

# SPACECRAFT CHARGING

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## GENERAL COMMENTS

- SPACECRAFT CHARGING INTERACTIONS COUPLE ENVIRONMENT TO SYSTEM PERFORMANCE THROUGH MATERIALS
- TECHNOLOGY IS STILL DEVELOPING
  - CONCERN FOR BOTH ENVIRONMENT-DRIVEN & OPERATING SYSTEM - DRIVEN INTERACTIONS
- MEETING ADDRESSED ENVIRONMENT BUT LACKED SPECIFIC MISSION REQUIREMENTS
  - REQUIRE SYSTEM DEFINITION TO PRIORITIZE INTERACTIONS
  - RECOMMEND SDI BRIEF SYSTEMS REQUIREMENTS
- NEED ADDITIONAL GROUP SUPPORT WORK TO SUPPLEMENT FLIGHT EXPERIMENTS

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## **MATERIAL PROPERTY CHANGES WITH ELECTRICAL STRESS AND TIME IN SPACE ENVIRONMENT**

- WHY PROBLEM:
  - STRESS ENHANCES AGING
  - RADIATION INDUCED INTERFACE FAILURES:
  - CURRENT SPACECRAFT BEHAVIOR STARTING TO BE UNDERSTOOD BUT MATERIALS AND OPERATING CONDITIONS CHANGING
  - LIFETIME EXTENDED
- GROUND TEST/THEORY CORRELATION:
  - DIELECTRIC COMMUNITY WORKING
  - SHORT TERM TESTING WITHOUT SPACE ENVIRONMENT
- WHAT IS STILL NEEDED
  - MATERIALS TESTING TO ESTABLISH RANGE OF INTERACTION

## **MATERIAL PROPERTY CHANGES WITH ELECTRICAL STRESS AND TIME IN SPACE ENVIRONMENT (CONTINUED)**

- WHY REQUIRE SPACE FLIGHT:
  - NEED SPACE ENVIRONMENT TO VERIFY BEHAVIOR
  - HIGH ALTITUDES OR POLAR FOR RADIATION
  - TIME IN ENVIRONMENT
- SUPPORTING WORK:
  - DIELECTRIC COMMUNITY
  - NOT DIRECTED TOWARDS SPACE APPLICATIONS

## **CANDIDATE EXPERIMENTS**

- MATERIAL PROPERTY CHANGES WITH ELECTRICAL STRESS AND TIME IN SPACE ENVIRONMENT
- HIGH VOLTAGE SYSTEM INTERACTIONS
- THIN-FILM COATING INTERACTIONS
- DISCHARGE CHARACTERIZATION
- "TAILORED" MATERIALS
- HEAVY STRESSED POWER SYSTEM DIELECTRICS
- PULSED POWER SYSTEM INTERACTIONS
- COMPOSITE INTERNAL NOISE GENERATION
- ACTIVE CHARGE CONTROL
- "RADIATION BELT" CHARGING

## **RADIATION BELT CHARGING BY ENERGETIC PROTONS AND ELECTRONS**

- WHY PROBLEM:
  - UPSET SEEMS TO OCCUR ON GPS
  - NO CHARGING MODEL EVALUATION
- GROUND TEST/THEORY CORRELATION
  - SHOULD BE ABLE TO TREAT BUT HASN'T BEEN YET
- WHAT IS STILL NEEDED:
  - EVALUATION OF EFFECT OF ENVIRONMENT
- WHY REQUIRE SPACE FLIGHT:
  - NEED ENVIRONMENT AND TIME IN SPACE

## **ACTIVE CHARGE CONTROL INTERACTIONS**

- **WHY PROBLEM:**
  - THIS IS A CHARGING MITIGATION TECHNIQUE, BUT IT CAN DEGRADE COATINGS BY BOMBARDMENT TIME EFFECT
- **GROUND TEST/THEORY CORRELATION:**
  - SHORT TERM TESTING
  - MODEL EXISTS BUT NOT VALIDATED
- **WHY REQUIRE SPACE FLIGHT:**
  - LONG TERM STUDY IN SPACE WITHOUT WALLS
- **SUPPORTING WORK:**
  - AFGL CHARGE CONTROL SYSTEM (XENON)
  - IAPS (MERCURY)

## **PULSED POWER INTERACTION-SYSTEM DYNAMIC RESPONSE TO 1 TO 100/SEC POWER PULSE**

- **WHY PROBLEM:**
  - BEHAVIOR IN PLASMA UNCERTAIN
  - AFFECTS SYSTEM PERFORMANCE
  - FLASHOVER
- **GROUND TEST/THEORY CORRELATION:**
  - THEORY BEING DEVELOPED
- **WHAT IS STILL NEEDED:**
  - THEORY AND TESTS DEMONSTRATION
- **WHY REQUIRE SPACE FLIGHT:**
  - NEED SPACE ENVIRONMENT
  - RADIATION ENVIRONMENT IMPORTANT
- **SUPPORTING WORK:**
  - SPEAR II
  - TEXAS TECH AND MAXWELL (TESTING)

**NOISE GENERATED IN COMPOSITES**  
**(SPACE INDUCED CHARGING COUPLED WITH RADIATION  
TO GENERATE NOISE IN MATERIALS)**

- WHY PROBLEM:
  - RF NOISE CAN COUPLE INTO COMMUNICATIONS AND SENSORS
- GROUND TEST/THEORY CORRELATION:
  - MEASURE RF LEVELS IN SMALL SAMPLES UNDER ELECTRICAL STRESS AND RADIATION
  - THEORY ADEQUATE BUT NUMBER OF PULSES UNKNOWN
- WHY REQUIRE SPACE FLIGHT:
  - NEED SPACE FLIGHT ENVIRONMENT
  - AURORAL OR HIGH ALTITUDE
  - CAN BE ADDED TO EXISTING S/C HAVING RF DETECTION SYSTEMS

**HEAVY STRESSED POWER SYSTEM DIELECTRIC**  
**(SDI APPLICATIONS UNDER HIGH VOLTAGE AND LARGE  
CURRENTS)**

- WHY PROBLEM:
  - STRONG ELECTRICAL STRESS AND INDUCED MAGNETIC FIELD REDUCE BREAKDOWN THRESHOLDS
- GROUND TEST/THEORY CORRELATION:
  - COMPONENTS UNDER STUDY
- WHAT IS STILL NEEDED:
  - COMBINED SYSTEM EFFECTS
  - SPACE ENVIRONMENT DEMONSTRATION
- WHY REQUIRE SPACE FLIGHT:
  - TOTAL SPACE ENVIRONMENT EFFECT
  - TIME IN SPACE

## **SYSTEM INTERACTIONS**

- SCOPE:
  - HIGH VOLTAGE
    - = HIGH VOLTAGE SOLAR ARRAYS
    - = STRUCTURE COLLECTION IN PLASMAS
    - = SCALING LAWS FOR SIZE, VOLTAGE, POWER FREQUENCY
    - = SHEATH EFFECTS
- WHY PROBLEM:
  - SYSTEM FLOATS ELECTRICALLY IN PLASMA ENVIRONMENT
  - BREAKDOWNS IN HIGH VOLTAGE SYSTEMS
- GROUND TEST/THEORY CORRELATION:
  - SMALL SCALE SAMPLE CORRELATES WITH THEORY
- WHAT IS STILL NEEDED:
  - SIZE, VOLTAGE, POWER, FREQUENCY SCALING
- WHY REQUIRE SPACE FLIGHT:
  - NEED COMPLETE SPACE ENVIRONMENT
  - CAN'T SIMULATE ON GROUND
- SUPPORTING WORK:
  - GROUND SUPPORT WORK
  - JAPANESE SPACE EXPERIMENT

## **THIN FILM COATING-STABILITY OF THIN-FILM OPTICAL AND ELECTRICAL COATINGS IN SPACE ENVIRONMENT**

- WHY PROBLEM:
  - COATING APPLIED FOR SPECIFIC OPTICAL OR ELECTRICAL PURPOSE SPACE--
- SPACE
  - SPACE CHARGING INTERACTION COUPLED WITH SPUTTERING OR CONTAMINATION MAY DESTROY COATING CHARACTERISTICS
- GROUND TEST/THEORY CORRELATION:
  - SHORT TERM TESTING
  - FLIGHT DATA NOT INSTRUMENTED FOR DETAILED EXAMINATION
- WHAT IS STILL NEEDED:
  - IDENTIFICATION OF COATINGS
- WHY REQUIRE SPACE FLIGHT:
  - NEED SPACE ENVIRONMENT

## **DISCHARGE CHARACTERIZATION**

- SOURCES:
  - WHAT ARE CONDITIONS FOR DISCHARGE INITIATION
- CHARACTER:
  - FREQUENCY, AMPLITUDES, REP RATE, TRANSFER FUNCTION, AND CHANGES WITH TIME IN SPACE
- WHY PROBLEM:
  - PROTECTION OF SYSTEM CIRCUITS DEPENDS ON KNOWLEDGE OF DISCHARGES
- GROUND TEST/THEORY CORRELATION:
  - DEDUCE DISCHARGE BEHAVIOR IN SPACE
  - CHARACTERISTICS NOT REPEATABLE
- WHAT IS STILL NEEDED:
  - THEORY AND TEST CORRELATION
- WHY REQUIRE SPACE FLIGHT:
  - NEED TOTAL ENVIRONMENT AND SPACECRAFT CONFIGURATIONS

## **"TAILORED" MATERIALS**

- SCOPE:
  - MATERIALS DEVELOPED FOR PROPERTIES TO MINIMIZE CHARGING LEVELS
  - CONDUCTIVITIES IN RANGE  $10^{-8}$  TO  $10^{-10}$  S/M<sup>2</sup>
- WHY PROBLEM:
  - CAN MITIGATE CHARGING CONCERNS
- GROUND TEST/THEORY CORRELATION:
  - QUASI-CONDUCTIVE MATERIALS UNDER DEVELOPMENT
- WHAT IS STILL NEEDED:
  - BETTER MATERIALS FOR THIS APPLICATION
  - DEMONSTRATE STABILITY IN SPACE ENVIRONMENT
- WHY REQUIRE SPACE FLIGHT:
  - DEMONSTRATE BEHAVIOR IN SPACE ENVIRONMENT
- SUPPORTING WORK:
  - GSFC
  - VIRGINIA TECH

## **SUMMARY**

- IDENTIFIED INTERACTIONS THAT WOULD AFFECT SYSTEM PERFORMANCE
- BETTER DEFINITION OF SYSTEM/MISSIONS REQUIRED
- GENERAL APPROACH FOR THIS AREA:
  - SMALL SCALE GROUND TESTS
  - MODELING OF INTERACTION
    - UNDERSTANDING
    - SCALING
  - FLIGHT VERIFICATION TEST