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 existentia
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 duration to identify which stressors or countermeasures are relevant at the beginning, 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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SPACE STATION CREW SAFETY
HUMAN FACTORS INTERACTION MODEL

1. PROTOCOLS

STRESSORS

COUNTER-MEASURES AGAINST STRESS

DEGRADED PERFORMANCE

COUNTER-MEASURES AGAINST ERRORS

SAFETY HAZARD

AUTONOMY FROM GROUND

SCHEDULING OVERLOAD
SCHEDULING CHANGES CREW ROTATION

FAMILY PROBLEMS
FAMILY INTERACTION/SECURE COMMUNICATIONS

DISAGREEMENTS WITH GROUND CONTROL
AUTONOMY FROM GROUND

TERRITORIALITY ACCESS/ NON-ACCESS

INCOMPATIBILITIES CREW SELECTION CREW TRAINING

SCHEDULING CONFLICTS
SOCIALLY DEVIANT BEHAVIOR DEPRESSION
CONFLICTING OBJECTIVES
TURF CONFLICTS
INCOMPATIBILITIES

DAILY SCHEDULING POST-FLIGHT DEBRIEFING
DISCIPLINE
CHANGES IN MISSION OBJECTIVES
NEGOTIATIONS
TRAINING GROUP PROCESS CRISIS MANAGEMENT (FOR ALL OF THE ABOVE)

LACK OF COORDINATION MISUNDERSTANDING
DELIBERATE CONFLICT
VIOLATION OF SAFETY CRITERION
IMPROPER ENTRY OR INADEQUATE ACCESS
LACK OF COOPERATION

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2. CRITICAL HABITABILITY I

- **STRESSORS**
  - VOLUME LIMITATIONS
  - NOISE
  - HOUSEKEEPING
  - HYGIENE CLEANLINESS

- **COUNTER-MEASURES AGAINST STRESS**
  - ARCHITECTURE: DESIGN
  - VIBRATION, ISOLATION AND CONTROL
  - ROUTINES AND TRAINING
  - PERSONAL PRACTICES

- **DEGRADED PERFORMANCE**
  - FEELINGS OF CLAUSTROPHOBIA
  - SLEEP DISTURBANCES
  - ENVIRONMENT QUALITY DETERIORATION
  - DISCOMFORT TO OTHERS

- **COUNTER-MEASURES AGAINST ERRORS**
  - PRIVACY OR EVACUATION
  - EARMUFFS, HEADSETS, DRUGS
  - ASSIGNMENT OF RESPONSIBILITIES
  - GROUP PRACTICES

- **SAFETY HAZARD**
  - IRRITABILITY
  - PARANOID
  - FAILURE TO RESPOND
  - BREAKDOWN IN LIFE SUPPORT

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CRITICAL HABITABILITY II

STRESSORS

THERMAL/HUMIDITY
CLOSING
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

AIR MOVEMENT
GAS COMPOSITION
CONTROL
TEMPERATURE AND
HUMIDITY
CONTROL

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

STRESSORS

DEGRADED PERFORMANCE

SAFETY HAZARD

COUNTER-MEASURES AGAINST STRESS

COUNTER-MEASURES AGAINST ERRORS

TASK ASSIGNMENT / ROLE DEFINITION

WORK ENVIRONMENT PROBLEMS

WORK ORGANIZATION / LEADERSHIP

TASK ASSIGNMENT

PHYSICAL LIMITATIONS

SCHEDULING AND COORDINATION CONFLICTS

STATION ORGANIZATION / DESIGN

LEADERSHIP TRAINING

TASK SELECTION

CREW SELECTION

GROUP MEALS AND MEETINGS

FATIGUE FACTORS

CONFLICTS WITH LEADERSHIP

MONOTONY, BOREDOM

STRAIN ON ENDURANCE

BLAME ASSIGNMENT

WORK STATION DESIGN

CRISIS RESOLUTION / CHAIN OF COMMAND

TASK ROTATION

MANDATORY PHYSICAL EXERCISE REGIMEN

CREW / BUDDY CHECKS AND DRILLS

MISTAKE / INADVERTENT ACTION

CONFLICTING ACTIONS

"FAMILIARITY BREEDS CONTEMPT LACK OF CAUTION"

"CUTTING CORNERS" PHYSICAL INABILITY TO PERFORM TASKS

LACK OF EFFECTIVE CREW INTER-ACTION

EVA ROUTINES AND PROCEDURES

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HUMAN FACTORS INTERACTION MODEL

4. CREW INCAPACITATION

<table>
<thead>
<tr>
<th>STRESSORS</th>
<th>COUNTER-MEASURES AGAINST STRESS</th>
<th>DEGRADED PERFORMANCE</th>
<th>COUNTER-MEASURES AGAINST ERRORS</th>
<th>SAFETY HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPACE SICKNESS</td>
<td>SELECTION/ADJUSTMENT</td>
<td>RELIABILITY</td>
<td>TREATMENT</td>
<td>CREW FAILURE TO RESPOND</td>
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<tr>
<td>GAS BUBBLES IN WATER</td>
<td>MAINTAIN/CHECK FUEL CELLS</td>
<td>GAS PAINS</td>
<td>SLING WATER TO SEPARATE GAS</td>
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<tr>
<td>ILLNESS</td>
<td>EXAMINATIONS AND HEALTH MAINTENANCE PROGRAM</td>
<td>SHORT TERM INCAPACITATION</td>
<td>TREATMENT</td>
<td>CONTAGION?</td>
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<tr>
<td>INJURY</td>
<td>SPACE INDUSTRIAL SAFETY</td>
<td>LONG TERM INCAPACITATION</td>
<td>RETURN TO EARTH?</td>
<td>DISTRACTION OF OTHER CREW MEMBERS</td>
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<tr>
<td>EMOTIONAL/MENTAL PROBLEM</td>
<td>CREW SELECTION GROUP TRAINING</td>
<td>STRAIN ON OTHERS/LACK OF TRUST</td>
<td>STABILIZE ON ORBIT?</td>
<td>SOcially deviant behavior?</td>
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<tr>
<td>FAILURE IN LIFE SUPPORT SYSTEM</td>
<td>ABANDON, EVACUATE ONE MODULE</td>
<td>CONFINEMENT, TRAUMA</td>
<td>RELIEF FROM DUTY</td>
<td>LOSS OF ACCESS TO CRITICAL FUNCT.jNS</td>
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<tr>
<td>DEATH</td>
<td>COUNSELING</td>
<td>TRAUMA TO CREW DISRUPTION OF TEAMWORK</td>
<td>REPAIRS, REPLACEMENT</td>
<td>PRESERVATION OR DISPOSAL OF BODY</td>
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### 5. PERSONAL CHOICE

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<tr>
<th>Stresses</th>
<th>Degraded Performance</th>
<th>Counter-Measures Against Errors</th>
<th>Safety Hazard</th>
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</thead>
<tbody>
<tr>
<td>COOKING/EATING HABITS</td>
<td>IRRITATION</td>
<td>ADEQUATE TRAINING</td>
<td>FIRE SMELLS</td>
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<tr>
<td>INDIVIDUAL PROPERTY</td>
<td>DEPRESSION</td>
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<td>OUTGASSING</td>
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<tr>
<td>BOREDOM, MONOTONY</td>
<td>PERSONAL AUTONOMY DIMINISHED</td>
<td>MONITORING AND CONTROL</td>
<td>OUTGASSING CONTAMINATION</td>
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<tr>
<td>CLOTHING</td>
<td>LACK OF VIGILANCE</td>
<td>ADEQUATE CREW ACTIVITIES</td>
<td>FLAMMABILITY</td>
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<td>PLANNING AND SCHEDULING</td>
<td>PRACTICAL JOKES</td>
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<td>DISTRACTION</td>
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<td>ACCIDENTS</td>
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<td>LINT PROBLEM</td>
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</tbody>
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**INDIVIDUAL SCHEDULE CHANGES**

**WORK PROCEDURE CHANGES**

**OPERATIONAL CHANGES**

|---------------------------------------|------------------------------|---------------------------------------------|-------------------------------------|-------------|------------|----------------------|--------------|----------|----------------------|

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