SMC Industrial Base & Mission Assurance Practices

Supply Chain 2016

8th NASA Supply Chain Quality Assurance Conference October 25 – 27, 2016 NASA Goddard Space Flight Center (GSFC)

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FRE & MISSILE SYSTEMS CENTR

Mr Dave Davis SMC Chief Systems Engineer 25 Oct 2016 SMC/EN



SMC Space Mission Portfolio



Space Superiority Space Situation Awareness - SBSS - Space Fence

Defensive Counter Space Offensive Counter Space



e <u>Space Support</u> Launch Systems Spacelift Range Sat Control & Network



FOUR MAJOR MISSION AREAS

Force Application Conventional Missiles Prompt Global Strike

WE DEVELOP, ACQUIRE, FIELD AND SUSTAIN SYSTEMS IN

SPACE AND MISSILE SYSTEMS CENTER

Space Force Enhancement Milstar/AEHF/EPS DSCS/GBS/WGS GPS DSP/SBIRS DMSP/DWSS NUDET (Nuclear Detection)

Developing, Delivering, and Supporting Military Space and Missile Capabilities to Preserve Peace and Win Conflicts



Space System Development

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- Launch is a "one-strike-andyou're-out" business
- Spacecraft must work by remote control for 15 years
 - Hostile environment
 - "Small" failures can cripple or end mission
 - No Beta Testing/LRIP and No On-Orbit Repair
 - Mandates Unique, High-Confidence Mission Assurance Culture



No "flight Testing" and No Service Calls in Space Mandates Unique, High-Confidence Mission Assurance Culture



Balancing the Needs for Space Acquisition



Must Assure Critical Requirements and Industrial Supply Capability Necessary to Support Current and Future USG Space Programs



Mission Assurance SMC 'Big MA"

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- Achieving a state of "high reliability" and high confidence that a system and it's supporting system components will perform the "Stated" mission.
 - The elements contributing to MA include all acquisition, contracting, legal, technical, and financial practices/policies, as well as manpower and skills which contribute to executing the mission.
 - Application of sound and proven requirements development, engineering, manufacturing, test/verification and the management control processes/practices which result in achieving a "high reliability" system.

Mission Assurance Processes Across Program Life Cycle







SM C Specifications and Standards Program



DoD Systems are Complex



SMC Compliance Standards List

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- SMC Technical Baseline
 - 69 documents
- Includes all four space system segments
 - Military (MIL-STD)
 - International (ISO)
 - Industry (AIAA, IEEE, SAE, etc))
 - SMC Standards
- Reflects current best practices
- Updated periodically
- SMC Instruction 63-106, 31 July 15
- Applies to all new development, acquisition and sustainment contracts
- Contractual compliance through the supplier chain, as appropriate

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Functional Areas of SMC Standards

Standard Practices

- Program/Subcontract Management
- Systems Engineering
- > Architecture Development
- Design Reviews
- Configuration Management
- > Quality Assurance
- Logistics
- > Manufacturing /Production Management
- Parts Management (non-space)
- Parts Management & Technical Rqts (space)
- Risk Management
- System Safety
- Occupational Safety and Health
- Reliability/Availability

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Subsystem/Component Standards

- > Electrical Power, Batteries
- > Electrical Power, Solar Cells/Panels
- Electromagnetic Interference & Control
- > Environmental Engineering; Cleanliness
- Human Systems Integration
- Interoperability
- Maintainability
- Mass Properties
- > Moving Mechanical Assemblies
- > Ordnance
- Pressurized Systems & Components
- Information Assurance/Program Protection
- Software Development
- Structures
- Survivability
- Test, Space & Ground

Industry consensus standards developed or adopted for use on SMC contracts



"Right Sizing" the SMC Specifications and Standards Program



Proven and Disciplined Technical Practices At the Core of SMC's Mission Assurance Approach

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- Proven Practices:
 - Based on 5+ decades of space experiences and often painful lessons learned
 - Key: Partnership with industry to provide a value-added check and balance (in the aftermath of 1990s Launch failures)
 - From launch revitalization to systems engineering revitalization to a mission assurance and Back-To-Basics focus
 - Fully collaborative with industry and the entire NSS space community: details captured in government regulations, policies, industrial and military Specifications & Standards (S&S), and in contractually compliant requirements
 - Encourage tailoring and use of equivalent Company or industry Command Media!
- Mission Assurance: The culmination of all the things the contractor and government team (organic and A&AS contractors etc) does to achieve mission success
 - Engineering, business practices, incentives, contract type, tailored oversight
- SMC policy mandates use of S&Ss in two categories (SMCI 63-106)
 - Those that directly contribute to mission success
 - Those needed for effective program implementation



MA Tailoring is Essential

- SMC/EN works with program offices and contractors to tailor
 - Mission success, budget, cost, schedule, risk, affordability, and program performance carefully balanced
- Tailoring not to delete or dilute a SS, but to implement the "intent" efficiently and economically
 - To provide confidence in achieving mission success and reduce program risk
- Concept: "Trust, But Verify"
- 69 SS today: International (ISO), Industry (AIAA), SMC technical practices of "what to do", not detailed "how to do"



Supply Chain Risk Management (SCRM)



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Trusted Systems and Networks (TSN)

• DoDI 5200.44, November 5, 2012 Protection of Mission Critical Functions to Achieve Trusted Systems and Networks

"Establishes policy and assigns responsibilities to minimize the risk that DoD's warfighting mission capability will be impaired due to vulnerabilities in system design or sabotage or subversion of a system's mission critical functions or critical components by foreign intelligence, terrorists, or other hostile elements."

Counterfeit Prevention

• DoDI 4140.67, April 26, 2013 DoD Counterfeit Prevention Policy

"Establishes policy and assigns responsibilities necessary to prevent the introduction of counterfeit materiel at any level of the DoD supply chain"







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DoD Program Protection focuses on risks posed by malicious actors



COUNTERFEIT PARTS

Parts, Materials & Processes Space Standards SMC-STD 010/011

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- Existing comprehensive PM&P management/technical program
 - Historically, effective at assuring quality parts, but "silent" on subject of counterfeit parts
- SMC sponsored the update/revision of two PMP Standards (Aerospace TORs) for Space and Launch Vehicles
 - Requires all PMP to be procured from the original qualified parts/materials equipment manufacture (OEM), or it's franchised/authorized distributor
 - Requires all parts be delivered with a certificate of compliance to military specification or space-level-equivalent source control drawing
 - Requires contractor to approve subcontractor PMP
 - Requires contractor to establish date/batch number control and twoway tractability for PMP used in flight hardware
 - Requires contractor to perform Destructive Physical Analysis (DPA) consistent with program technical requirements and MIL-STD-1580



PMPCB / PMP Selection List

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• **PMPCB**

- Requires establishment of a Parts, Materials and Processes Control Board (PMPCB) with the following responsibilities:
 - Review and approve all PMP
 - Establish and maintain all PMP lists
 - Review results of DPAs, Material Review Board (MRB) actions, and failure analysis.
 - Ensure laboratories and facilities used for screening and/or evaluation of PMP are adequate.
 - Establish and maintain a prohibited PMP list
 - Review all GIDEP, NASA, DOD, contractor, subcontractor and other agency PMP alerts, advisories, and reports for relevance to items used in the system.

PMP Selection List

 parts and materials are technically justified with approved and qualified sources of supply, approved procurement specifications, and defined application conditions

Parts Procurement

 All parts shall be procured from the part original equipment manufacturer (OEM) or its franchised, fully authorized distributor, and shall come with an OEM certificate of compliance.



Additional Standards - Counterfeit

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- SAE AS-5553A
 - Fraudulent/Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition

• MIL-STD-3018; w/CHANGE 2; 2 June 2015

- DEPARTMENT OF DEFENSE STANDARD PRACTICE PARTS MANAGEMENT
- 3.4 Counterfeit part. A suspect part that is a copy or substitute without legal right or authority to do so or one whose material, performance, or characteristics are knowingly misrepresented by a supplier in the supply chain. Parts which have been refinished, upscreened, or uprated and have been identified as such, are not considered counterfeit.
- j. Counterfeit parts. The parts management plan shall address the detection, mitigation, and disposition of counterfeit parts. Electronic, electrical, and mechanical parts are to be addressed. AS5553 should be used as guidance for electronic parts.

• SAE AS6500 (Manufacturing Management Program)

- SAE AS5553 Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- 5.4.1 Supply Chain and Material Management
 - d. Counterfeit Parts: The organization shall implement a counterfeit parts prevention program to prevent the acquisition and incorporation of counterfeit parts or parts embedded with malicious logic into factory and test equipment and delivered products. The program shall include procedures for prevention, detection, and reporting of counterfeit parts



AFSPC Commander Announces Space Enterprise Vision

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4/12/2016 - PETERSON AIR FORCE BASE, Colo. -- General John Hyten, commander of Air Force Space Command, announced the command's Space Enterprise Vision here today. The SEV is the result of an AFSPC-commissioned study that looked at how to make the nation's national security space enterprise more resilient.

The August 2015 SEV study addressed the findings of several previous studies that identified the U.S. space enterprise is not resilient enough to be successful in a conflict that extends to space. The SEV also recognizes that acquisition and programmatic decisions can no longer occur in mission area stovepipes, but must instead be driven by an overarching space mission enterprise context.

To guide the development of this future enterprise, the SEV proposes using a new optimizing concept called "resilience capacity" to characterize and evaluate space capabilities. Resilience capacity will measure how well space enterprise forces can respond to the full range of known threats, and how quickly they can adapt to counter future threats, while continuing to deliver space effects to joint and coalition warfighters. It will replace the traditional "functional availability" metric used for decades to plan and manage individual constellations, but which does not account for emerging threats.

DATA COLLECTION/ ANALYSIS

Example: Unit Thermal Test Erosion



●P J •G •C ◆D AE

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- Data shows reducing thermal cycles has an effect on problems during system thermal testing
- Note: with increasing complexity comes increasing harness and thermal equipment problems. Unit level testing will not solve this system TV problem

Equiv Cycles = Test cycles*(Delta °C/85)²

Reducing unit thermal cycles results in increased system test defects

What Anomalies are Likely to be Detected?

Vehicle dynamic test anomalies

| Frequency Regime | Potentially Affected Components | Potential Anomalies |
|---------------------|-------------------------------------|-----------------------------|
| Lower - Vehicle | >> Wire harnesses | >> Connectors/pins loosened |
| Vibration | >> Connectors | >> Fasteners loosened |
| | >> Hinges, latches, linkages | >> Parts loosened/debonded |
| (Typically <150 Hz) | >> Panels/Embedded Heat Pipes | >> Contaminates |
| | >> Propulsion tanks/piping | loosened/FOD |
| | >> Wave guide | >> Wave guide misalignment |
| | >> Antenna/SV inteface | >> Antenna alignment shifts |
| Higher - Vehicle | >> Electronics PCBs, slices, boards | >> Wires/circuits shorted |
| Acoustics | >> Solder connections | >> Solder connections |
| | >> Relays | broken |
| (Typically >150 Hz) | >> Unit internal contamination | >> Relay failure/chatter |
| | >> Deployment mechanisms | >> Contamination dislodged |
| | >> Propulsion fluid hardware | >> Preloads lost |
| | | >> Leakage |
| | | >> Unlatched components |



What Anomalies are Detected in Vehicle Acoustics Tests? Data from 108 NSS vehicle acceptance acoustics tests

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- Acoustic test effectiveness: 0.4-0.7 Mission Degrading Anomalies (MDAs) per test
 - Consistently reported by Aerospace for 25 years
 - Verified by JPL and others
- Roughly one MDA per two space vehicles
- 69 total anomalies; 55 of 69 medium significance or worse
- Likelihood may be low, but impact severe
- Deployables particularly sensitive due to lack of redundancy

Anomalies Detected in Acoustic Testing 108 Acceptance NSS Satellites







Industrial

Base



Unclassified SMC Critical Technology Risk Assessment



Leverages inputs from Government, Aerospace and Industry to identify technologies at risk



CTL Risk Matrix





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ID Name

- A40 Aluminum 1 Packaging/House
- 2 Aerospace-Grade Rayon
- 3 Ammonium Perchlorate
- 4 Atomic Clocks
- 5 Bearings
- 6 Carbon Fibers
- CCDs 7
- CdZnTe Substrates for IR 8a Detectors (111)
- CdZnTe Substrates for IR 8b
- Detectors (211)
- 9 Cellophane for Batteries Ceramic Packages
- 10 11 Connectors
- 12 Control Moment Gyros Cryocoolers 13
- 14 Diode Glass
- 15 Diodes
- 16 Fast Steering Mirrors 17 Fiber Optics Cable
- 18 Fuel Valves
- 19 Fuses
- 20 GaAs FET
- 21 Gas Valves and Regulators
- Germanium Substrates for 22
- Solar Cells
- 23 Glass for Optics
- 24 HBTs
- 25 Helium
- 26 Hermetic Tantalum Capacitors
- **High Current Relays** 27
- 28 High Efficiency Power Supplies
- 29 High Power Laser Diodes
- **High Speed Digital Electronics** 30 for Fiber Optics Systems
- **High-Power Solid State** 31 Amplifiers
- 32 IBC Detectors
- 33 Infrared Dispersive Elements
- 34 Integrated Optics Chips
- 35 Lead Free Coatings
- 36 Lightweight Structures

38 Loop Heat Pipes 39 Low CTE Glass

- 40 Lubricant
- 41 MMICs

ID Name

37

42 Nickel-Coated Graphite Powders

Liquid Rocket Engines

- 43 NiH2 Batteries
- non-volatile Memory/Flash 44 Memory
- 45 OCXO and Resonators
- 46 **Optical Coating for Mirrors**
- 47 **Optical Coatings for Solar Cells**
- **Optical Filter** 48
- **Optical Mirror Materials -**49 Beryllium
- 50 **Optical Mirror Materials - SiC**
- 51 Ordnance
- 52 Power MOSFETs
- Precision Foil Resistors 53
- 54 Precision Gyroscopes
- Printed Wiring Boards 55
- Rad Hard ASIC 56
- 57 Rad-Hard FPGA
- 58 Rare Earth Metals
- Reaction Wheel Assembly 59
- Read-out Integrated Circuits 60 (ROICs)
- 61 Rocket Fuels (Hydrazine)
- Rocket Fuels (N2O4) 62
- 63 Sapphire Substrates
- Sensor Chip Assemblies 64
- 65 Silver-Zinc Batteries
- 66 Slip Rings
- Solid Rocket Motors 67
- 68 Star Tracker
- 69 Super Luminescent Diodes
- 70 Tantalum Chip Capacitors
- 71 Transistors
- Traveling Wave Tube Amplifiers 72 (TWTAs).
- 73 Viscous Dampers



Wide Breath of IB Projects

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Traveling Wave Tubes

Batteries



Infrared Detectors

RL10 Rocket Engine

Photovoltaics

Radiation Hardened Electronics

Trusted Foundries/Services

Reaction Wheel Assemblies



Radiation

Hardened

Electronics



Radiation Environments/ Effects



A Space Radiation Effects Infrastructure





Committee on Foreign Investment in the United States

(CFIUS)



Committee on Foreign Investment in the United States (CFIUS)

- The Committee on Foreign Investment in the United States (CFIUS) reviews foreign acquisitions, mergers and takeovers of U.S. businesses that raise national security issues.
- CFIUS, working by consensus, has the power to approve a transaction or send it to the President for his decision.
- CFIUS operates on statutory deadlines consisting of an initial 30-day review, a possible further 45-day investigation, and a possible Presidential decision lasting 15 days.
- CFIUS is chaired by the Department of Treasury (Treasury), and includes representatives from 15 other United States government departments, agencies and offices.
- While filing with CFIUS is generally voluntary, and the Committee reviews less than 10% of all inbound foreign transactions, it has the authority to compel a review of a transaction that is not filed voluntarily.



SMCIB/ CFIUS Assessment

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Use of Product/technology on space systems

- Is it a company that is critical to the space industrial base?
 - Do they supply parts to SMC programs (Space, Ground, User Terminals)
 - Are SMC programs planning to use the supplier in the future
 - Do other NSS programs or NASA use this supplier
 - Do their products need to be Trusted though the DMEA process
 - Are they a single source or do other companies supply similar or identical parts at the same level of trust
 - How long would it take to reconstitute the capability
- Is the company's technology critical to SMC?
 - Does this company possess Intellectual Property (IP) that is critical to SMC and other space providers.
 - Has the government invested in the company to help them create the IP needed for NSS programs
 - Does this IP extend beyond the space community; Does it effect other DOD areas
 - Is the company ITAR compliant
 - Does the IP need to be ITAR protected from the foreign buyer
 - Is their customer's IP (designs, masks, ...) potentially vulnerable, with the new company construct
 - Do other companies/sources have equivalent IP for use on SMC programs
 - if so, do they have sufficient protections in place to protect their customer's IP



SMC/NRO/MDA/NASA/Industry

COLABORATION



JEDEC/ G1 2

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- JEDEC Committee:
 - Government Liaison JC-13JC-13 is responsible for standardizing quality and reliability methodologies for solid state products used in military, space, and other environments requiring special-use condition capabilities beyond standard commercial practices. This includes long-term reliability and/or special screening requirements.
- JC-13: Government Liaison
- JC-13.1 Subcommittee: Discrete Devices
- JC-13.2 Subcommittee: Microelectronic Devices
- JC-13.4 Subcommittee: Radiation Hardness: Assurance and Characterization
- JC-13.5 Subcommittee: Hybrid, RF/Microwave, and MCM Technology
- G12 Solid State Devices Committee
- The G-12 Solid State Devices Committee develops solutions to technical problems in the application, standardization, and reliability of solid state devices. This is implemented by evaluation and preparation of recommendations for specifications, standards, and other documents, both government and industry, to assure that solid state devices are suitable for their intended purposes.



NASA Electronics Parts Advisory Group (NEPAG)

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- NASA Electronics Parts Advisory Group (NEPAG) Domestic Telecon (weekly/~2hrs) International Telecon (monthly)
- Weekly PM& P Community Information Sharing forum hosted by NASA to facilitate identification of PM&P issues for purpose of Cross Program Information Exchange and assessment of potential enterprise level applicability/collaborative mitigation strategies across many government agencies using high reliability PM&P. Teleconferences held since 2000.
- Participants (Org)
- NASA HQ; Ames Research Center; Glenn Research Center; Goddard Space Flight Center; Jet Propulsion Laboratory; Johnson Space Center; Kennedy Space Center; Langley Research Center; Marshall Space Flight Center; U.S. Air Force / SMC; The Aerospace Corporation; DLA Land and Maritime; Def. Stand. Prog. Off. (DSPO) / GIDEP; Johns Hopkins University-APL; Missile Defense Agency (MDA); National Reconnaissance Office (NRO); Northrop Grumman ICBM Support; U. S. Air Force / NWC ICBM Sys Div; U. S. Army / AMRDEC; U. S. Navy / NAVSEA
- Example Topics for the Week:
- DLA Land and Maritime Audit Schedule; DLA-VQ Audits Projection for FY14; DLA News -Major issues being worked (DLA-VA, DLA-VQ) VQ); Deutsch Audit Report ; Mismating of D-SUB Connectors; Industry V5 Telecon Update; Semicoa Update; PIND Test Enhancement; DLA Land and Maritime SMDs Review Status



Aerospace Technical Forums

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Spacecraft Thermal Control Workshop

- The Spacecraft Thermal Control Workshop, now in its 25th year, provides the aerospace community a forum to share new technology developments, analytical techniques, and lessons learned in spacecraft thermal control. Companion Workshop on Thermophysics in Microgravity
- Aerospace Testing Seminar
- The Aerospace Testing Seminar (ATS) provides a forum to communicate and exchange knowledge for the improvement and implementation of aerospace testing technology.
- Space Power Workshop
- The Space Power Workshop provides an informal, unclassified, international forum for the exchange of ideas and information on space power. Technical presentations on advances in both components and system concepts are presented.
- Spacecraft and Launch Vehicle Dynamic Environments Workshop
- Workshop objective is a forum to discuss the best approaches for designing, modeling, analyzing, and testing modern space systems for acoustic, vibration, and shock environments.
- Manufacturing Problem Prevention Program (MP3)
- The MP3 meeting enables an exchange of information between Space and Missile Systems Center, Los Angeles Air Force Base, and the contractor community on ways to prevent problems and minimize schedule and cost impacts on space programs.
- Space Parts Working Group
- The Space Parts Working Group is an unclassified, international forum to disseminate information to the aerospace industry and to resolve problems with high-reliability electronic piece parts needed for space applications.

Alerts, Warnings, Advice, Resolutions, and Experience (AWARE)

Problem Alert List

| AWAR Alerts, W | RE arnings | , Advice, Resolutio | ns, and Experience | RSS Feed | AEF | ROSPACE |
|--------------------------------------------------------------------------------------------------------------------------------|---------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------|----------------|
| AWARE | PMP | CYBER SOFTW | ARE SCRM | | | |
| General List Problems Watchlist Notification Only Search Add New Problem Instructions Advisory Input Form | List Select clickin | t the advisory number of the ng the text in each column he Notification Only | problem t <mark>h</mark> at you wish to vie ading. | w. <mark>The</mark> problem list can be sorted (ascen | ding or <mark>d</mark> e | scending) by |
| Reports | | New Advisory - less than 3 | 1 days old | | 1.00 | |
| Program Overview | | PUMPS Advisory Number | Other Advisory Numbers | Problem Summary | <u>Type</u> | Last Updated |
| esponse By Program lert Summary | n NEW | AWARE-15-0036E | E - EPAP2015-0011 | Silicone Contamination of Parts | Open | April 22, 2015 |
| dministration laintain People laintain Picklists | NEW. | AWARE-15-0035P | G - CHM-P-15-01 P - 15-0035P | Positronic connector contacts were gold plated without nickel under-plate. GIDEF CHM-P-15-01. | Open | April 14, 2015 |
| otifications eport Creation | NEW | AWARE-15-0034N | N - T2015-00021 | Fuse Sensitivity to Soldering Reflow Process | Open | April 20, 2015 |
| rganizations isplay advisories for Uncheck All | NEW | AWARE-15-0033N | N - T2015-00020 | Faulty Process Used for Prohibited Material Analysis | Open | April 20, 2015 |
| PMPEF (P) | | AWARE-15-0032E | E - EPAP2015-0010 | Connector Failure | Open | April 22, 2015 |

In addition to PMP, AWARE now contains Cyber, Software, and SCRM





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- Enterprise Initiatives Essential To Mission Assurance
 - Space is a niche market
- Trusted Systems/Cyber Practices Evolving
 - Supply Chain Risk Management (SCRM)/Counterfeit
- Fragile aspects of Space Industrial Base
- Radiation Hardened Electronics challenges
 - Technology nodes/trusted foundries
- Increased frequency of CFIUS Cases in recent years







SPACE AND MISSILE SYSTEMS CENTER



"Airpower begins 22,000 miles up in space"







