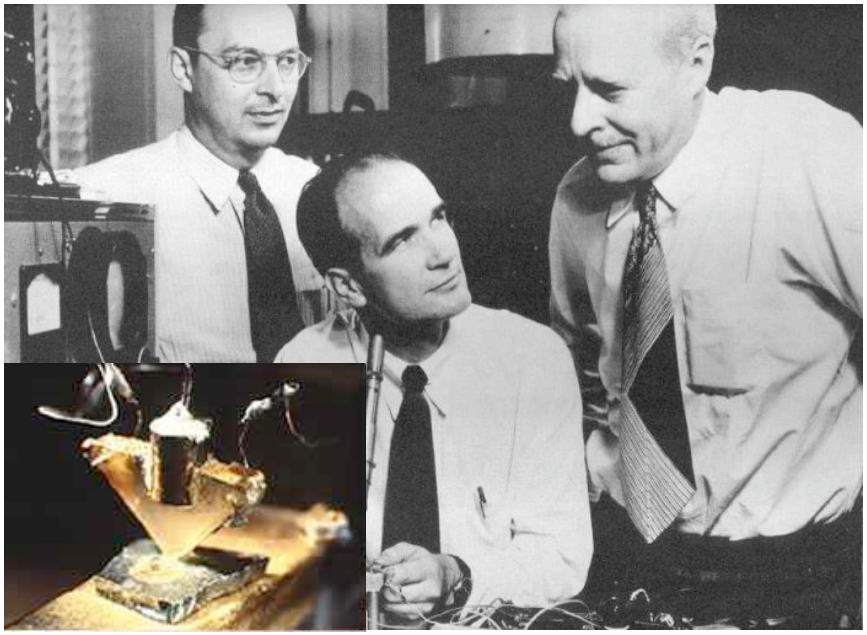
AIM-7E Southeast Asia *USAF Photo*

AIM-7E-2

AIM-7D, 7E, 7E-2: Combat Results in Vietnam 1965-73

Firing attempts: 612
Hits: 97 (15.8%)
Kills: 56 (9.2%)*
BVR Kills: 2

* *Project Red Baron III,* Vol. 1, *Executive Summary*, p. 18.



John Bardeen, William Shockley, Walter Brattain, Bell Labs, 1947

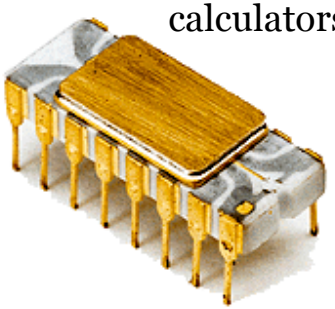
The Nobel Prize in Physics 1956

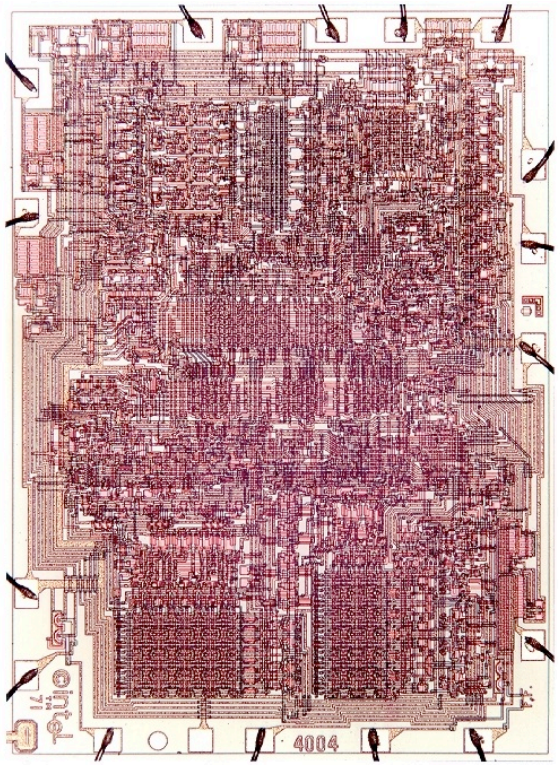
"for their researches on semiconductors and their discovery of the transistor effect"

Intel's 4004 Microprocessor, 1971

Invented by **Federico Faggin**, **Ted Hoff**, & **Stan Mazor**

A 4-bit, 740 KHz, CPU designed for "embedded applications" such as calculators

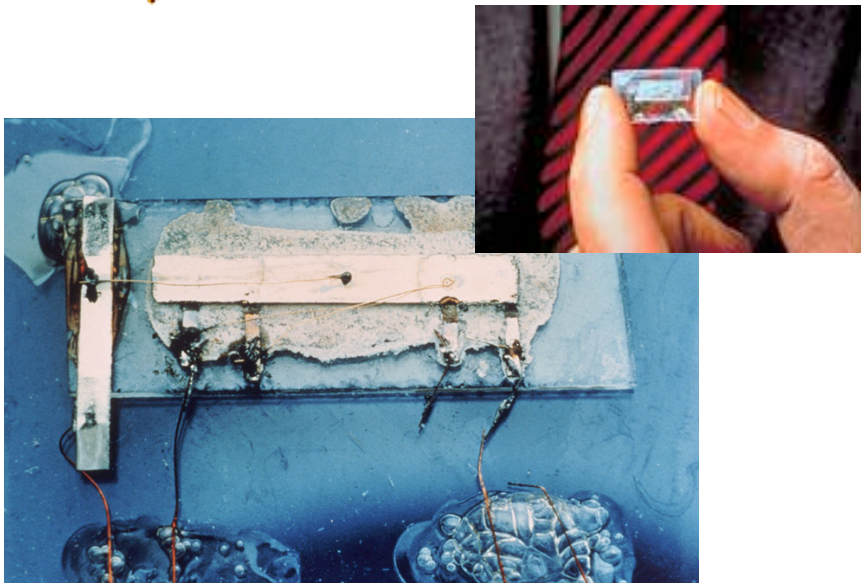




The Integrated Circuit, 1958-59

Invented independently by **Jack Kilby** (Texas Instruments) & **Robert Noyce** (Fairchild Semiconductors)

Kilby shared 1/2 the 2000 **Nobel Prize** in physics "for his part in the invention of the integrated circuit"

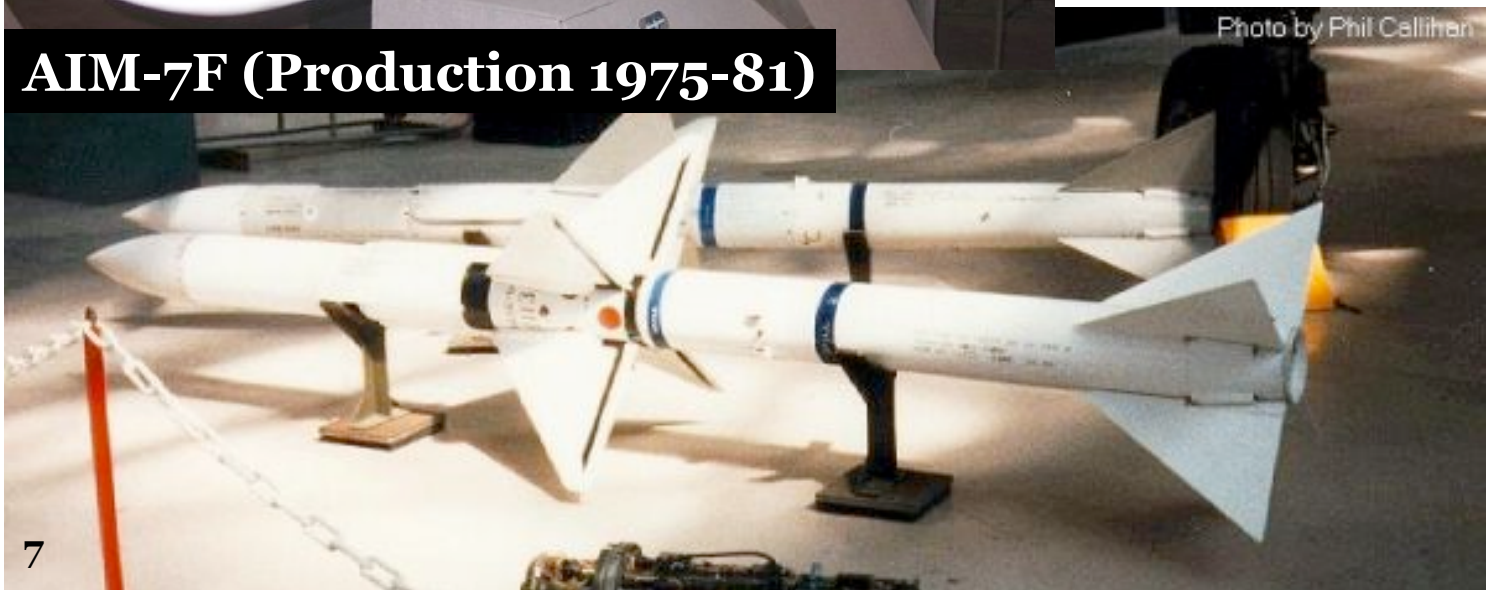


AIM-7M *Decisive Engagement* Results in Operation Desert Storm, 1991

Firing attempts: 44*
Hits: 30 (68.2%)
Kills: 24/26 (54.5%/59.1%)
Initial BVR Shots: 19 (43%)

** Omits 44 "expenditures" in logistics records not in decisive engagements*

AIM-7F (Production 1975-81)



GBU-28A/B (4,700 lbs)

GBU-10 (2,081 lbs)

GBU-24/B (2,315 lbs)

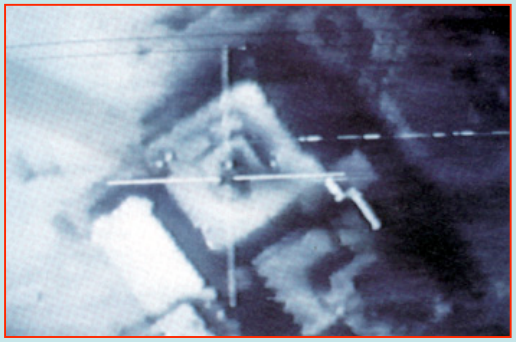
GBU-16 (1,092 lbs

GBU-27/B (2,350 lbs)

GBU-12 (611 lbs)

GBU-22/B (720 lbs)

F-117 in 1991:

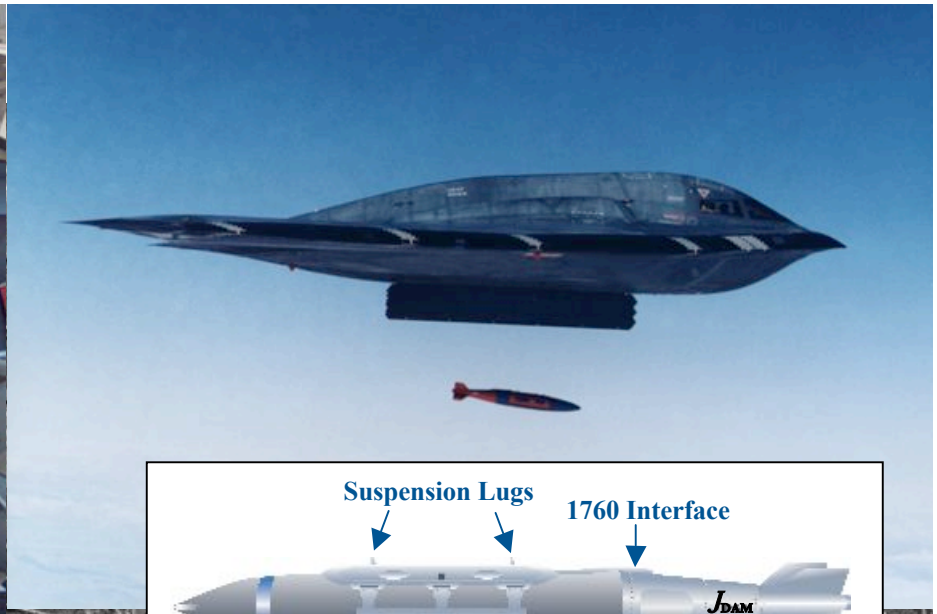


2,065 munitions dropped during **1,299 sorties**

- **1,651 Hits (80% excluding no-drops)**
- **414 Misses**
- Clear-air limited

1.4 strikes/sortie versus

- 0.125-0.250 for F-111Es in Desert Storm
- 0.001 or less for B-17s in WW II



JDAM Impact

JDAM Impact

JDAM Impact

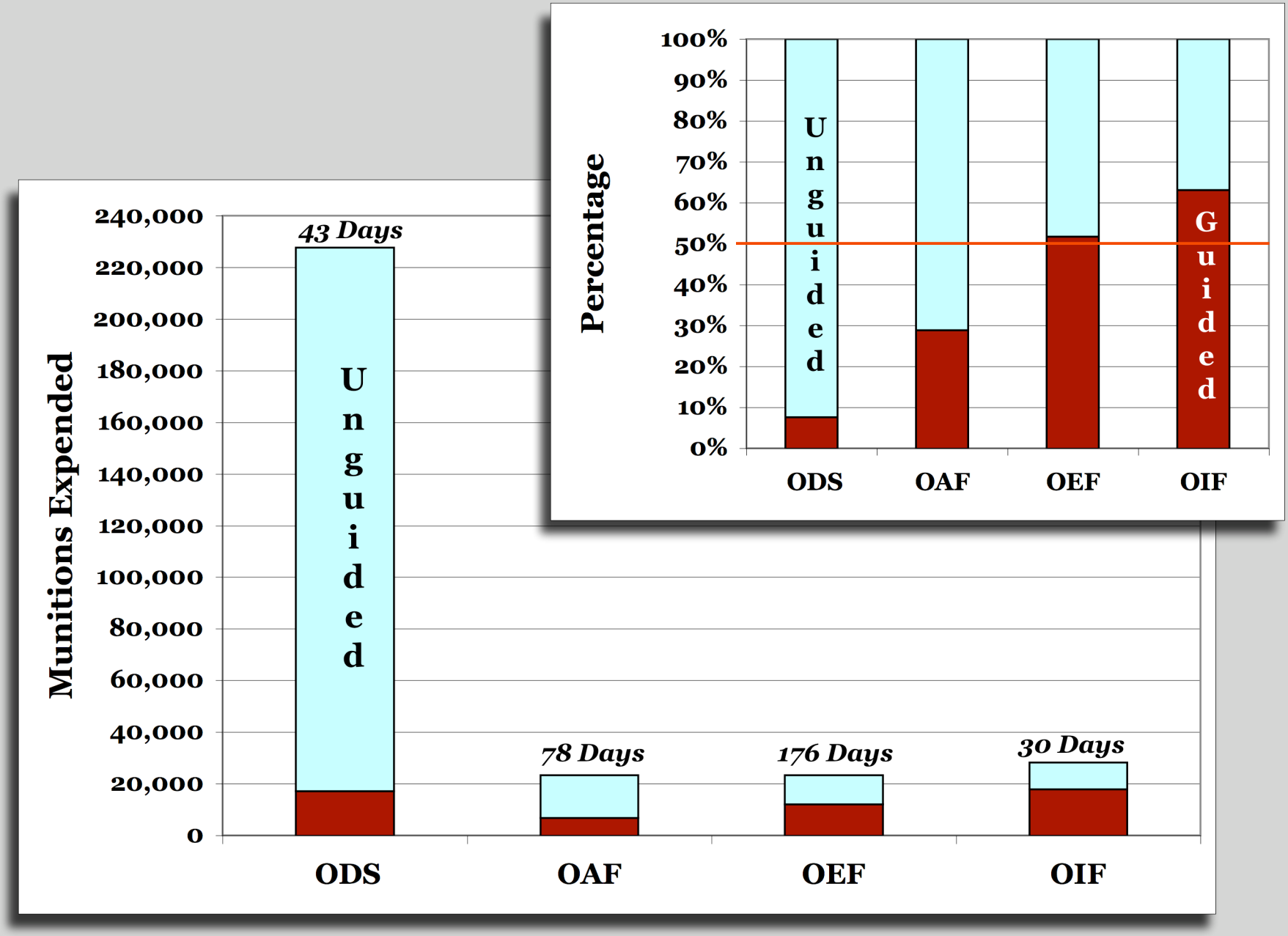
JDAM Impact

JDAM Impact

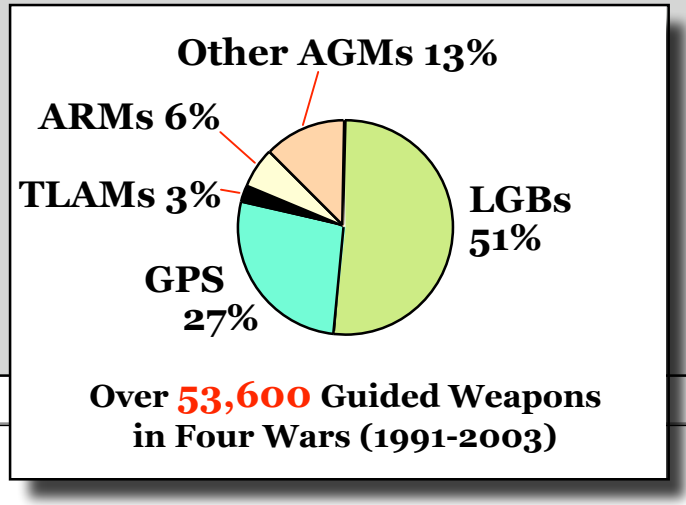
JDAM Impact

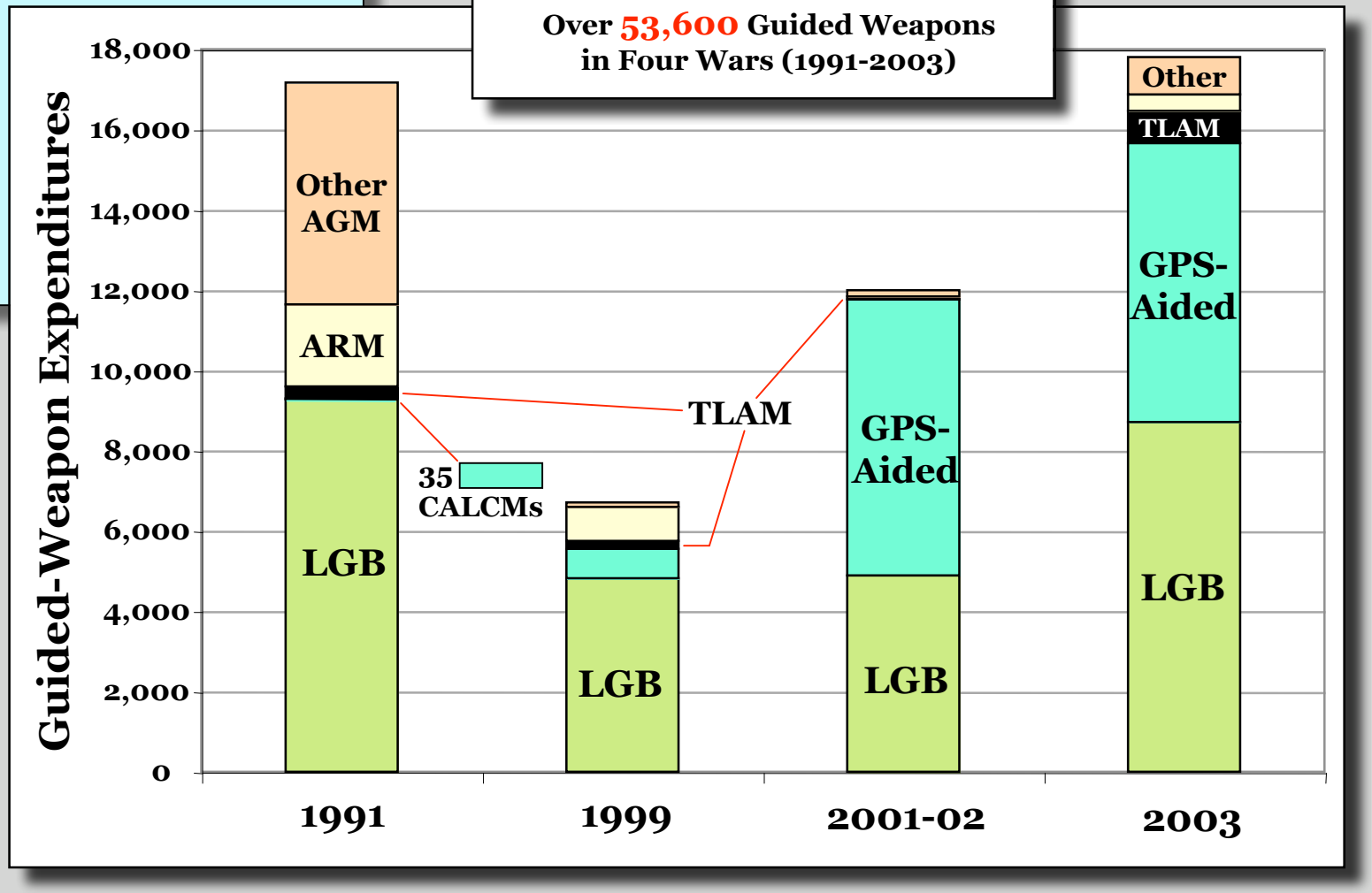
MiG-29s

Post-strike Obvra Base, Serbia, following 17 April 1999 B-2 Strike

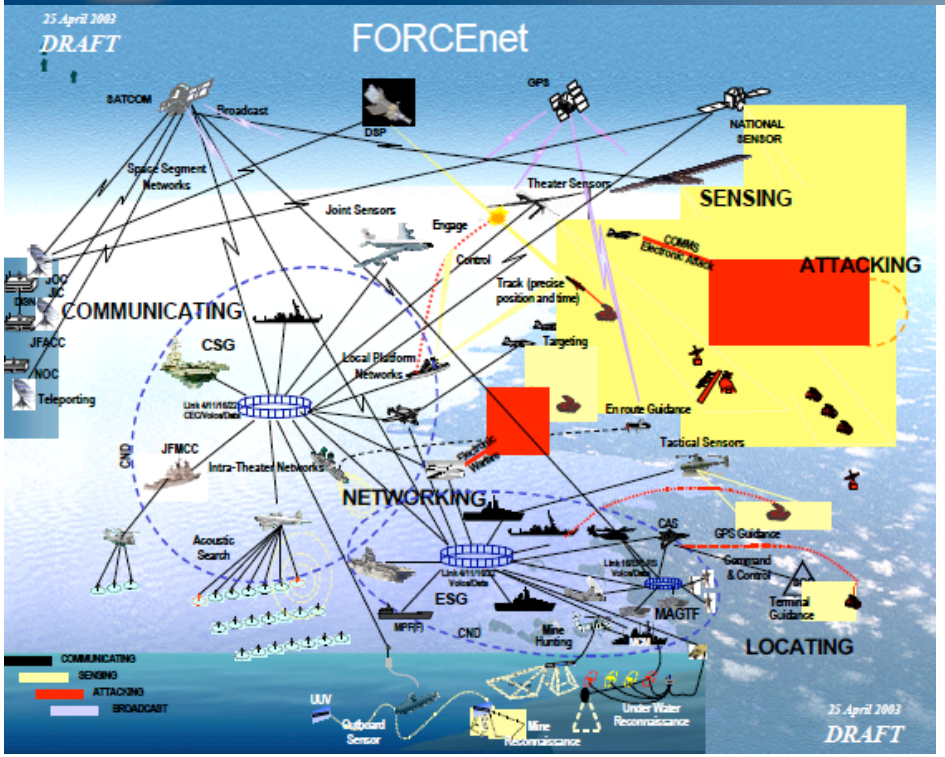

Munitions Expended
240,000
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
43 Days
78 Days
176 Days
30 Days
Unguided
ODS
OAF
OEF
OIF
Percentage
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Unguided
Guided
ODS
OAF
OEF
OIF

AGM = Air-to-Ground Munition (Maverick, etc.)
ARM = Anti-Radiation Missile (HARM, Shrike)
LGB = Laser-Guided Bomb
TLAM = Tomahawk Land Attack Missile
CALCM = Conventional Air Launched Cruise Missile
GPS = Global Positioning System (mostly JDAM & CALCM)

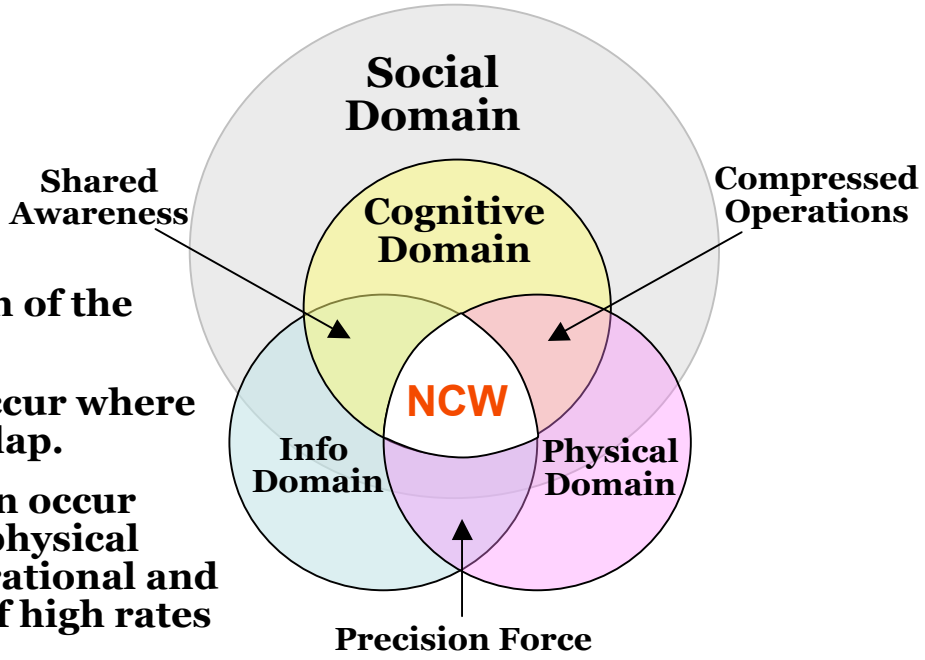




Office of Force Transformation
Network-Centric Operations



Network Centric Warfare (NCW) exists at the intersection of the social, cognitive, information & physical domains.



Precision force "is created at the intersection of the information and physical domains."

Shared awareness and tactical innovation occur where the information and cognitive domains overlap.

Time compression and lock-out phenomenon occur within the intersection of the cognitive and physical domains, enabling tactics to give rise to operational and even strategic effects and the development of high rates of change.

RAND PROJECT AIR FORCE

Learning Large Lessons:
The Evolving Roles of Ground Power and Air Power in the Post-Cold War Era

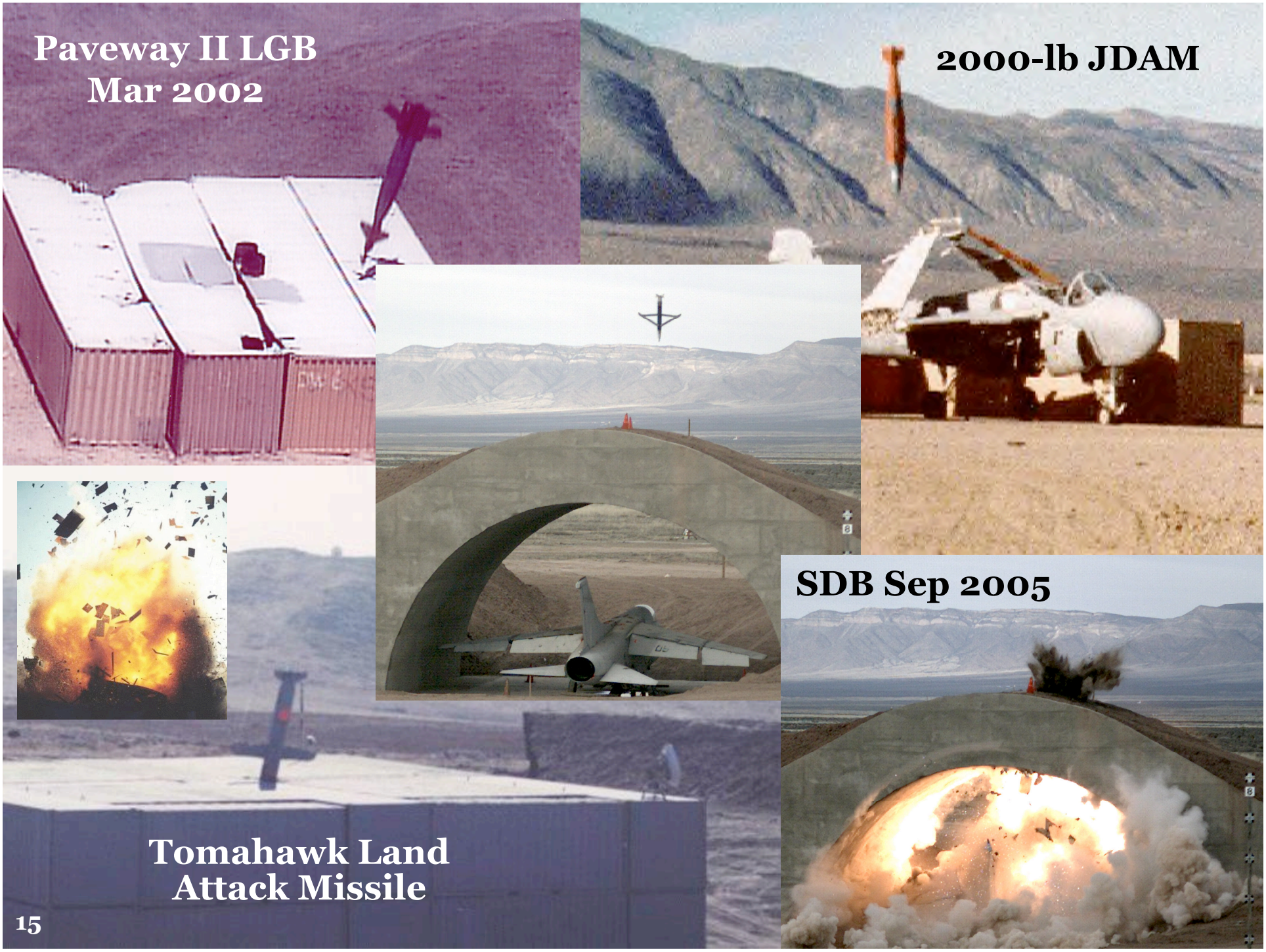
Dr. Dave Johnson

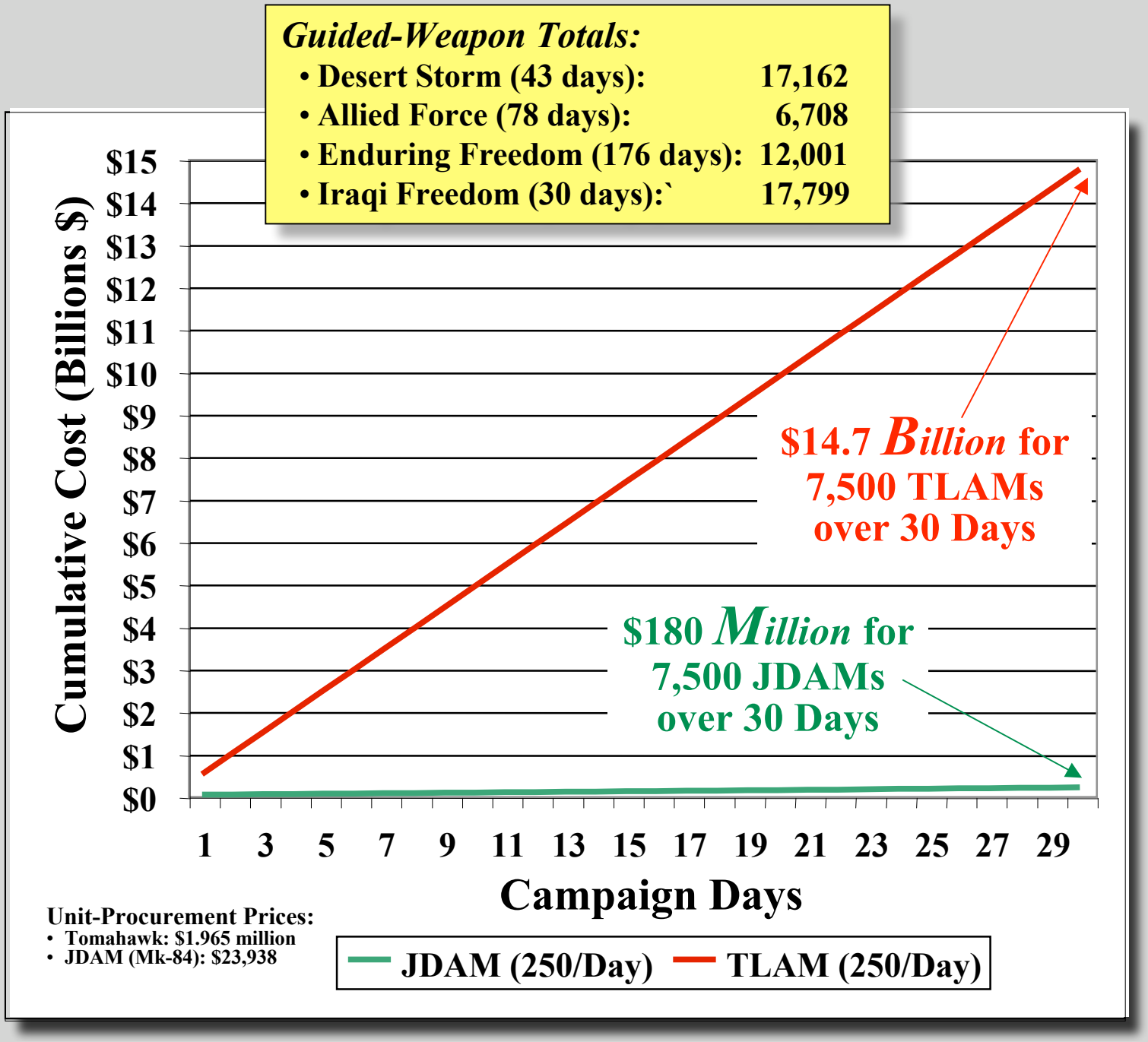
Principal Warfighting Insights

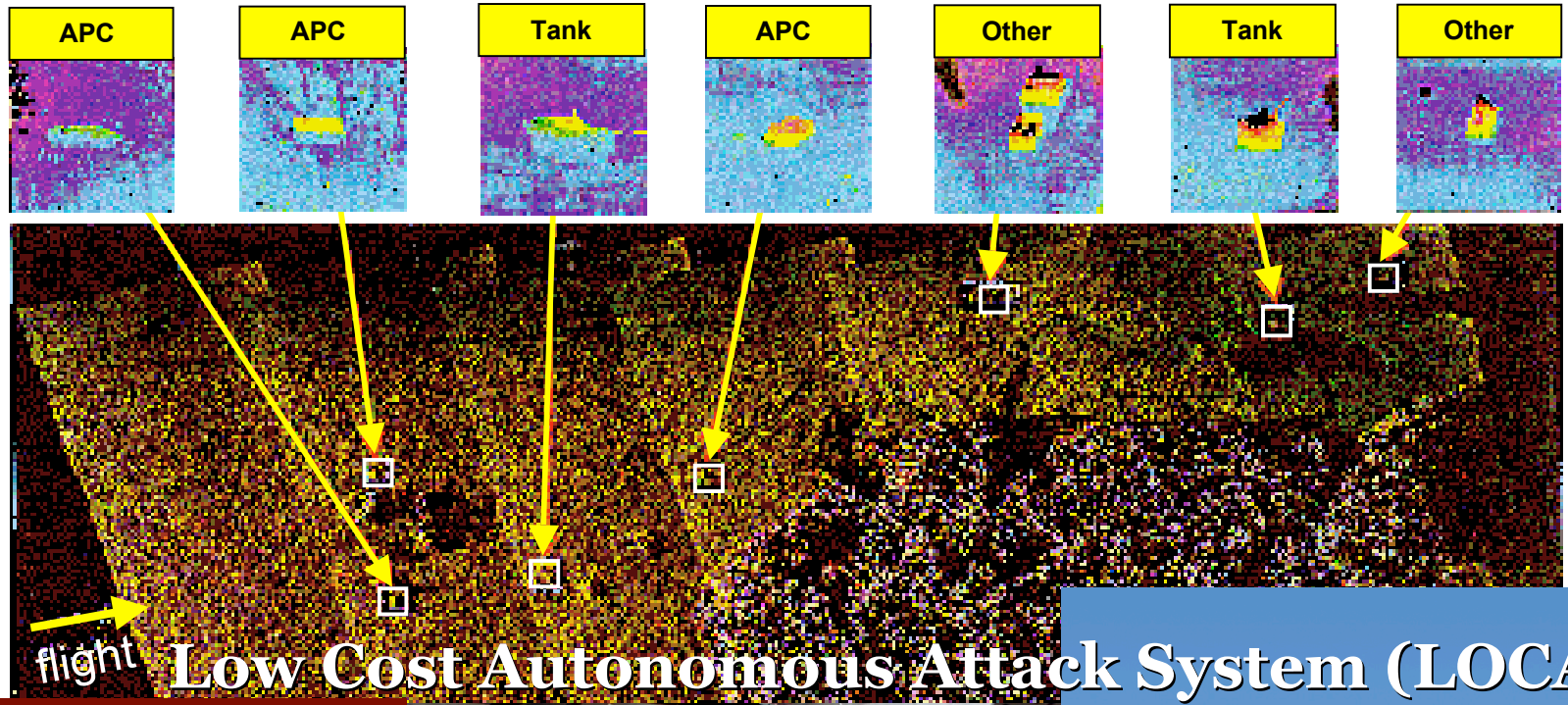
- Today's environment:
  - Fixed-winged air power, enabled by C4ISR, largely operates with impunity, setting the conditions for:
    - Air dominance of a theater
    - Effective attack of enemy fielded forces at the strategic and operational levels
    - Joint force dominant maneuver
  - Ground power, enabled by air dominance is:
    - The decisive element at the tactical level (where situational awareness is still problematic)
    - The key at the strategic level in achieving national objectives after the warfight

The OIF Operational Realities

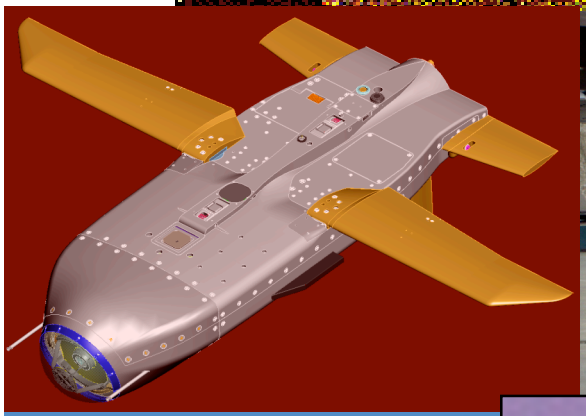
- **Total Apache deep attack sorties: < 80**
- **Fixed-wing KI/CAS DMPIs struck: > 15,500**


Paveway II LGB
Mar 2002
2000-lb JDAM
SDB Sep 2005
Tomahawk Land
Attack Missile

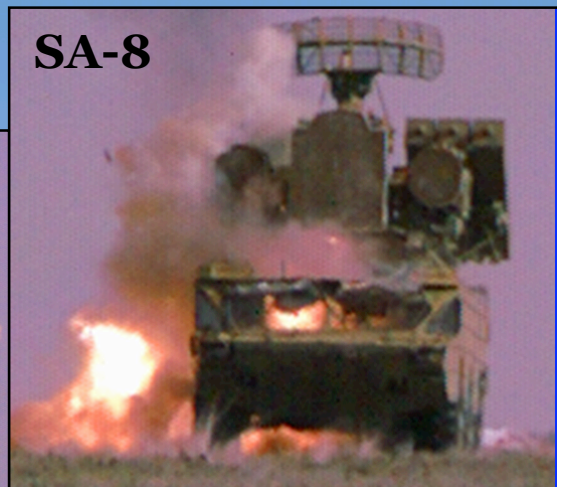

Guided-Weapon Totals:
• Desert Storm (43 days): 17,162
• Allied Force (78 days): 6,708
• Enduring Freedom (176 days): 12,001
• Iraqi Freedom (30 days):` 17,799
Cumulative Cost (Billions $)
$15
$14
$13
$12
$11
$10
$9
$8
$7
$6
$5
$4
$3
$2
$1
$0
$14.7 Billion for 7,500 TLAMs over 30 Days
$180 Million for 7,500 JDAMs over 30 Days
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Campaign Days
Unit-Procurement Prices:
• Tomahawk: $1.965 million
• JDAM (Mk-84): $23,938
JDAM (250/Day)
TLAM (250/Day)



Low Cost Autonomous Attack System (LOCAAS)



SA-8



Conclusions

- Long Gestation: 6 Decades & Counting
- Variable Acceptance (Early Adopters vs Skeptics)
- U.S. Trends:
  - Movement toward mostly precision campaigns
  - Robust guidance mix (laser, GPS, etc.)
  - Increasingly robust sensor & targeting networks
- Nuclear Caveats
- Past Thresholds ("revolutionary"):
  - LGBs
  - Solid-state electronics
  - TLAM + LGBs: accuracy independent of range
  - OIF: a changed relationship between air & ground
- Future Thresholds
  - Precision attack of imprecisely located DMPIs (LOCAAS)
  - Long-range & accuracy independent of cost

Conclusions of a 2001 DSB

Defense Science Board Task Force

on

HIGH ENERGY LASER WEAPON SYSTEM APPLICATIONS

June 2001

Office of the Under Secretary of Defense
For Acquisition, Technology, and Logistics
Washington, D.C. 20301-3140

- **High-energy laser (HEL) technologies have matured enough for fielding on aircraft, space vehicles, ships & ground vehicles to be "feasible over the next two decades"**
- **HEL systems are an area of exploitable U.S. technological advantage**
- **HEL systems offer speed-of-light engagement of a variety of targets with a range of precisely controlled effects & low-cost-per-shot**

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