SPACE STATION CREW SAFETY
HUMAN FACTORS INTERACTION MODEL

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As NASA prepares plans to develop a space station, one of the major Human Factors study tasks is to develop an approach to Crew Safety. NASA has always been a paradigm of safety consciousness and recognizes that safety will be a key to reliability and human productivity on the space station.

In evaluating safety strategies, it is also necessary to recognize both qualitatively and quantitatively how this space station will be different from all other spacecraft. During the initial phase of this study, it was recognized that the major difference between space station and previous spacecraft is the role of human factors and extra-vehicular activity (EVA). In this project, a model of the various human factors issues and interactions that might affect crew safety is developed.

The first step addressed systematically the central question: How is this space station different from all other spacecraft? A wide range of possible issues was identified and researched. Five major topics of human factors issues that interacted with crew safety resulted: Protocols, Critical Habitability, Work Related Issues, Crew Incapacitation and Personal Choice.

Second, an interaction model was developed that would show some degree of cause and effect between objective environmental or operational conditions and the creation of potential safety hazards. The intermediary steps between these two extremes of causality were the effects on human performance and the results of degraded performance. The model contains three milestones: stressor, human performance (degraded) and safety hazard threshold. Between these milestones are two countermeasure intervention points. The first opportunity for intervention is the countermeasure against stress. If this countermeasure fails, performance degrades. The second opportunity for intervention is the countermeasure against error. If this second countermeasure fails, the threshold of a potential safety hazard may be crossed.

An example of how this interaction model works can be demonstrated. Under Critical Habitability, the primary environmental stressors include confinement, isolation and separation from earth. There are two subgroups of within the first countermeasure against these stressors, social and architectural interventions. The social factors are communication with family and friends, visitors to the station and recreation. The architectural factors are design, station geometry and "local vertical" reference orientations and windows. When these social and architectural design level countermeasures against stress are not effective, crew performance may degrade in the form of morale deterioration, impaired
judgement or faulty perceptions. The second set of countermeasures, against
errors are operational or group social activities plus personal existential
actions. These social subset countermeasures include group activities, hobbies
and time for personal interests. The design/physical countermeasure sub-
group includes color coding on interior functions, lighting and video systems.
To the extent that this second defense of countermeasures is not successful,
the threshold of potential safety hazards may be crossed. In this instance,
potential safety hazards include a breakdown in group process and teamwork,
and mistakes occurring in judgement, perception or action.

The third step, which is now in progress, is to apply a system of weighting to the
various stressors and countermeasures in order to be able to evaluate their
relative importance. This weighting will also require an element of time dura-
tion to identify which stressors or countermeasures are relevant at the begin-
ning, middle or end of missions, and which are short-lived or chronic in nature.
SPACE STATION CREW SAFETY
HUMAN FACTORS CONCERNS

1. PROTOCOLS
   - AUTONOMY FROM GROUND

2. WORK RELATED ISSUES
   - TASK ASSIGNMENT
   - ROLE DEFINITION

3. CRITICAL HABITABILITY

4. CREW INCAPACITATION

5. PERSONAL CHOICE
   - INDIVIDUAL SCHEDULE CHANGES
   - OPERATIONAL CHANGES
   - WORK PROCEDURE CHANGES

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## 1. PROTOCOLS

### STRESSORS
- Scheduling Overload
- Family Problems
- Disagreements with Ground Control
- Territoriality
- Incompatibilities

### AUTONOMY FROM GROUND
- Scheduling Changes
- Family Interaction/Secure Communications
- Autonomy from Ground
- Access/Non-Access
- Crew Selection/Crew Training

### DEGRADED PERFORMANCE
- Scheduling Conflicts
- Socially Deviant Behavior
- Conflicting Objectives
- Turf Conflicts
- Incompatibilities

### COUNTER-MEASURES AGAINST STRESS
- Daily Scheduling Post-Flight Debriefing
- Discipline
- Changes in Mission Objectives
- Negotiations
- Training Group Process Crisis Management (For All of the Above)

### COUNTER-MEASURES AGAINST ERRORS
- Lack of Coordination
- Misunderstanding
- Deliberate Conflict
- Violation of Safety Criterion
- Improper Entry or Inadequate Access
- Lack of Cooperation

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SPACE STATION CREW SAFETY
HUMAN FACTORS INTERACTION MODEL

2. CRITICAL HABITABILITY I

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<th>COUNTER-MEASURES AGAINST STRESS</th>
<th>DEGRADED PERFORMANCE</th>
<th>COUNTER-MEASURES AGAINST ERRORS</th>
<th>SAFETY HAZARD</th>
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<tbody>
<tr>
<td>VOLUME LIMITATIONS</td>
<td>ARCHITECTURE: DESIGN PRIVACY, WINDOWS</td>
<td>FEELINGS OF CLAUSTROPHOBIA LACK OF PRIVACY</td>
<td>PRIVACY OR EVACUATION</td>
<td>IRRITABILITY PARANOID</td>
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<tr>
<td>NOISE</td>
<td>VIBRATION, ISOLATION AND CONTROL</td>
<td>SLEEP DISTURBANCES POOR COMMUNICATION</td>
<td>EARMUFFS, HEADSETS, DRUGS COMMUNICATION DEVICES</td>
<td>FAILURE TO RESPOND</td>
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<tr>
<td>HOUSEKEEPING</td>
<td>ROUTINES AND TRAINING</td>
<td>ENVIRONMENT QUALITY DETERIORATION</td>
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<tr>
<td>HYGIENE CLEANLINESS</td>
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HUMAN FACTORS INTERACTION MODEL

CRITICAL HABITABILITY II

STRESSORS

- THERMAL/HUMIDITY CLOSER ATMOSPHERE
- CONFINEMENT ISOLATION SEPARATION
- ARTIFICIAL LIGHTING

COUNTER-MEASURES AGAINST STRESS

- ENVIRONMENTAL CONTROLS
- COMMUNICATION WITH FAMILY AND FRIENDS
- VISITORS
- SOCIAL EVENTS
- RECREATION COUNSELING
- ARCHITECTURE GEOMETRY STOWAGE AND RETRIEVAL "LOCAL VERTICAL"
- LIGHTING DESIGN, "NATURAL LIGHT"

DEGRADED PERFORMANCE

- DISCOMFORT IRRITABILITY
- LONELINESS MORALE
- DETERIORATION IMPAIRED
- JUDGMENT PERCEPTION UNDER STRESS
- CLAUSTROPHOBIA
- FATIGUE IRRITABILITY BLURRED VISION

COUNTER-MEASURES AGAINST ERRORS

- AIR MOVEMENT
- GAS COMPOSITION
- CONTROL TEMPERATURE AND HUMIDITY
- GROUP ACTIVITIES
- HOBBIES
- PERSONAL INTERESTS
- PERCEPTION AND JUDGMENT CHECKS
- COLOR CODING
- LIGHTING
- MULTIPLE ACCESS CHOICES
- MOBILITY AIDS
- PERSONAL RESTRAINTS
- SPECIAL TASK LIGHTING

SAFETY HAZARD

- INCREASED ANXIETY
- IMPAIRED RESPONSE
- BREAKDOWN IN GROUP PROCESS, TEAMWORK
- MISTAKES IN JUDGMENT, PERCEPTION OR ACTION
- PARANOIA
- MISTAKEN PERCEPTION

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3. TASK RELATED ISSUES

<table>
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<th>SAFETY HAZARD</th>
<th>COUNTER-MEASURES AGAINST ERRORS</th>
<th>DEGRADED PERFORMANCE</th>
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<tr>
<td>MISTAKE/INADVERTENT ACTION</td>
<td>CONFLICTING ACTIONS</td>
<td>LACK OF CAUTION</td>
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<td>INADEQUATE DESIGN</td>
<td>CRISIS RESOLUTION/CHAIN OF COMMAND</td>
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<td>WORK ENVIRONMENT PROBLEMS</td>
<td>TASK SELECTION</td>
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<td>PHYSICAL LIMITATIONS</td>
<td>CREW SELECTION</td>
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<td>SCHEDULING AND COORDINATION CONFLICTS</td>
<td>CREW/Buddy CHECKS AND DRILLS</td>
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<td>GROUP MEALS AND MEETINGS</td>
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EVA ROUTINES AND PROCEDURES

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4. CREW INCAPACITATION

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<td>SPACE SICKNESS</td>
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<td>TREATMENT</td>
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<td>STABILIZE ON ORBIT?</td>
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<td>EMOTIONAL/</td>
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<td>MENTAL PROBLEM</td>
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<td>BEHAVIOR?</td>
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<td>FAILURE IN LIFE</td>
<td>ABANDON,</td>
<td>LOSS OF ACCESS</td>
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<td>SUPPORT SYSTEM</td>
<td>EVACUATE ONE MODULE</td>
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<td>DEATH</td>
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<td>LACK OF EXPERTISE</td>
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5. PERSONAL CHOICE

**STRESSORS**
- COOKING/EATING HABITS
  - SHARED MEALS
  - ACCOMMODATION FOR INDIVIDUAL CREW PREFERENCE
- INDIVIDUAL PROPERTY
  - EDUCATION MONITORING AND CONTROL CREW TRAINING
- BOREDOM, MONOTONY
  - ENTERTAINMENT CREW SELECTED ACTIVITIES
- CLOTHING
  - VARIETY, LAUNDRY CREW PREFERENCE

**DEGRADED PERFORMANCE**
- IRRITATION
- DEPRESSION
- PERSONAL AUTONOMY DIMINISHED
- LACK OF VIGILANCE
- IRRITATION, DISCOMFORT
- LESS PERSONAL FREEDOM

**SAFETY HAZARD**
- ADEQUATE TRAINING
- MONITORING AND CONTROL
- ADEQUATE CREW ACTIVITIES PLANNING AND SCHEDULING
- CLEAN FILTERS
- LINT PROBLEM

**INDIVIDUAL SCHEDULE CHANGES**
- WORK PROCEDURE CHANGES
- OPERATIONAL CHANGES

**PERSONAL HABITS:**
- SMOKING
- ALCOHOL DRUGS

**CREW SELECTION CREW TRAINING**
- REASONS FOR CONCEALMENT WITHDRAWAL SYMPTOMS POOR HEALTH INTERFERENCE WITH DUTIES
- COUNSELING?
- EVACUATION EARLY CREW CHANGEOUT
- FIRE IMPAIRED JUDGMENT DESTRUCTION OF "TEAM"

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