Rare Earth Materials

Overview – Critical Military Uses

Date: February 24, 2011

To: Rare Earth Roundtable

Presented By: **TBD**

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Military Uses

- **Jet fighter engines and other aircraft components, including generators that produce electricity for aircraft electrical systems;**
- **Missile guidance systems, including precision guidance munitions, lasers, and smart bombs;**
- **Electronic countermeasures systems;**
- **Underwater mine detection systems;**
- **Antimissile defense systems;**
- **Range finders, including lasers; and**
- **Satellite power and communication systems, including traveling wave tubes (TWT), rare earth speakers, defense system control panels, radar systems, electronic counter measures, and optical equipment.**

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Military Applications (cont.)

Air to Air Missiles – Rare earth magnet motors and actuators control flight trajectory.

AIM –9X Sidewinder

[Ref 18, p. 5]

Military Applications (cont.)

Air-to-Surface Missiles - Fins are controlled by rare-earth magnets that direct the missile based on guidance data from rare-earth microwave-sensing devices.

AIM-120 AMRAAM

AIM-120
AMRAAM missile launch

[Ref 18, p. 5]

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Military Applications (cont.)

Cruise missiles - The guidance system of the Tomahawk is connected to tail control fins that use direct drive rare earth magnet actuators.

[Ref 18, p. 6]

Military Applications (cont.)

Smart bombs – Precision guidance ordnance use rare-earth actuators to control fin surfaces during delivery.

[Ref 18, p. 6]

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Military Applications (RE Lasers)

- **Nd:YAG lasers are used as rangefinders, target designators, and target interrogators.**
- **Rare-earth laser interrogators are used for enemy detection and countermeasures.**

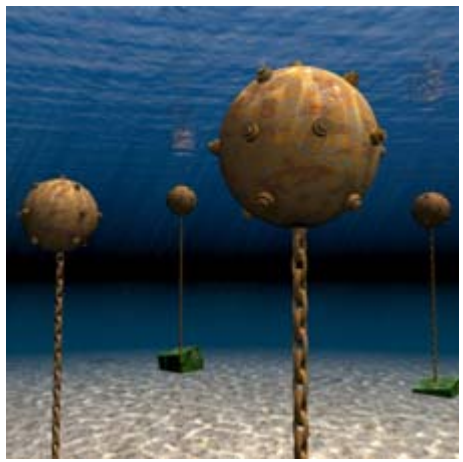
Laser targeting system on Abrams M1A1 tank

Nd:YAG designator-rangefinder laser

[Ref 18, p. 6]

Military Applications (RE Lasers cont.)

- **The airborne "Magic Lantern" uses a blue-green frequency-doubled Nd:YAG laser to scan below the water surface for mines.**



Magic Lantern Mine Detection Laser System with Rare Earths

[Ref 18, p. 7]

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Military Applications (cont.) (RE Communications Systems)

Satellite Communications

- **Traveling wave tubes (TWT) and klystrons that generate and amplify microwaves use rare-earth magnets in their waveguides. Rare earth permanent magnets are used to focus electron beams in TWT and klystrons.**

Erbium-doped fiber and fiber amplifiers

- **Applied in high-capacity fiber optic systems.**

TWT amplifier for satellite communications

klystron

[Ref 18, p. 7-8]

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Military Applications (RE Speakers)

- **Decoy speaker systems**
- **Stealth technology – Noise cancellation technology uses NdFeB magnets and Terfenol-D speakers to reduce the acoustic signature of helicopter blades.**

High power speaker systems

Noise cancellation

[Ref 18, p. 8]

Military Applications (RE Aircraft)

- **Actuators for flight control surfaces of aircraft, including flaps, rudder, and ailerons.**

- **Thermal barrier coatings (yttria-stabilized zirconia) in "hot" sections of jet engines.**

Flap actuator

Hot section thermal barrier coatings

[Ref 18, p. 8-9]

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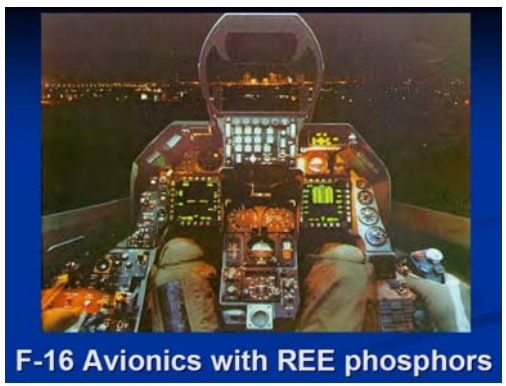
Military Applications (cont.) (RE Displays and Optics)

- **Weapons systems/avionics displays – rare earth phosphors for enhanced vision**
- **Optics - cerium-based compounds are used as polishing media for many types of optical lenses encountered in the battlefield.**

[Ref 18, p. 9]


F-16 Avionics with REE phosphors

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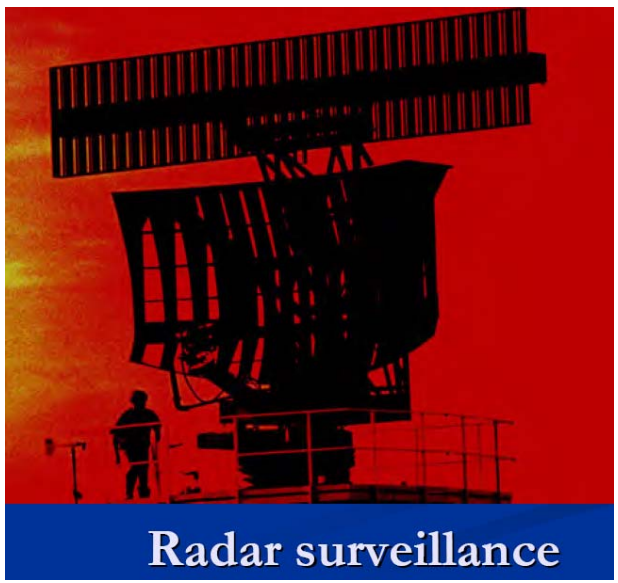
Military Applications (RE Rader)

- **Radar traveling wave tubes (TWT) use rare earth magnets to focus the microwave energy. Used in radars systems for air traffic control, search and surveillance, and weapons fire-control.**
- **Yttrium-iron garnets (YIG) and yttrium-gadolinium garnets (YGG) are used in phase shifters, tuners, and filters.**
- **PATRIOT (Phased Array Tracking to Intercept of Target) air defense missile system.**



[Ref 18, p. 10]

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Military Applications (cont.) (RE Sonics/Ultrasonics)

Sonar - Terfenol-D rare-earth alloy is used for high-power sonar on ships and submarines.

Ultrasonic transducers are used in ultrasonic welding and ultrasonic machining.

[Ref 18, p. 11]

Sonic transducers (Terfenol-D) – used by the oil industry to increase the strategic supply of oil by enhance freeing oil from formations.

High power transducer

Ultrasonic machining

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Military Applications (cont.) (RE Electronic Countermeasures)

U.S. Navy EA-18 Growler with electronic warfare avionics suite

[Ref 18, p. 12]

Chinese JH-7A fighter with unknown electronic jammer

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