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# HYPERBARIC TREATMENT

by

Michael T. Amoroso  
Systems Engineer

Crew Health Care System (CHeCS)

McDonnell Douglas Space System Company, Space Station Division

1100 Hercules Suite 220

Houston, Texas 77058

Phone (713) 283-6541

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# HYPERBARIC TREATMENT

by  
Michael T. Amoroso  
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## ■ OUTLINE

- Introduction
- Problem Formulation
- Proposed Approaches
- Summary
- Panel Discussion

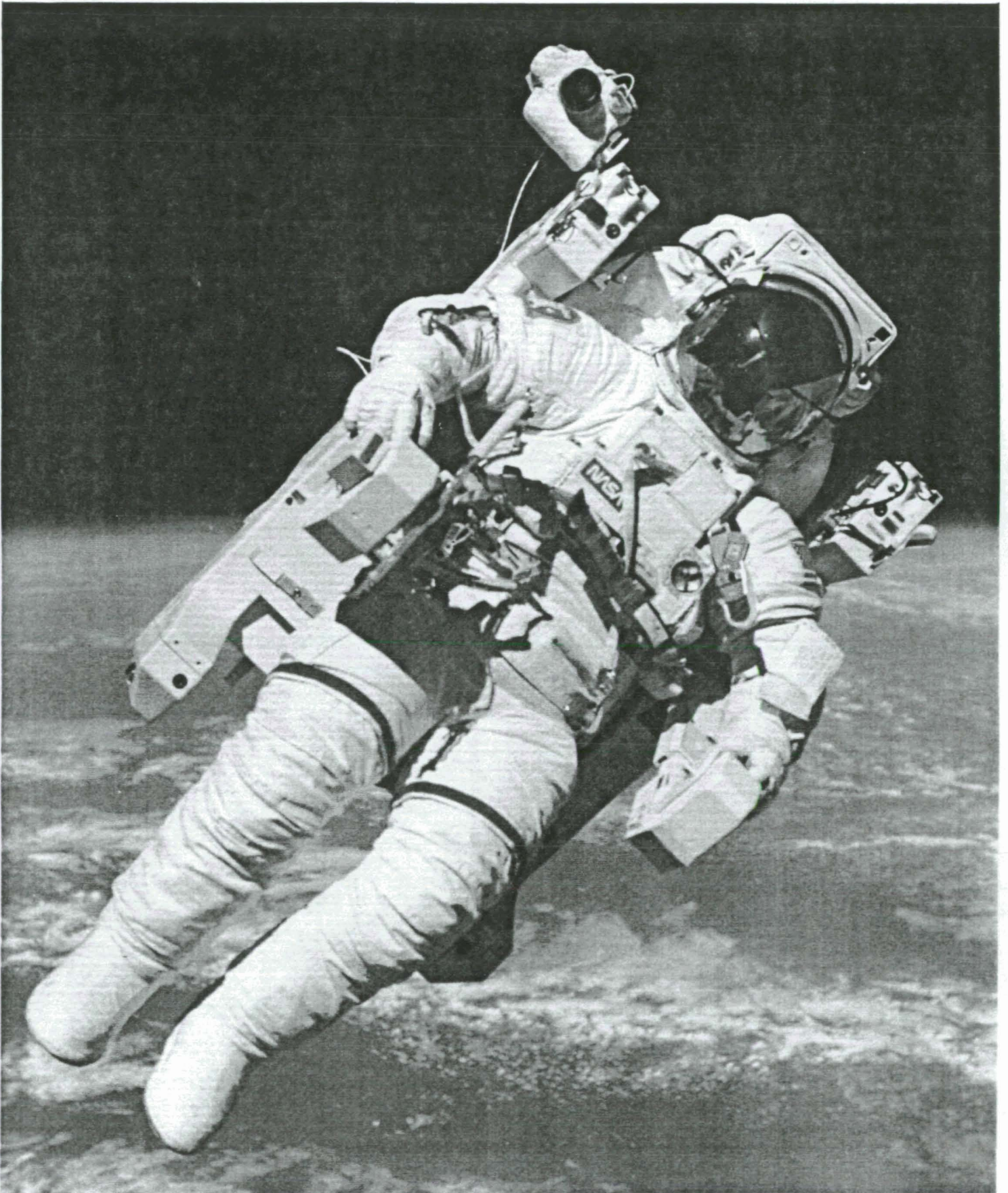
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# HYPERBARIC TREATMENT

by  
Michael T. Amoroso  
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## ■ INTRODUCTION

- Hyperbaric Treatment - Purpose
- Decompression sickness - Description
- Sources of decompression sickness
- Physical description
- Forms of decompression sickness
- Hyperbaric treatment of decompression sickness
- Duration of treatment



# HYPERBARIC TREATMENT

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## ■ PROBLEM FORMULATION

- Determination of duration of hyperbaric treatment
- Decision points in determining the duration of treatment
- Relationship of exhaled breath gas composition to decompression sickness
- Required equipment to monitor inert gases in exhaled breath
- Space Station unique circumstances

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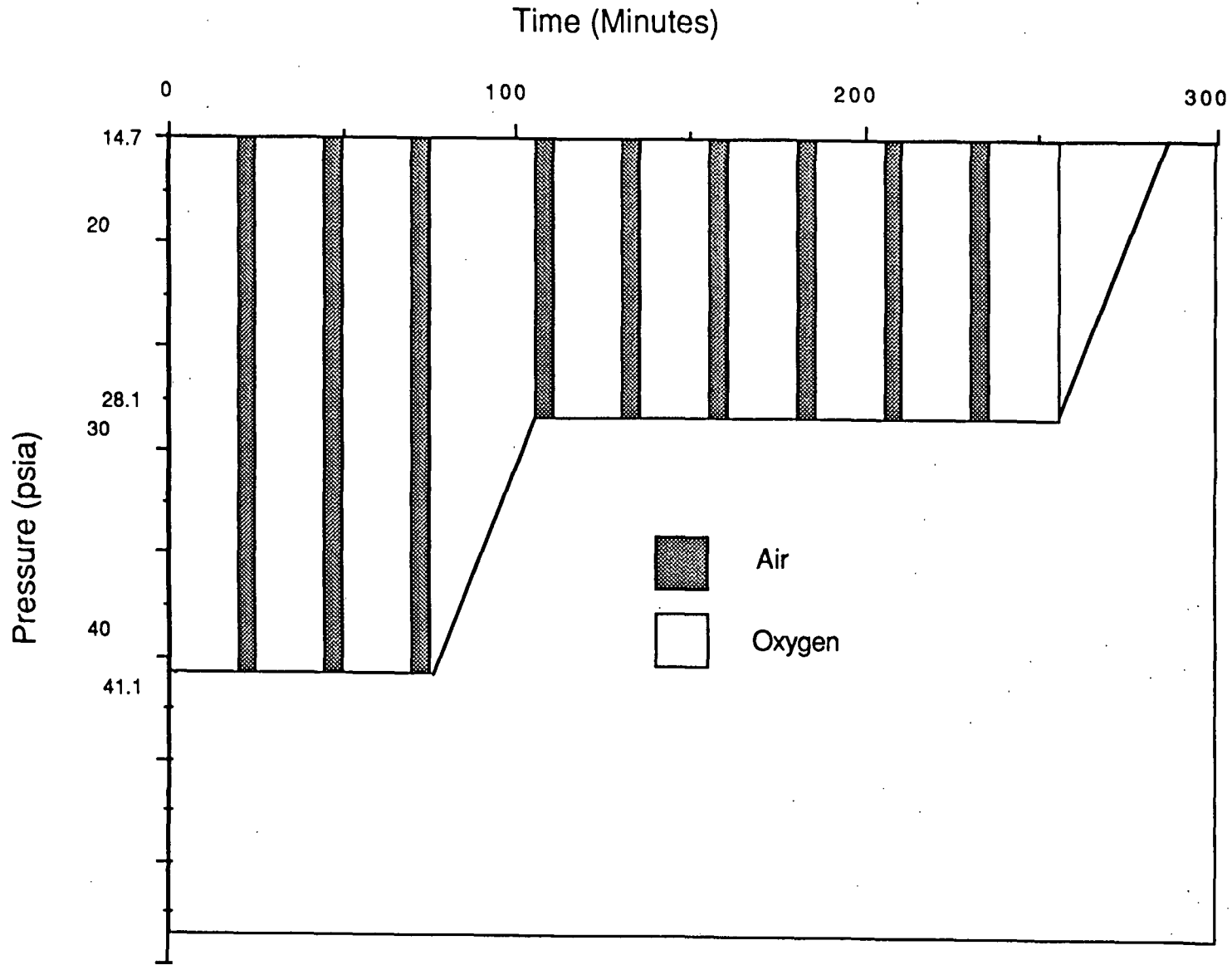
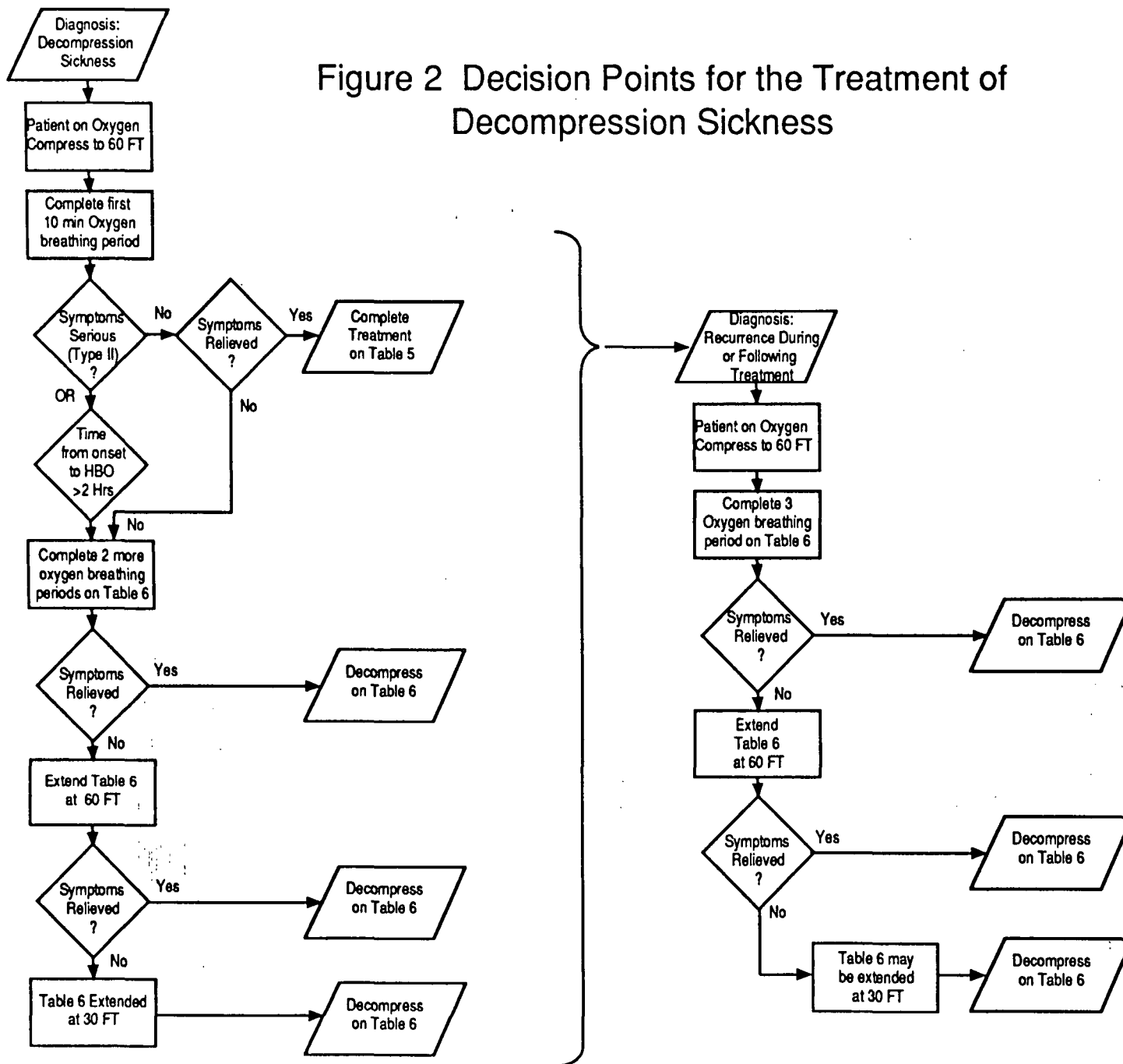


Figure 1 Hyperbaric Treatment Table 6.

Figure 2 Decision Points for the Treatment of Decompression Sickness



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## ■ PROPOSED APPROACHES

- Optimize the duration of hyperbaric treatment
  - Reasons
- Utilize all information available
  - Types of data available

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# **HYPERBARIC TREATMENT**

by  
**Michael T. Amoroso**  
**(Continued)**

## **■ SUMMARY**

- **Derived design goals of Hyperbaric Treatment**
- **Traditional treatment protocols**
- **Instrumentation already available**
- **Hundreds of hyperbaric chambers could benefit**

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# **HYPERBARIC TREATMENT**

by  
**Michael T. Amoroso**  
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## **■ SUMMARY (Continued)**

### **● (Opening question for Panel discussion)**

**Is it possible to use Fuzzy Logic and the additional information available to accurately determine the required duration of hyperbaric treatment?**

**– The additional information is :**

- 1). Instrument Data: hyperbaric chamber pressures, pressure rate of change, and the exhaled breath gas compositions**
- 2). The objective data from the examining attendant: patient's vital signs**
- 3). The subjective data: from the patient's responses to the questions of the attendant**
- 4). The exposure data: duration and pressure of exposure**

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# HYPERBARIC TREATMENT

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## ■ SUPPLEMENTAL INFORMATION

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**Michael T. Amoroso  
Systems Engineer**

**Crew Health Care System (CHeCS)**

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# **HYPERBARIC TREATMENT**

by  
**Michael T. Amoroso**  
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## ■ **OUTLINE**

- **Introduction**
- **Problem Formulation**
- **Proposed Approaches**
- **Summary**
- **Panel Discussion**

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# HYPERBARIC TREATMENT

by  
Michael T. Amoroso  
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## ■ INTRODUCTION

- **Hyperbaric Treatment is the medical protocol used to treat Decompression Sickness.**
- **Decompression Sickness can result from exposure to a significant reduction in ambient pressure.**
- **Space Station crewmembers risk decompression sickness when they perform an extra-vehicular activity (working outside the Space Station). Another risk is the unexpected decompression of a Space Station module.**
- **Decompression sickness is characterized by inert gases in the body coming out of solution and forming gas bubbles in the body tissues.**
- **The most common form of decompression sickness is the bends. Severe cases can be fatal.**

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# HYPERBARIC TREATMENT

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Michael T. Amoroso  
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## ■ INTRODUCTION (Continued)

- The only definitive treatment for decompression sickness is hyperbaric treatment - treating the patient with pressure and oxygen for sustained periods of time.
  - A common hyperbaric therapy protocol is shown in Figure 1. This table and others were developed by the Navy, essentially by trial and error.
- Hyperbaric treatments for Space Station will range from 2 Hours to a maximum of 67 Hours at pressures as high as 2.8 atmospheres.
- Hyperbaric treatment requires 3 persons, in addition to the person being treated. This involves the entire Space Station crew.

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# HYPERBARIC TREATMENT

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## ■ PROBLEM FORMULATION

- There are no quantitative measurements which can be monitored to accurately determine the required duration of hyperbaric treatment.
- Figure 2 shows decision points that terrestrial observers use to determine the duration of hyperbaric treatment.
  - The decision points are boolean. No provisions are made for partial relief of symptoms.
- Examination of the relationship between the amount of inert gases in the exhaled breath and the amount of inert gases remaining in the body.
  - Not a deterministic relationship. Other data needed.
- A form of mass spectrometer can determine the inert gasses in the exhaled breath.
  - This equipment will be available on Space Station.

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# HYPERBARIC TREATMENT

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## ■ PROBLEM FORMULATION (Continued)

- Unique circumstances onboard Space Station
  - Minimal crew of 4
  - Far away from help
  - No Medical Doctor
  - Limited amount of resources

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# HYPERBARIC TREATMENT

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## ■ PROPOSED APPROACHES - DESIGN GOALS

- Optimize duration of Hyperbaric Treatment to:
  - Get medical treatment to a crewmember in hyperbaric treatment.
  - Return injured crewmember to earth as soon as possible.
  - Alleviate other crewmembers from hyperbaric duties to perform critical activities.
  - Conservation of Resources.
- Utilize all available information in determination of ideal duration of treatment.
  - Objective instrument data
  - Objective medical attendant data
  - Subjective data from patient's responses
  - Exposure data

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# **HYPERBARIC TREATMENT**

by  
**Michael T. Amoroso**  
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## ■ **SUMMARY**

- **Derived design goals of Hyperbaric Treatment of decompression sickness**
  - Reduce delays in treating other injuries
  - Return patient to earth as soon as possible
  - Free up other crewmembers for critical activities
  - Conserve vital resources
- **Traditional treatment protocols do not optimize the design goals**
  - Boolean decisions based on primarily subjective inputs
- **The instrumentation to provide objective inputs will be available on Space Station.**
- **Hundreds of hyperbaric chambers in terrestrial use could benefit from an accurate determination of required hyperbaric treatment.**

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# HYPERBARIC TREATMENT

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## ■ SUMMARY (Continued)

### ● (Opening question for Panel discussion)

Is it possible to use Fuzzy Logic and the additional information available to accurately determine the required duration of Hyperbaric Treatment?

– The additional information is :

- 1). Instrument data: hyperbaric chamber pressures, pressure rate of change, and the exhaled breath gas compositions.
- 2). The objective data from the examining attendant: patient's vital signs.
- 3). The subjective data: from the patient's responses to the questions of the attendant.
- 4). The exposure data: duration and pressure of exposure.

Topic: Hyperbaric Treatment Control  
Presenter: Mike Amoroso

Comment: (Amoroso) Every time astronauts do EVA, they risk decompression sickness. With decompression sickness, pressure and oxygen treatment must be in precise control. Three people are required to perform hyperbaric treatment – timekeeper, chamber controller and an astronaut is needed to control the pressure. They monitor three variables – oxygen, pressure, and time.

Q (Brown): Is there a correlation between past treatments and additional data? (refer to the summary on page 7 of presentation)

A:  
- Exhaled breath can be used, but more information is needed.  
- Duration of exposure and time of overall treatment is not currently being looked at by anyone.  
- No data to clarify change to treatment tables; they were developed through trial and error. SCUBA diving incidents make up the most cases of the bends.  
- Active modelling is not being performed.  
- No bends on Space Activity. It is estimated that there is a 2-3% treatable bends risk per EVA.

Q (Lawler): What about data from the Russians?

A (Spoor): The Russians say they have no problems. There has been one instance of joint pains which may or may not be attributable to the bends (both the U.S. and Russia have reported this).

Comment: (Spoor) When dealing with human sickness, you often get "fuzzy" answers (subjective information). For example, trying to detect the extent of numbness, how "weak" is an arm, "are you 'ok'?". The inputs to the decision maker are not distinct values.

Q (Aldridge): Has there been treatment based on anything other than the hyperbaric chamber?

A (Spoor): It's possible to bring the Shuttle cabin down as low as is feasible; pump up space suit as high as possible (1.3 - 1.5 atmosphere).

Q (Lawler): Will Life Sciences "buy off" on this application?

A (Spoor): They see the potential.

Q (Lawler): Have you talked with the CHCS people (on the NASA side)

A (Spoor): Yes, we have been talking to Dr. Norfleet (Crew Hyperbaric).

Comment: Value added of using fuzzy logic application --> elimination of using an extra crew member for treatment.

Q (Stegall): Is there some way to implement the application as an advisory position?

A: Absolutely. The ultimate (medical) decision is with the doctor (on the ground).

Comment: (McRoberts) There are three tests:

- (1) How does the patient feel?
- (2) Schedule of decompression
- (3) Executing - sequential