Kennedy Space Center	SPACE STATION HUMAN PRODUCTIVITY WORKING GROUP **CONTAMINATION**	BIOMEDICAL OFFICE FEBRUARY 28, 1984

DEFINITION: CONTAMINANT → CONTAMINATE

REFERS TO THAT WHICH ON COMING INTO CONTACT WITH SOMETHING WILL MAKE IT IMPURE, UNCLEAN, OR **UNFIT FOR USE**; TO POLLUTE, SOIL, DECAY, INFECT, OR CORRUPT; TO **COMPROMISE** OR ADVERSELY AFFECT **BEING** AND **FUNCTION** WITH UNDESIRABLE ELEMENTS.

THIS IMPLIES THAT AN ORIGINAL CONDITION PRECEDES CONTAMINATION -- APPLICABLE TO INTENDED **SPACE STATION DESIGN**.

BASIC COMPONENTS IN CONTAMINATION:

A. **THAT WHICH IS CONTAMINATED**

- HUMAN CREW - PREEMINENTLY
- OTHER LIFE FORMS
- EQUIPMENT AND SYSTEMS ONBOARD
- PROCESSES AND ACTIVITIES

B. **CONTAMINANTS (FACTORS)**

- TYPES AND SOURCES
- EFFECTS AND CONSEQUENCES
- ASSESSMENT AND QUANTIFICATION
- CONTROL AND DECONTAMINATION

N.B.: AS IN THE HUMAN CASE, MANY ELEMENTS CAN BE EITHER OBJECT OR SOURCE OF CONTAMINATION!

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KSC FORM 16-463NS (4/82)

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THE PROBLEM

THE "NEW WORLD" REVISITED

- GROWING POPULATION IN ORIGINALLY PRISTINE ENVIRONMENT
- LIMITED BASIC RESOURCES
- INCREASING AMOUNTS OF WASTE/DEBRIS INTO A FINITE CONTAINMENT
- BYPRODUCTS AND EFFLUENTS OF INDUSTRIALIZATION
- MICROBIAL THEORY REASONABLY WELL UNDERSTOOD AND OPERATIVE
- EXOTIC AND UNEXPECTED INPUTS (E.G. NUCLEAR WASTES, BIZARRE REACTIONS)
- INCOMPATIBILITIES OF VARIED INTEREST GROUPS
- MENTAL AND PSYCHIC OVERLOAD

N-B-: PROGRESS OF THESE CONTAMINATING EVENTS IN A MICROCOSM WILL FOLLOW A GREATLY **COMPRESSED TIME SCALE** WITH **LIMITED BUFFER CAPACITY**

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PURPOSE - TASKS

- RECOGNIZE AND EVALUATE THE PROBLEM(S) - **DESIGN SPACE STATION** ACCORDINGLY
  - IDENTIFY POTENTIAL CONTAMINANTS - SOURCES AND TYPES
  - DETERMINE SCOPE AND MAGNITUDE OF CONTAMINATION EFFECTS: TOXICOLOGICAL, MICROBIOLOGICAL, IMPURITIES
  - DEVELOP MATHEMATICAL MODELS FOR PREDICTIVE METHODS
  - IDENTIFY STATE-OF-THE-ART AND ADVANCED TECHNOLOGIES NEEDED FOR MONITORING CONTAMINANTS AND FOR DECONTAMINATION
  - DESIGN AUTOMATED MONITORING AND CONTROL SYSTEMS - LINKED TO TOX DATABASE AND MATH MODELS
  - DETERMINE OPTIMAL MEANS FOR MANAGING CONTAMINATION AND DESIGN AS INDICATED - A GLOBAL ISSUE
  - ESTABLISH ESSENTIAL BACK-UP PROVISIONS AS AUXILIARY MEDICAL DATABASE TO ASSIST RAPID DELIVERY OF APPROPRIATE MEDICAL CARE

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SOURCES AND TYPES OF CONTAMINANTS:

- FUELS AND MECHANICAL SYSTEMS
- PAYLOADS/EXPERIMENTS
- HUMAN CREWMEMBERS
- NON-HUMAN BIOLOGICALS
- MATERIALS
- ENERGIES

- CHEMICALS
- GASES
- PARTICULATES
- AEROSOLS
- MICROBIOLOGICALS
- ELECTROMAGNETIC RADIATION
- IONIZING RADIATION
- THERMAL ENERGY
- MECHANICAL ENERGY

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HUMAN TOXICOLOGIC DATA BASE

- MAJORITY OF CONCERNS FOR HUMAN CREWS
- UNIQUE SPACE STATION CONDITIONS
  - CONTINUOUS 24-HOUR EXPOSURE (8-HOUR TLV'S NOT APPLICABLE)
  - SYSTEM NOT PERIODICALLY REFURBISHED (PURGED, GROUND PROCESSED)
  - HAZARDOUS OPERATIONS/MATERIALS NOT PREVIOUSLY ENCOUNTERED
- LIKELIEST PROBLEMS, ORGAN SYSTEMS AFFECTED, CONSEQUENCES
- INTERRELATION WITH MEDICAL CARE SYSTEM

MICROBIOLOGICAL POTENTIAL PATHOGENS

SYSTEMS MALFUNCTION

- LIFE SUPPORT SYSTEM (ANOMALOUS, OVERLOAD)
- OPTICAL SURFACES, ELECTRONICS
- MATERIALS PROCESSING
- HOUSEKEEPING

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QUANTIFICATION OF CONTAMINANTS

- KNOWN
  - HUMAN OUTPUTS
    - RESPIRATORY
    - SKIN
    - URINARY
    - GASTROINTESTINAL
  - OTHER LIVING COMPONENTS
  - FOOD PRODUCTS, PROCESSING BYPRODUCTS
  - ONBOARD MATERIALS
  - MICROBIOLOGICALS
- LESS WELL DOCUMENTED
  - MATERIALS PROCESSING
  - MICROBIOLOGICALS - MUTANTS, VARIANTS
  - EXOTIC PHYSICO-CHEMICAL REACTIONS
  - ONBOARD INCIDENTS (I.E., SPILL, FIRE)
- PREDICTIVE MODELLING
  - REQUIRES CONTINUOUSLY UPDATED DATABASE

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SOLUTIONS:

- PREVENTION

- MONITORING
  - TECHNOLOGIES, SENSORS, ANALYZERS; DISTRIBUTION, FREQUENCY
  - DATA INTERPRETATION, DECISION
  - RESPONSE ACTUATORS

- ACTION/CONTROL
  - ALARMS
  - REDUCTION, ELIMINATION
    DECREASE INPUT, INCREASE FILTRATION/SCRUBBING, PURGE
  - ISOLATION, SHIELDING, PROTECTIVE DEVICES
  - RETREAT (SAFE HAVEN)
  - MEDICAL TREATMENT (OR SYSTEMS' EQUIVALENT)

- AUTOMATION
  MINIMIZE HUMAN REQUIREMENTS FOR CONTAMINATION CONTROL, DECONTAMINATION

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HISTORICAL LESSONS

- ALL SPACE CRAFT EXPERIENCE TO DATE
  - EMPHASIS ON LONGER DURATION
  - ATTENTION TO MORE SERIOUS/POTENTIAL PROBLEMS (E.G., HYPERGOLS, WASTE MANAGEMENT)
- SUBMARINES
- MINING
- METALLURGICAL INDUSTRIES
- CLEAN ROOMS
- MEDICAL ISOLATION
- MICROBIOLOGICAL RESEARCH AND MANUFACTURING
- EXTREME ENVIRONMENTS (E.G., BAROMETRIC PRESSURE, TEMPERATURE, HUMIDITY)

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TECHNOLOGIES REQUIRED:

INTEGRAL TO ALL OF **SPACE STATION**; COMPELLING FOR **ECLSS** AND **LOGISTICS** MODULE

- DETERMINE BEST MEANS (OR OPTIONS) FOR HANDLING EACH CASE
- IDENTIFY STATE-OF-THE-ART AND NEW TECHNOLOGIES TO IMPLEMENT
- GROUND TEST/MATH MODEL TO OPTIMIZE CONTROL
- DESIGN CONTROL AND MONITORING SYSTEMS TO MAXIMIZE AUTOMATION
- FLIGHT TEST COMPONENTS/SUBSYSTEMS WHERE FEASIBLE
- DETERMINE DEGREE OF SYSTEM CENTRALIZATION VERSUS MODULAR INDEPENDENCE
- ASSURE CAPABILITY TO UPGRADE SPACE STATION SYSTEMS

N.B.: SIZE, MASS, SPACE, COST WILL NECESSARILY CONSTRAIN TECHNOLOGIES

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MAJOR AGENCY **DECISIONS** FOR THE **CONTAMINATION** ISSUE

- MISSIONS AND OBJECTIVES OF SPACE STATION
- CENTRAL VERSUS DISTRIBUTIVE/MODULAR SYSTEM
- ESTABLISHMENT OF APPLICABLE TOXIC EXPOSURE TOLERANCES
- LEVEL OF AUTOMATION VERSUS HUMAN RESPONSIBILITY
- ELEMENTS AND DEGREE OF SYSTEMS CLOSURE
- WHEN TO FREEZE TECHNOLOGIES