PRESENTATION TO COMMITTEE ON SPACE-BASED ADDITIVE MANUFACTURING OF SPACE HARDWARE

Colonel Rex R. Kiziah
Permanent Professor and Head
Department of Physics, USAF Academy
(Presenting for Air For Space Command Chief Scientist Office)

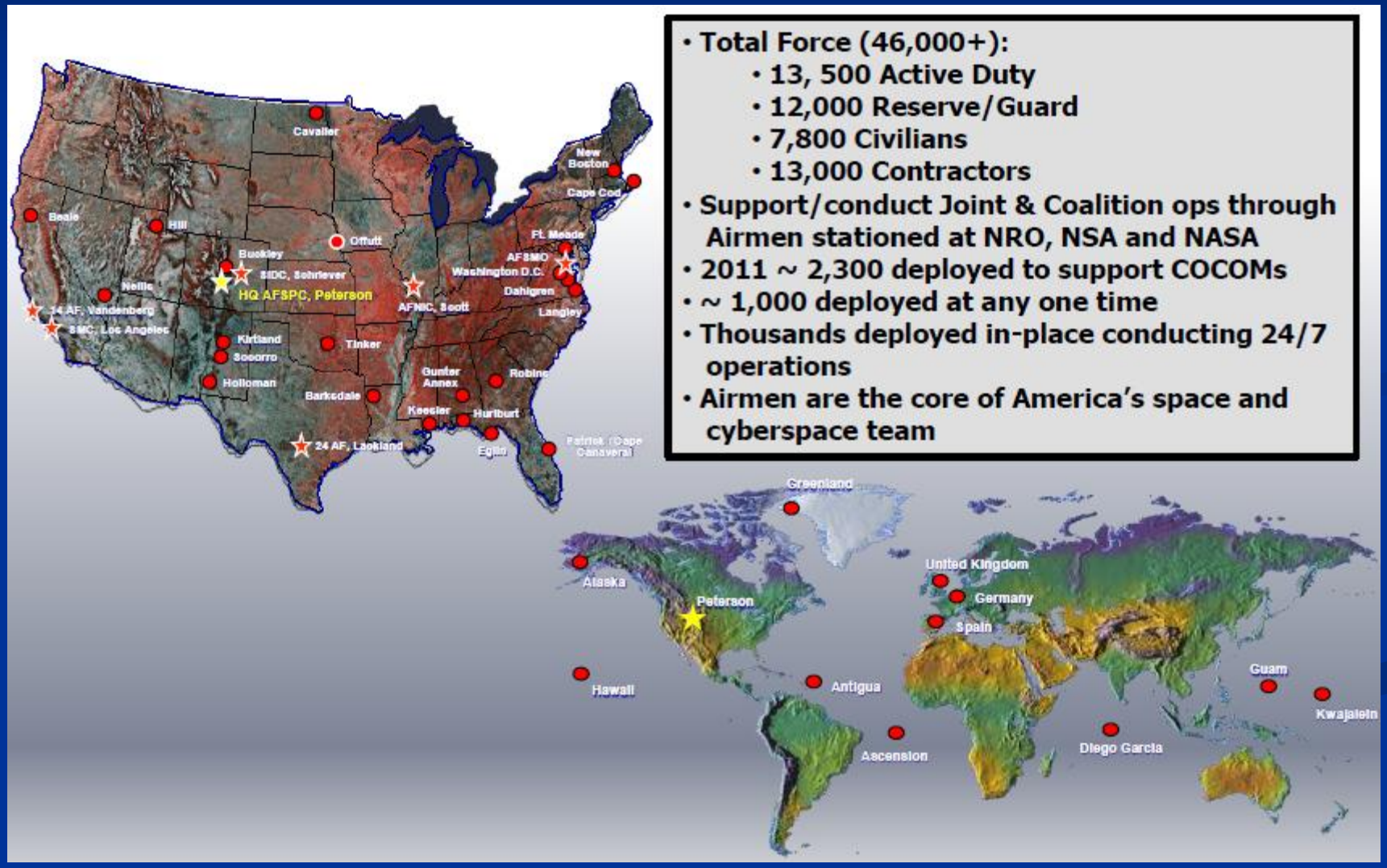
20 August 2013

Contact Info:
rexkiziah@usafa.edu
(W) 719-333-3510/2423
(C) 719-200-6762

INTRODUCTION

- 3D printing humor
  - http://www.youtube.com/watch?v=tsz9GUZv1IA

AIR FORCE SPACE COMMAND



- Total Force (46,000+):
  - 13, 500 Active Duty
  - 12,000 Reserve/Guard
  - 7,800 Civilians
  - 13,000 Contractors
- Support/conduct Joint & Coalition ops through Airmen stationed at NRO, NSA and NASA
- 2011 ~ 2,300 deployed to support COCOMs
- ~ 1,000 deployed at any one time
- Thousands deployed in-place conducting 24/7 operations
- Airmen are the core of America's space and cyberspace team

AIR FORCE SPACE COMMAND

***14TH AIR FORCE*:**

Provides space capabilities for joint fight through operational missions of spacelift, PNT, satellite comms, missile warning & control

***SPACE AND MISSILE SYSTEMS CENTER*:**

Designs and acquires all AF and most DoD space systems; oversees launches, completes on-orbit checkouts

***24TH AIR FORCE*:**

Provides combatant commanders w/ trained and ready cyber forces which plan and conduct cyberspace operations

AIR FORCE SPACE COMMAND

- **Space Capabilities:**
  - **Spacelift ops at East & West launch bases—DoD, NASA, commercial launches**
  - **Command and control of all DoD satellites**
  - **In-theater secure communications; weather and navigational data for ground, air and fleet operations; threat warning**
  - **Monitor ballistic missile launches around the world to guard against surprise attack on North America**
  - **Tracking/characterization of satellites & space debris**
  - **Protecting U.S. space assets**

AIR FORCE SPACE COMMAND

- **Cyberspace Capabilities:**
  - **Assure the mission—finding and using best tools, skills, and capabilities to ensure ability to fly, fight, and win in air, space and cyberspace**
  - **Conduct cyberspace operations through subordinate units within 24th AF**
  - **Establish, operate, maintain and defend AF networks and conduct full-spectrum operations**

AFSPC SPONSORHSIP OF STUDY

- No AFSPC requirements for additive manufacturing in general/specific to satellite design/build/launch/ops
  - AFSPC does not specify for industry the “how to” for satellite design, build and launch
  - AFSPC develops only performance requirements
- AFSPC and AFRL together identify S&T needs relevant to AFSPC mission areas
  - To be discussed by Dr. Greg Spanjers, AFRL Space Capability Lead
  - Findings and recommendations of this study will feed into AFRL, Space & Missile Systems Center and AFSPC activities

AFSPC SPONSORHSIP OF STUDY

- **AFSPC Long-Term Science and Technology (S&T) Challenges (AFSPC/CC Memorandum 30 Dec 2011)**
  - **Eliminate cyber restrictions that limit situational awareness; command, control, comms and computers; positioning, navigation and timing; and cyber ops**
  - ***Provide full-spectrum launch capability at dramatically lower cost—enable rapid, routine, affordable (>10x) and responsive access to space**
  - **Provide real-time, predictive, cross-domain, assured situational awareness**
  - ***Establish resilient space/cyber systems—enable rapid reconstitution and reconfiguration (exploit fractionated, composable, virtual and self-configuring technologies)**

AFSPC SPONSORHSIP OF STUDY

- **AFSPC and Air Force Office of Scientific Research Visionary Workshop (April 2012)**
  - **Purpose: Gain critical insight into scientific advancements & technological breakthroughs that will fuel next revolutions in space and cyberspace**
  - **Assembled group of "big thinkers" *outside AF, DoD, government and space community* in effort to generate key insights for AFSPC to consider for 2030 and beyond**
  - **One of insights from the workshop was idea of on-orbit additive manufacturing of satellites due to potential (perhaps revolutionary) implications with respect to launch, satellite design and space operations**

AFSPC STUDY NEEDS

"If what you're doing is not seen by some people as science fiction, it's probably not transformative enough." **Sergey Brin**

- **5 Primary Tasks of Study Statement of Task are NOT equally important from AFSPC perspective**
  - **Tasks 1 and 2 should not be emphasis areas—information from these tasks are needed as baseline/"launching point" for committee, but already exists**
  - ****Tasks 3, 4, 5 (4 additional tasks if funding/time permit) should be emphasis areas**
    - **Study effort to be an in-depth exploration of "what could be"**
    - **Study should be as forward looking into the future as reasonably possible (20 to 40 years)**
    - **AFSPC specifically interested in *a future capability to additively manufacture in space a fully functional spacecraft and the implications of such a capability for spacecraft design, launch and on-orbit operations***

SOME AF STUDIES

- FY2013 AF Scientific Advisory Board Study: Microsatellite Mission Applications (FOUO, but final study abstract is publicly releasable)
- Global Horizons Final Report, USAF Global Science and Technology Vision, AF/ST TR 13-01, 21 June 2013
- Technology Horizons: A Vision for Air Force Science and Technology 2010-30, AF/ST-TR-01-PR, September 2011

SUGGESTIONS FOR PEOPLE, ORGANIZATIONS TO ENGAGE

- Terry T. Wohlers, Wohlers Associates, Inc. (Wohlers Annual Report on Additive Manufacturing)
- Professor Hod Lipson, Director of Cornell's Creative Machines Laboratory—pioneering additively manufactured robots—"robot strolls out of 3D printer"
- W. M. Keck Center for 3D Innovation, UTEP (Professor Ryan Wicker is part of study committee)
- National Additive Manufacturing Innovation Institute
- Oak Ridge National Laboratory Manufacturing Demonstration Facility (Craig Blue)
- Lawrence Livermore National Laboratory (Chris Spadaccini)
- GE Aviation; Optomec, Inc.; PARC; Stratasys Digital Materials Team
- VA Tech DREAMS Laboratory (Dr. Chris Williams)

AFSPC STUDY NEEDS

- **Questions?**

"If what you're doing is not seen by some people as science fiction, it's probably not transformative enough."
Sergey Brin