Water Processor and Oxygen Generation Assembly

Contract H-29387D

Final Report

December 5, 1997

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Prepared by
UNITED TECHNOLOGIES CORPORATION
HAMILTON STANDARD SPACE SYSTEMS INTERNATIONAL, INC.
WINDSOR LOCKS, CONNECTICUT 06096

Prepared by: John Bedard
Approved by: Engineering Manager (OGA)

Approved by: Engineering Manager (WP)
Approved by: Program Manager
1.0 Introduction:

This report documents the results of the tasks which initiated efforts on design issues relating to the Water Processor (WP) and the Oxygen Generation Assembly (OGA) Flight Hardware for the International Space Station. This report fulfills the Statement of Work deliverables requirement for contract H-29387D.

The following lists the tasks required by contract H-29387D:

1. HSSSI shall coordinate a detailed review of WP/OGA Flight Hardware program requirements with personnel from MSFC to identify requirements that can be eliminated without affecting the technical integrity of the WP/OGA Hardware.

2. HSSSI shall conduct the technical interchanges with personnel from MSFC to resolve design issues related to WP/OGA Flight Hardware.

3. HSSSI will initiate discussions with Zellwegger Analytics, Inc. to address design issues related to WP and PCWQM interfaces.

2.0 Major accomplishments during the reporting period:

2.1 Initial requirements review:

HSSSI conducted several internal reviews of the WP/OGA Flight Hardware technical and programmatic requirements. The result of these reviews was a list of questions, issues and assumptions.

HSSSI has submitted this list to MSFC that will serve as a basis of generating the specification and ICD requirements for the WP/OGA Flight Hardware. Within this list are recommendations and assumptions to provide reduced requirements without effecting the integrity of the hardware.

A study of data items (DI) that are currently required on several other NASA programs has been conducted. This list along with HSSSI's recommendations for the flight program DIs will be provided at the TIM scheduled in December. The goal is a list of DIs that will minimize the cost to the program.

2.2 Technical Interchange Meeting

A Technical Interchange Meeting (TIM) was conducted at MSFC on November 19, 1997. Attachment I is a copy of the slide presented. The presentation covered the following topics: program schedule milestones, pre-start tasks, specification and ICD questions / issues, MSFC SOW, Data Items, EEE Parts, and OGA Power Supply. A near term schedule was developed and agreed to at the meeting and is provided in figure 1.

As a result of the TIM an Action Item List was generated and is in figure 2.
FIGURE 1

- Program Requirements Review at MSFC 2/24-26/98
- Draft Statement of Work 3/1/98
- Baseline System Schematics 2/24/98
- Draft Interface Control Documents 1/15/98
- Draft B1 System Specifications & CFI Specifications 1/15/98
- TIM #2 at SSI for Requirements Development 1/13-15/98
- TIM #1 at MSFC for Requirements Development 12/16-18/97
- Technical and Business Meeting at MSFC 11/19/97
- Contract # A TP 11/7/97

Near Term Schedule

OCA 8 WP
<table>
<thead>
<tr>
<th>STATUS</th>
<th>RESPONSIBLE</th>
<th>DUE DATE</th>
<th>DESCRIPTION</th>
<th>NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed</td>
<td>B. Kandulas</td>
<td>12/1/97</td>
<td>Provide spec software (Doors) into MSFC</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>D. Clout</td>
<td>12/1/97</td>
<td>DTSN SOW for OCA Power Supply</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>B. Bagdigan</td>
<td>12/1/97</td>
<td>MSFC Response in writing on Spec and ICD</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>D. Clout/D. Parker</td>
<td>12/1/97</td>
<td>Include DL description, SSI Recommendation on Program Data Items</td>
<td>2</td>
</tr>
</tbody>
</table>

**FIGURE 2**

**TECHNICAL MEETING 11/1/97**

**WATER PROCESSOR OCA ACTION ITEM LIST**
2.3 Zellweger Analytics, Inc.

HSSSI has initiated discussions with Zellweger Analytics, Inc. to address design issues related to WP and PCWQM interfaces. HSSSI and Zellweger conducted telephone conversations on Nov. 6 and 13, 1997 to review program status and history. These telecons were in preparation for TIM held at MSFC on Nov. 20, 1997 with HSSSI and MSFC in attendance. The minutes of the meeting are provided in Attachment III. Please note that financial data contained in minutes have been removed from Attachment III for this submittal. Topics included in Zellweger's presentation were PCWQM status, schedule, design issues, manpower requirements, and a review of the recent trade study efforts funded by MSFC. In addition, Zellweger discussion included the iodine and conductivity sensor assembly (CISA) program conducted for Boeing following the PCWQM program shutdown. This assembly was investigated for potential implementation into the WP and OGA system designs.

3.0 Additional Tasks

During this contract period, HSSSI has initiated additional tasks to support the items in the Statement of Work:

1. Internal schematic reviews on both the WP and OGA have been initiated.
2. Computer models of the WP and OGA schematics have been initiated.
3. Review of RIDs from WP PDR held in March, 1992.
4. Program Planning Tasks such as development of the initial program organization, identifying preliminary work breakdown structures, configuration control planning, and data rights reviews.

4.0 Conclusion

HSSSI has fulfilled the requirements of the Statement of Work for Contract H-29387D. The dialogues initiated between MSFC, HSSSI and Zellwegger have been informative and productive.
ATTACHMENT I
Oxygen Generator Assembly

and

Water Processor

Technical Meeting

at

Marshall Space Flight Center, Huntsville

November 19-20, 1997
OGA & WP Technical Meeting

List of HS Attendees

Dale Cloud - Project Engineering Manager (OGA) (11/19)
Dave Parker - Project Engineering Manager (WP) (11/19-20)
Mike O'Toole - Lead Electrical Design (11/20)
Lynn Rollins - Purchasing Manager (11/20)
Mike Stanley - Program Manager (11/19-20)
Rich Mason - Field Engineer (11/19)
Mike Tosca - Subcontract Program Manager (11/19-20)
Kevin Grohs - Contracts (11/19)
Dexter Wheelock - Financial (11/19)
Donna Grossman - Mechanical Design (11/19-20)
OGA & WP Technical Meeting

Agenda

Wednesday, November 19-1:00-4:30

Organization Charts (MFSC & HS)
Schedule Milestones
Pre-Start Tasks
Specification Issues
ICD Issues
MSFC SOW/ Preliminary List of Data Items
EEE Parts
OGA Power Supply
System Schematics
OGA Tour at 4755
OGA & WP Technical Meeting

Agenda

Thursday, November 20-8:30-4:00

Zellweger Analytic Presentation
  - PCWQM
    • Status
    • Design
    • Issues
    • Schedule
  - I2/Conductivity Sensor
    • Status
    • Design
    • Issues
  - Contract Issues (HSSSI & Zellweger)
  - Manpower (HSSSI & Zellweger)

OGA & WP Technical Meeting
Preliminary Organization Chart

PROGRAM MANAGER
M. Stanley

Subcontract Manager
M. Tosca

Quality
A. Lamas

Contracts
K. Grohs

OGA Project Manager
D. Cloud

Financial
D. Wheelock

Operations
K. Montemagni

WP Project Manager
D. Parker

Water Handling ORUs
R. Kundrodas

Filter & Chem. Bed ORUs

Reactor and GLS ORUs
J. Bedard

Power Supply

Cell Stack

N₂H₃ Hardware

Water Loop ORU

System & Motor Controller

PCWQM ORU
OGA & WP Technical Meeting
Near Term Schedule

- Contract 1 ATP 11/7/97
- Technical and Business Meeting at MSFC 11/19/97
- TIM #1 at MSFC for Requirements Development
- TIM #2 at SSI for Requirements Development
- Draft B1 System Specifications
- Draft Interface Control Documents
- Finalize System Schematics
- Issue Statement of Work
Schedule Milestones

OGA & WP Technical Meeting

- Contract 1 ATP 11/7/97
- WP GLS CR&D Contract ATP 11/97
  - Technology Trade Study
  - Hardware Procurement and Test
  - Deliver Prototype Hardware to MSFC 7/98
  - System Requirements Definition 11/97-2/98
  - Receive RFP 2/98
  - Flight Contract ATP 7/98
  - OGA PDR 8/98
  - ISS WP vs JSC ALS Decision Point 2/99
  - WP Delta PDR 8/98
  - CDR 3rd Quarter 99
  - System Delivery 7/01
  - Node 3 Launch 7/02
OGA & WP Technical Meeting
Pre-Start Tasks
Contract 1 & 2

- Program Planning
- System Specification
- ICD
- Initial Design Tasks
OGA & WP Technical Meeting

Pre-Start Tasks

- Program Tasks - Contract 1
  - Internal Kickoff Meeting November 13, 1997
  - PD for Contract 1
  - PDR Info and RID Review (WP)
  - Final Report, December 1997
OGA & WP Technical Meeting

Pre-Start Tasks

- Program Planning-Contract 2
  - Issue Program Directives
  - Proprietary Notification List
  - Detailed Manpower Plan
  - Continue Detailed Schedule Planning
  - Finalize WBS Structure
  - Documentation-POP, Q Plan, M&P Plan, Mfg Plan, etc.
OGA & WP Technical Meeting

Prestart Tasks

- System Specifications-Complete Jan 1998
  - TIM at MSFC for Requirements Review-Contract 1
  - Resolve AI’s from TIM-Contract 1
  - TIM at SSI for specification development-Contract 2
  - Write and issue B1 system specification-Contract 2
  - Weight, power and volume studies, for specification input-Contract 2
OGA & WP Technical Meeting

Prestart Tasks

• Interface Control Document (ICD)- Complete Feb 1998
  – TIM at MSFC ICD Issues Review-Contract 1
  – Resolve AI’s from TIM-Contract 1
  – Assist MSFC in ICD preparation-Contract 2
OGA & WP Technical Meeting
Prestart Tasks-OGA

• Initial Design Tasks
  – Review OGA System Schematic-Contract 1
    • Safety Review
    • Determine location of I/X bed
    • Computer model for system dynamics
  – Component Specifications Dec 1997-Jan 1998-Contract 2
    • Revise mini specifications
    • Bellows tanks
OGA & WP Technical Meeting
Prestart Tasks-OGA

- Initial Design Tasks (continued)
  - Preliminary Parts and Drawings Lists, Jan 1998-Contract 2
  - Power Supply Interface Definition-Contract 1
OGA & WP Technical Meeting

Prestart Tasks-WP

Initial Design Tasks
- Review WP System Schematic-Contract 1
- Liquid and gas sensor alternate concepts
- Waste water and delivery schematic trades
- Scrubber for MLS gas outlet
- Removal of the sterilization ORU
- Evaluate alternate location of conductivity sensors
- Computer model for system dynamics
OGA & WP Technical Meeting

Prestart Tasks-WP

Initial Design Tasks (continued)

  - Revise mini specifications
  - Bellows tanks
  - Review RID status
  - Develop list of PDR open issues and review for current action
- Preliminary Parts and Drawings Lists, Jan 1998-Contract 2
OGA & WP Technical Meeting

Prestart Tasks-WP

- Initial Design Tasks
  - PCWQM-Zellweger CDR Presentation, Dec 1997
    - Review CDR and program documentation -Contract 1
    - Attend TIM/CDR presentation at MSFC, Nov 20, 1997-Contract 1
    - Quality survey of Zellweger, Dec 1997-Contract 2
    - TIM at Zellweger’s to continue technical/programmatic discussions, Dec 1997-Contract 2
OGA & WP Technical Meeting
Specification Issues

- See attached sheets
SPECIFICATION QUESTIONS/COMMENTS:

- Utilize the latest revision SSP documents. Some of these suggested documents are:
  - Electrical power - SSP 30482, Vol. 2
  - Materials/Processes - SSP 30233
  - EEE Parts - SSP 30312 & SSP 30423
  - Electromechanical Radiation - SSP 30237 (Testing - SSP 30238)
  - Grounding - SSP 30240
  - Bonding - SSP 30245
  - Cable/wire Design - SSP 30242
  - Workmanship - NHB series
  - Human Performance/Human Engineering - SSP 50005
  - Structural - SSP 30559
  - Fracture Control - SSP 30558
  - Reliability - Ex: FMEA/CIL SSP 30234
  - Safety - Ex.: Safety Hazard Analysis SSP 30309
- What are the Classification of Characteristics requirements?
- Are we required to use the Boeing quick disconnects?
- We are assuming the edge break (or radii) requirements of SSP50005 (not NASA-STD-3000).
- Does MSFC have any hydrogen safety requirements, design standards, explosion pressure factors, and/or ventilation requirements?
- What are the maintenance requirements?
- Are blind-mate quick disconnects and/or electrical connectors acceptable?
- Does MSFC have any preferred or recommended common hardware, such as:
  - slides
  - quick disconnects
  - valves
  - sensors
  - flex lines
  - electrical connectors
  - fasteners
- Are there any fastener preload/torque analysis requirements?
- HS to have the capability to define the verification methodology for each shall statement subject to MSFC approval
- Need operational timeline profiles for water usage on ISS.
- HS recommends NC-55 for acoustic requirement. Rack panels provide attenuation against the NC-50 station requirement.
- How will the systems be shipped to MSFC (as a system or as ORU's)?
- MSFC to define minimum expendable life.
- Establish performance requirements when the system is exposed to low ambient pressure 9.0 Psia and 10.0 to 10.6 psia operation for 1095 days.
- Verify inlet waste water system filtration level is 100 micron.
• HS will develop specifications utilizing MIL-STD-490.
• HS is assuming the following failure tolerance:
  0 fault tolerant for function (i.e. fail safe)
  1 fault tolerant for critical failures
  2 fault tolerant for catastrophic failures
  1 fault tolerant for marginal failures
• What are the weight, power, volume requirements for each system?

RELIABILITY/SAFETY QUESTIONS:

• What is the functional criticality of the systems?
• If the system fails, what actions would be taken? What are the backups?
• Will the controller be considered one fault tolerant under the proper design conditions? (such as watch dog timers, periodic ram/rom tests, separation of critical redundant signals)
• Is there a space station atmospheric monitor that would backup the OGA so far as detecting hydrogen below the lower explosive limit?
QUESTIONS/COMMENTS FOR MSFC
11/18/97

MECHANICAL DESIGN QUESTIONS/COMMENTS

Rack questions/comments:

- What is the exact double rack configuration? We need drawings ASAP.
- Where are the rack keep-out volumes?
- Where are the allowable attachment points?
- What size and configuration are the attachment points?
- What is the total load bearing capacity of the rack? We need this value for racks both with and without the centerpost.
- Is there a load limit per post?
- Is there a load limit per attachment bolt?
- Where is the interface panel (at the stand-off) and what is its configuration? What are the electrical and fluid interface configurations?
- What is the expected rack structure deflection (i.e., what clearance is required between the hardware and the rack)?
- Is there a CG location requirement?
- What electrical bonding provisions are provided in the rack?

Packaging questions/comments:

- Our assumption is that if an Avionics Air Assembly is required, it is not part of our packaging volume.
- Besides front access, what other maintenance access is allowed?
- Is liquid cooling available? What heat rejection capacity is available?
- How much heat can be dumped into the rack?
- We will supply all ducting, tubing, and harnessing required to interface from the interface panel and/or the Avionics Air Assembly to our hardware.

Structural questions/comments:

- What is the natural frequency requirement?
- What are the quasi-static loads?
- What are the random vibration loads?
- Is there a required method for load combination?
- What are the safety factor requirements?
- What are the fracture control requirements?
- Is there a problem with tying across rack corner posts (side-to-side or front-to-back)? In this case, what loads from the rack are inputted into our ORU’s?
- Who is responsible for the structural analysis of our ORU’s as part of the rack?
OGA & WP Technical Meeting

ICD Issues

- See attached sheets
Water Processor Interfaces:

Ambient Air
  Temperature Range
  Pressure Range
  Dew Point Range
  Oxygen Concentration Range

Nitrogen (In) (Water Storage ORU) - approximately .5 lbs per day required
  Temperature Range
  Pressure Min.
  Flow Rate Max.
  Dew Point Range

Waste Water (In) (Waste Water ORU)
  Temperature Range
  Pressure Range
  Flow Rate
    Average Lb/min
    Peak Lb/min
  Quality (Contaminants/constituents)

Gas Vent (Out) (Waste Water ORU)
  Constituents/properties
  Physical connection

Oxygen Supply (In) (Catalytic Reactor ORU)
  Pressure Min.
  Flow Rate Max.

Gas Vent (Out) (Gas Separator ORU)
  Physical
  Ambient Pressure Range
  Dew Point Range

Product Water Supply (Out) (Water Storage ORU)
  Back Pressure
  Water Quantity Required

Electrical Power
  SSP 30263:002  RPCM Requirements
  SSP 30482, Vol. 1 and Volume 2 Power Requirements
Data Bus (1553)

Assembly Commands
- INITIALIZE
- STANDBY
- OPERATE
- SHUTDOWN
- HARD STOP
- BIT EXECUTION
- REPROCESS
- OVERRIDE

Assembly Sensor/Status Feedback (as a minimum)
- Fault Status/Isolation (As processed within the embedded controller)

Non-operating Environments by Phase (Transportation, Storage, Prelaunch, Launch, etc)
- Temperature
- Pressure
- Humidity
- Vibration
- Acceleration
- Shock
- Acoustics
Oxygen Generator Interfaces:

Ambient Air
Temperature
Pressure
Relative Humidity
Dew Point
Oxygen Concentration

Nitrogen (In)
Temperature
Pressure
Flow Rate
Dew Point
Quality (Contaminants/constituents)

Feed Water (In)
Temperature
Pressure
Flow Rate
Quality (Contaminants/constituents)

Coolant Water (In)
Temperature
Pressure
Flow Rate
Quality (Contaminants)

Coolant Air (In) (If any)
Temperature
Pressure
Flow Rate
Dew Point

Hydrogen Supply (Out)
Back Pressure

Hydrogen Vent (Out)
Allowable Purge Gas Mix
Continuous or Time Restricted
Rate, Maximum
Back Pressure
QUESTIONS/COMMENTS FOR MSFC
11/18/97

Oxygen Supply (Out)
Back Pressure
Production Rate

Electrical Power (From RPCM to PSM and rest of assembly)
SSP 30263:002
SSP 30482, Vol. 1 (Interface C)

Data Bus (MIL-STD-1553B)
DSBG 9549 ??
Assembly Commands (Fixed duty cycle and production rate)
IMMEDIATE SHUTDOWN
ON
OFF
MANUAL
Assembly Sensor/Status Feedback
Oxygen Pressure
Cell Current
Cell Voltage
Conductivity Sensor (Output)
Fault Status/Isolation (As processed within the embedded controller)

Power Supply
Input Power
Output Power
Control/Feedback Signals
Mechanical Interfaces

Non-operating Environments by Phase (Transportation, Storage, Prelaunch, Launch, On-orbit, Return-to-earth)
Temperature
Vibration
Acoustics
Pressure
Acceleration
Humidity
Shock
OGA & WP Technical Meeting
MSFC SOW and Data Items
OGA & WP Technical Meeting

EEE Parts

- Reliability Level
- Source
OGA & WP Technical Meeting

OGA Power Supply

GFE
ATTACHMENT II
November 25, 1997
ZA971633

Hamilton Standard
Space Systems International, Inc.
1 Hamilton Road
Windsor Locks, CT 06096-1010
Tel: 860-654-6000

Attention: Ms. Lynn M. Rollins, Purchasing Manager; M/S 1A-3-Z65


Dear Ms. Rollins,

The subject ISS PCWQM TIM Minutes and a copy of ZALC’s TIM presentation package are enclosed and are being submitted to you for your information and further distribution as you deem appropriate. ZALC is in the process of working the action items we were assigned at this meeting and will provide responses to you as they become available.

Should you have any questions regarding any of the above material, please contact the undersigned at 281-332-2484, Ext. 57.

Regards,

Ken Smith
Program Manager

cc. (Ltr. & Minutes only)

Mr. Donald L. (Layne) Carter, Mail Stop ED-62
George C. Marshall Spaceflight Center
Marshall Space Center, AL 35812
Meeting Minutes: International Space Station (ISS) Process Control Water Quality Monitor (PCWQM) Introductory Technical Interchange Meeting (TIM)

Location: Building 4610, Room 5015, George C. Marshall Space Flight Center, Marshall Space Center, AL

Date/Time: November 20, 1997 (8:30 a.m. to 5:30 p.m.)

Attendees:
- National Aeronautics and Space Administration/Marshall Space Flight Center (NASA/MSFC):
  - Bob Bagdigian, ED62
  - Layne Carter, ED62
  - Jim Reuter, OB3

- Hamilton Standard Space Systems International (HSSSI), Inc.
  - Windsor Locks, CT: Donna Grossman, Mechanical Engineer; Dave Parker, Project Manager; Lynn Rollins, Purchasing Manager (“Buyer”); Mike Stanley, Program Manager for Water Processor; Michael Tosca, Major Subcontracts Manager.
  - Huntsville, AL: Rich Mason, Site Technical Representative; Mike O’Toole, Electrical Engineer.

- Zellweger Analytics League City (ZALC):
  - Dale Dougherty, Chief Engineer; Ken Smith, Program Manager

Purpose: The purpose of the meeting was to introduce key members of the NASA/MSFC, HSSSI and ZALC ISS Water Processor (WP) and PCWQM program teams to one another and provide a background and overview of the PCWQM program. Historical prospective was provided for both PCWQM and ICSA Programs as well as discussions for current and future work. Previous telecons regarding restarting the PCWQM contract were held 11-6-97 and 11-13-97.

The meeting was opened by Mr. Layne Carter who, in turn, introduced the other meeting attendees. These introductions provided a “voice-with-a-face” association and some discussion ensued delineating the roles these individuals will have in the Water Processor and PCWQM programs. Next, Mr. Dave Parker gave some introductory remarks, presented a meeting Agenda and Schedule, and turned the meeting over to Mr. Ken Smith.

Mr. Smith began with a PCWQM Programmatic presentation (attached) providing Schedule and Manpower charts for the next three years. Discussion took place asking for clarifications where necessary and when Hamilton Standard anticipates funding which can then be used to begin ZALC’s PCWQM efforts. Currently a sole source justification describing why Hamilton Standard is the only qualified Water Processor vendor to NASA is being executed by MSFC/NASA. It is anticipated that a Letter Contract between MSFC and HSSSI will be complete on or before
January 1, 1998. at which point HSSSI can formally provide same to ZALC.

Dale Dougherty then went through a PCWQM and ICSA history presentation (attached) describing how the design evolved to the PCWQM-SEU, then to ICSA. The work done for ION Systems was presented and discussed as well as what technical tasks need to be addressed in the near future. Discussion ensued as to why the SEU design should be abandoned in lieu of a ‘stand alone’ PCWQM and all concurred that the latter, if it can be designed feasibly, makes the most sense.

MSFC electrical design engineers joined the meeting at 1:30 to review the UV Ballast Supply requirements so they can determine if they can provide such a supply to us for incorporation into the PCWQM, as GFE.

Following the UV Power Supply segment of the meeting, Mr. Smith went over the Rough Order of Magnitude (ROM) pricing and related assumptions that ZALC had developed and submitted to NASA/MSFC previously, based on preliminary program requirements and delivery schedules provided by NASA. ZALC’s CY98 PCWQM Program manpower figures and pricing data were provided formally to Ms. Lynn Rollins in response to her earlier request for same.

Upon completing the presentation and discussion segments of the meeting, participants adjourned to Bldg. 4655 where they were given a brief tour and overview description of the ECLSS Stage-10 Test Setup by Mr. Layne Carter. The Stage-10 Water Processor (WP) and Process Control Water Quality Monitor (PCWQM) were the focus of this activity.

Action Items resulting from the subject meeting were as follows:

<table>
<thead>
<tr>
<th>AI#</th>
<th>Assignee</th>
<th>Due Date</th>
<th>Action Item/Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ZALC (DD, KS)</td>
<td>11-24-97</td>
<td>Provide copies of slides presented.</td>
</tr>
<tr>
<td>2</td>
<td>ZALC (DD)</td>
<td>12-01-97</td>
<td>Provide copy of UV Lamp drawing for MSFC electrical designers to review.</td>
</tr>
<tr>
<td>3</td>
<td>ZALC (DD)</td>
<td>01-15-98</td>
<td>Need Draft of a UV Ballast Power Supply SCD for MSFC</td>
</tr>
<tr>
<td>4</td>
<td>ZALC (KS, DD)</td>
<td>01-15-98</td>
<td>Review PCWQM-SEU RIDs from CDR and consider whether they are applicable or OBE.</td>
</tr>
</tbody>
</table>

Ken Smith, ZALC GPU Program Mngr
Dale Dougherty, ZALC Chief Engr
Dave Parker, HSSSI Project Mngr
Lynn Rollins, HSSSI Purchasing Mngr
OGA & WP Technical Meeting
Agenda

Thursday, November 20-8:30-4:00

Zellweger Analytic Presentation
  – PCWQM
    • Status
    • Design
    • Issues
    • Schedule
  – I2/Conductivity Sensor
    • Status
    • Design
    • Issues
  – Contract Issues (HSSSI & Zellweger)
  – Manpower (HSSSI & Zellweger)

### ISS PROCESS CONTROL WATER QUALITY MONITOR (PCWQM) DESIGN & DEVELOPMENT SCHEDULE

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>1998 Qtr 1</th>
<th>1998 Qtr 2</th>
<th>1998 Qtr 3</th>
<th>1998 Qtr 4</th>
<th>2000 Qtr 1</th>
<th>2000 Qtr 2</th>
<th>2000 Qtr 3</th>
<th>2000 Qtr 4</th>
<th>2001 Qtr 1</th>
<th>2001 Qtr 2</th>
<th>2001 Qtr 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Program Milestones</td>
<td>1d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Definitize/Start Flight Contract</td>
<td>130d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Develop-Concur on E.D. w/HSD</td>
<td>47d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Develop-Concur on S.O.W. w/HSD</td>
<td>47d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Prep Proposal based on ED/SOW</td>
<td>30d</td>
<td>Mon 3/9/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Complete/Ship Proposal</td>
<td>1d</td>
<td>Mon 4/20/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>HSD Review /Evaluate Proposal</td>
<td>15d</td>
<td>Tue 4/21/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Support Fact Finding by HSD</td>
<td>14d</td>
<td>Tue 5/12/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Negotiations w/HSD</td>
<td>10d</td>
<td>Mon 6/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Sign Contract</td>
<td>2d</td>
<td>Mon 6/15/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Formal CSD</td>
<td>1d</td>
<td>Wed 7/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Ramp-Up Manpower (Phase-I)</td>
<td>33d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Mech. Eng.</td>
<td>33d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Tech. Writer/Editor-CM/DM</td>
<td>33d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Contract/SubContract Admin/Buyer</td>
<td>33d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Product Assurance Eng./Mgr.</td>
<td>33d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>PP&amp;C (Contract)</td>
<td>33d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Ramp-Up Manpower (Phase-II)</td>
<td>36d</td>
<td>Mon 6/15/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Elec. Eng. X 2</td>
<td>35d</td>
<td>Mon 6/15/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Mech. Eng.</td>
<td>35d</td>
<td>Mon 6/15/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Test Eng.</td>
<td>35d</td>
<td>Mon 6/15/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Project: PCWQM PROG.; 1996 - 2001**

**Date: Mon 11/17/97**

---

**A:\PROJECT4.MPP**

---

**Page 1**

---

**Mon 11/17/97 7:31 PM**
# ISS PROCESS CONTROL WATER QUALITY MONITOR (PCWQM) DESIGN & DEVELOPMENT SCHEDULE

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>1998 Qtr</th>
<th>1999 Qtr</th>
<th>2000 Qtr</th>
<th>2001 Qtr</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>Eng/Lab Tech. X 2</td>
<td>35d</td>
<td>Mon 6/15/98</td>
<td>Qtr 1</td>
<td>Qtr 2</td>
<td>Qtr 3</td>
<td>Qtr 4</td>
</tr>
<tr>
<td>37</td>
<td>SR&amp;QA Eng.</td>
<td>35d</td>
<td>Mon 6/15/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Sfw. Eng. (Contract)</td>
<td>35d</td>
<td>Mon 6/15/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Locate, Lease &amp; Prepare Facility</td>
<td>42d</td>
<td>Thu 1/1/98</td>
<td>Qtr 1</td>
<td>Qtr 2</td>
<td>Qtr 3</td>
<td>Qtr 4</td>
</tr>
<tr>
<td>47</td>
<td>Locate</td>
<td>6d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Lease</td>
<td>6d</td>
<td>Tue 1/13/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Make Pre-Move In Facility Mods</td>
<td>15d</td>
<td>Wed 1/21/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Move Personnel &amp; Stored Items</td>
<td>24d</td>
<td>Thu 2/12/98</td>
<td>Qtr 1</td>
<td>Qtr 2</td>
<td>Qtr 3</td>
<td>Qtr 4</td>
</tr>
<tr>
<td>51</td>
<td>Move Furniture &amp; Fixtures</td>
<td>4d</td>
<td>Thu 2/12/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Move in Personnel &amp; Setup Offices</td>
<td>1d</td>
<td>Wed 2/18/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Move Archived PCWQM Documentation</td>
<td>6d</td>
<td>Thu 2/19/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Move Parts &amp; Materials</td>
<td>7d</td>
<td>Fri 2/27/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Move Assy &amp; Test Equipment</td>
<td>6d</td>
<td>Tue 3/10/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>Get PCWQM Baseline under CM</td>
<td>77d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Review archived PCWQM Docc.</td>
<td>11d</td>
<td>Fri 2/27/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Place latest Rev's in Active Files</td>
<td>12d</td>
<td>Fri 2/27/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>Verify CM baselines</td>
<td>11d</td>
<td>Tue 3/17/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>Update CM baseline, if Req'd</td>
<td>11d</td>
<td>Wed 4/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>Update SDD to Agreed Config.</td>
<td>8d</td>
<td>Wed 4/8/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>SetUp Labs/Work Areas</td>
<td>82d</td>
<td>Thu 1/1/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Bonded Stores</td>
<td>6d</td>
<td>Thu 2/19/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Project:** PCWQM PROG.; 1998 - 2001  
**Date:** Mon 11/17/97  
**A:\PROJECT4.MPP**  
**Page 2**  
**Mon 11/17/97 7:31 PM**
<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>91</td>
<td>Blue LED's</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>92</td>
<td>Red LED's</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>93</td>
<td>Photodectors</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>IR Sources</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>Elec. Connectors</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>96</td>
<td>Wire</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>97</td>
<td>I.C.'s</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>98</td>
<td>Resistors &amp; Capacitors</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>Subcontract Items</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>Quick Disconnects</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>101</td>
<td>AC Synchronous Motors</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>102</td>
<td>Stepper Motors</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>pH Probes</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>104</td>
<td>Valves</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>105</td>
<td>2-Way</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>106</td>
<td>3-Way</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>107</td>
<td>Regulators</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>Flow Restrictors</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>109</td>
<td>Pressure Transducers</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>Pumps</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>111</td>
<td>Optics</td>
<td>261d</td>
<td>Mon 3/2/98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>------------------</td>
<td>----------</td>
<td>--------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>164</td>
<td>Ship Hardware &amp; ADP's</td>
<td>1d</td>
<td>Fri 6/29/01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>155</td>
<td>Contract Closeout Complete</td>
<td>1d</td>
<td>Fri 9/28/01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PCWQM PROGRAM ISSUES/COST DRIVERS

What is to be delivered?

- Flight Units
- Protoflight Units
- Qual Units
- Special Test Equipment
- Spares

What requirements are to be imposed?

- Space Station Full Flight, Crit 1R
- Space Station Protoflight
- NASA Flight Experiment
PCWQM PROGRAM ISSUES/COST DRIVERS

What is the desired delivery date/(s) ?

ASAP

Best date based on overall program cost, but not later than ___

Driven by availability of funds

What programmatic requirements must be flowed down to subcontractors ?

Full

Partial

None
PCWQM PROGRAM ISSUES/COST DRIVERS

Will DCMO be required to perform source inspection/acceptance at subcontractor facilities?

Yes

No

To what extent will HSD QA & DCMO be involved in our assembly and test activities?

Heavily

Minimally
PCWQM PROGRAM ISSUES/COST DRIVERS

Will Zellweger be given MRB authority?

Yes

No

Will NASA facilities be available to support environmental testing? Can they be used?

JSC

MSFC
PCWQM PROGRAM ISSUES/COST DRIVERS

What EEE Part Requirements are to be imposed?

Class - "S"

MIL-883B

Best Commercial Grade

Will a detail-level Finite Element Analysis be required?

Full FEA required

Tailor based on areas of concern

Not required
PCWQM PROGRAM ISSUES/COST DRIVERS

What program reviews are to be conducted?

Delta - CDR

FCA/PCA

AR

What will the program status reporting requirements be?

Monthly cost, schedule and performance

Variance analysis, recovery plans, etc.

SDB Subcontracting
<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Labor Hours</td>
<td>$76,752</td>
</tr>
<tr>
<td>Total Labor Cost</td>
<td>$1,967,282</td>
</tr>
<tr>
<td>Overhead @ 11%</td>
<td>$234,130</td>
</tr>
<tr>
<td>Direct Material</td>
<td>$176,856</td>
</tr>
<tr>
<td>Direct Subcontract Labor</td>
<td>$1,378,987</td>
</tr>
<tr>
<td>Direct Contract Labor</td>
<td>$210,000</td>
</tr>
<tr>
<td>Direct Freight</td>
<td>$26,042</td>
</tr>
<tr>
<td>Direct Travel</td>
<td>$63,360</td>
</tr>
<tr>
<td>Other Direct Costs</td>
<td>$36,000</td>
</tr>
<tr>
<td>Total Direct Cost</td>
<td>$7,780,829</td>
</tr>
<tr>
<td>G&amp;A @ 25.7%</td>
<td>$1,590,330</td>
</tr>
<tr>
<td>Fixed Fee</td>
<td>$389,041</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$8,169,871</td>
</tr>
</tbody>
</table>

1. 36 Month Program
2. Average H.C. = 12.4
3. One PCWOM delivered to Space Station Protolight Requirements
4. Approx. $227K/mo. Funding Req'd.
## PRICING FOR ION STAGE-11 PCWQM REQUEST FOR PROPOSAL

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Evaluate/Definitive Program Requirements</td>
<td>200</td>
<td>160</td>
<td>60</td>
<td>220</td>
<td>8</td>
<td>160</td>
<td>800</td>
<td>800</td>
<td>$23,408</td>
<td>160</td>
<td>400</td>
<td></td>
<td></td>
<td></td>
<td>$3,700</td>
</tr>
<tr>
<td>B</td>
<td>Identify/Select Valve Suppliers</td>
<td>70</td>
<td>70</td>
<td></td>
<td></td>
<td>8</td>
<td>80</td>
<td>228</td>
<td>570</td>
<td>$15,303</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Conduct Packaging Analysis</td>
<td>80</td>
<td>120</td>
<td>40</td>
<td></td>
<td>150</td>
<td>180</td>
<td>570</td>
<td>570</td>
<td>$15,303</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Mod CO2 Detector Source</td>
<td>80</td>
<td>120</td>
<td>200</td>
<td>120</td>
<td>6</td>
<td>60</td>
<td>160</td>
<td>200</td>
<td>$22,882</td>
<td>570</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Identify/Select Supplier for UV Power Supply</td>
<td>40</td>
<td>20</td>
<td>16</td>
<td></td>
<td>8</td>
<td></td>
<td>800</td>
<td>800</td>
<td>$3,044</td>
<td>300</td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td>$3,044</td>
</tr>
<tr>
<td>F</td>
<td>Identify/Select Suppliers for Other Long-Life/Key Components</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td></td>
<td>4</td>
<td></td>
<td>8</td>
<td>60</td>
<td>192</td>
<td>300</td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td>$5,540</td>
</tr>
<tr>
<td></td>
<td>Stepper Motors</td>
<td>40</td>
<td>40</td>
<td>30</td>
<td></td>
<td>4</td>
<td></td>
<td>7</td>
<td>20</td>
<td>141</td>
<td>276</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH Probes</td>
<td>40</td>
<td>40</td>
<td>10</td>
<td></td>
<td>4</td>
<td></td>
<td>8</td>
<td>60</td>
<td>141</td>
<td>276</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regulators</td>
<td>40</td>
<td>40</td>
<td>60</td>
<td></td>
<td>4</td>
<td></td>
<td>8</td>
<td>60</td>
<td>122</td>
<td>256</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Optics</td>
<td>40</td>
<td>40</td>
<td></td>
<td>6</td>
<td>6</td>
<td></td>
<td>4</td>
<td>20</td>
<td>132</td>
<td>300</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pumps</td>
<td>40</td>
<td>80</td>
<td>20</td>
<td></td>
<td>8</td>
<td></td>
<td>8</td>
<td>120</td>
<td>276</td>
<td>570</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flow Restrictors</td>
<td>40</td>
<td>40</td>
<td></td>
<td>6</td>
<td>6</td>
<td></td>
<td>8</td>
<td>60</td>
<td>156</td>
<td>256</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pressure Transducers</td>
<td>60</td>
<td>80</td>
<td></td>
<td></td>
<td>8</td>
<td></td>
<td>8</td>
<td>60</td>
<td>256</td>
<td>570</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IR Sources</td>
<td>40</td>
<td>40</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
<td>4</td>
<td>20</td>
<td>112</td>
<td>256</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blue LED's</td>
<td>40</td>
<td>20</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
<td>2</td>
<td>10</td>
<td>76</td>
<td>160</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red LED's</td>
<td>40</td>
<td>20</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
<td>2</td>
<td>10</td>
<td>76</td>
<td>160</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Photodetectors</td>
<td>40</td>
<td>20</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td>6</td>
<td>10</td>
<td>100</td>
<td>300</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Identify/Select Supplier for Firmware Controller Components</td>
<td>70</td>
<td>140</td>
<td>80</td>
<td>24</td>
<td>40</td>
<td>40</td>
<td>300</td>
<td>300</td>
<td>$11,578</td>
<td>300</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Identify and Coordinate Transfer of Items from ICSA Program</td>
<td>160</td>
<td>80</td>
<td>80</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>200</td>
<td>200</td>
<td>$20,609</td>
<td>300</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modify Dog's and Associated Part Lists to Reflected Changes</td>
<td>160</td>
<td>160</td>
<td></td>
<td>240</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>$20,609</td>
<td>300</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Package Refurbished/Upgraded Stage-11 PCWQM Unit for Ship</td>
<td>20</td>
<td>30</td>
<td></td>
<td></td>
<td>30</td>
<td></td>
<td>80</td>
<td>80</td>
<td>$2,547</td>
<td>300</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Report</td>
<td></td>
<td>60</td>
<td>40</td>
<td></td>
<td>30</td>
<td></td>
<td>130</td>
<td>456</td>
<td>50</td>
<td>$4,560</td>
<td>300</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL LABOR HRS</td>
<td></td>
<td>1440</td>
<td>1440</td>
<td>200</td>
<td>322</td>
<td>342</td>
<td>603</td>
<td>1440</td>
<td>6187</td>
<td>$178,174</td>
<td>200</td>
<td></td>
<td>76</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL LABOR $</td>
<td></td>
<td>$52,013</td>
<td>$52,013</td>
<td>$3,985</td>
<td>$11,437</td>
<td>$7,493</td>
<td>$10,257</td>
<td>$37,210</td>
<td>$3,786</td>
<td>$178,174</td>
<td>$7,521</td>
<td>$14,500</td>
<td>100</td>
<td>$2,547</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG/Mo. Assuming 8 Mo. Project</td>
<td></td>
<td>1.0</td>
<td>1.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
<td>0.1</td>
<td>0.5</td>
<td></td>
<td>0.1</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Additional Notes
- MGR: 360       $103,058.40
- SNS: 1440  $37,298.80
- ENG: 864  $18,930.24
- SPL: 0  $0.00
- DFT: 603  $10,257.03
- STG: 200  $3,985.00
- MCH: 200  $3,786.00

### Other Costs
- LABOR HRS: 6187
- LABOR $$: $178,178
- O.H. @ 25%: $209,663
- MATERIAL $$: $7,521
- DCI $$: $33,950
- GLA @ 10%: $109,672
- FEE @ 5%: $26,857
- TOTAL: $564,000
ASSUMPTIONS RELATED TO PCWQM PROGRAM ROM COST ESTIMATE

1. Design Baseline is PCWQM-SEU Multiple ORU Configuration as submitted to Boeing in March 1995.

2. Space Allocation for the PCWQM is same as for the PCWQM-SEU, plus an additional 6" in depth for Power Supply and Firmware Controller.

3. ICSA Pre-Production and ProtoFlight Units will be returned from Boeing to facilitate the ProtoFlight Iodine and Conductivity Sensors being used in the PCWQM.

4. PCWQM/ICSA STE will be returned from Boeing to support testing.

5. All PCWQM and/or ICSA Program residual equipment, hardware and spare parts will be returned from Boeing for use on this program.

6. All PCWQM and/or ICSA Program documentation and data will be returned from Boeing for use on this program.
ASSUMPTIONS RELATED TO PCWQM PROGRAM ROM COST ESTIMATE

7 Incremental EEE Part Lists and EEE Parts Applications Analysis reports will not be required. EEE Parts Lists and related analyses updates will be submitted as they are completed.

8 Full Environmental Qual (Protolflight-Levels) and ATP will be performed on Top Assembly

9 A detailed part-level Finite Element Analysis will not be required. Thermal and structural analyses will be limited to specific areas of concern.

10 Detailed incremental Mass Properties Reports will not be required. Estimates and actuals will be submitted as appropriate.

11 Software code will be written and delivered in C++

12 Individual valves will not require position indicators.
13 FDI will be limited to only that which is necessary to isolate a problem to the ORU-level.

14 Drawings, parts lists and other deliverable documents can be delivered on electronic media using industry standard formats.

15 On-orbit maintenance will be limited to ORU removal and replacement.

16 A delta-CDR will be held approx. 12 months after CSD.

17 This will be approx. a 36 month program, assuming it starts in July 1998, following a planned six-month build-up and requirements definitization period. (Duration heavily dictated by procured item lead times and test durations)

18 Solid Phase Acidifier ORU can be replaced after 2000 hrs. (Approx. 3 mo.) of operation.
ASSUMPTIONS RELATED TO PCWQM PROGRAM ROM COST ESTIMATE

19  pH Probe ORU can be replaced after 8760 hours (approx. 12 mo.) of operation. Note: Strong possibility exists that this life limit can be extended appreciably (i.e., to 36 mo.) thru testing.

20  All PCWQM external interfaces (mechanical/structural, electrical, thermal, fluid) are clearly defined and agreed upon at a very early stage of the program.

21  Program Planning, Scheduling, and Control requirements will not dictate a full time PP&C Specialist.

22  Full Environmental Qual (Protolflight-Levels) and ATP will be performed on Top Assembly
PCWQM Program Technical History

- Boeing decided in 1991 to eliminate UV Ballast Supply, DC/DC Power Supplies, Firmware Controller, Turbidity Sensor, and Class S EEE parts from contract as a cost reduction.
- Boeing was to provide Class S EEE parts and handle integration of Astro's PCWQM-SEU to Boeing's FWC, UV Supply, DC Power Supply, and PCWQM software 3 years after PCWQM-SEU delivery.
- PCWQM-SEU presented at CDR was "single ORU" although a TIM took place in April '93 discussing multiple ORU configuration - Boeing didn’t want to change baseline for CDR.
PCWQM Program Technical History

- 154 RIDs issued at CDR, one of which used to justify design change to Multiple ORU PCWQM-SEU.
- "Least number of RIDs issued to any Space Station subcontractor" . . . All closed by start of ICSA build.
- Based upon the development testing status at the time, Multiple ORU configuration became defined as follows . . .
**PCWQM ORU's MANIFOLD ASSEMBLIES**

<table>
<thead>
<tr>
<th>ORU Number</th>
<th>Orbital Replacement Unit (ORU) Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PCWQM Top Assembly, Less ORU - 2 and ORU - 3 (3 to 5 Year Life)</td>
</tr>
<tr>
<td>2</td>
<td>Heated Solid Phase Acidifier (SPA) Module (90 Day Life @ 42% Duty Cycle)</td>
</tr>
<tr>
<td>3</td>
<td>SPA #2, pH Assembly, and Valves (&gt;1 Year Life)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manifold Number</th>
<th>Manifold Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ORU Interface Manifold (Connects ORU - 3 to mainframe)</td>
</tr>
<tr>
<td>2</td>
<td>ORU - 3 Manifold (Connects ORU - 2 to ORU - 3)</td>
</tr>
<tr>
<td>3</td>
<td>ORU - 2 Manifold (Piece Part Detail of ORU - 2)</td>
</tr>
<tr>
<td>4</td>
<td>UV Reactor Interface Manifold (Ties to UV Reactor, Cold Plate, &amp; Mounting Plate)</td>
</tr>
<tr>
<td>5</td>
<td>Oxygen Manifold (Oxygen Gas Loop)</td>
</tr>
<tr>
<td>6</td>
<td>Sample Out Manifold (Ties Waste Out to QD - 4)</td>
</tr>
<tr>
<td>7</td>
<td>Recirculation Manifold (Sample Loop Inlet Valve)</td>
</tr>
</tbody>
</table>
ELECTRICAL INTERFACES

ELECTRICAL INTERCONNECT
PCWQM-SEU BUS INTERFACE

BOEING
FNC & CABLE I/F

ASTRO
PCWQM

Address latch

Data latch

16 Pin Choke for Buffer-Driver

16 Pin Latches
# ELECTRICAL INTERFACE

## ADDRESS TABLE

(ELECTRICAL HW ↔ SW INTERFACE)

<table>
<thead>
<tr>
<th>Address Bus Selection Word</th>
<th>Description</th>
<th>Data Bus Control/Status/Data Word</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0</td>
<td>FUNCTION</td>
<td>BUS DATA</td>
<td></td>
</tr>
<tr>
<td>0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1</td>
<td>D +1</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>0 0 0 0 1 0 1 1 1 0 1 0 0 0 0 1</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>0 1 0 0 0 0 1 0 0 1 0 0 0 0 0 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1</td>
<td>PRESS</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
</tbody>
</table>

*Notes:
- T = Known
- A = Unknown
- X = Not Applicable
- N/A = Not Available
- * = System reset, initialize

3.4.2.6
ELECTRICAL INTERFACES

ELECTRICAL INTERCONNECT TIMING DIAGRAM & SOFTWARE INTERFACE

DWG #7330035, REV. C
# System Level Design

## Development Testing Compliance

<table>
<thead>
<tr>
<th>UNIT</th>
<th>REQUIRED/DERIVED ACCURACY</th>
<th>TEST TYPE</th>
<th>MEASURED ACCURACY TO DATE</th>
<th>SCHEDULED TEST DATE DOCUMENT NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>± 0.5</td>
<td>Formal</td>
<td>&lt; ± 0.36 pH</td>
<td>Complete, see AIC-SS-1202</td>
</tr>
<tr>
<td>Motor Pump</td>
<td>± 0.01 ml/min (derived)</td>
<td>Formal</td>
<td>± 0.01 ml/min</td>
<td>Complete, see AIC-SS-1167</td>
</tr>
<tr>
<td>1/4 Inch Temperature</td>
<td>± 1.0 °F</td>
<td>Formal</td>
<td>± 0.36 °F</td>
<td>Complete, see AIC-SS-1220</td>
</tr>
<tr>
<td>1/4 Inch Conductivity</td>
<td>± 1.0 μS/cm</td>
<td>Formal</td>
<td>± 0.25 μS/cm</td>
<td>Complete, see AIC-SS-1220</td>
</tr>
<tr>
<td>Iodine</td>
<td>± 0.2 mg/l</td>
<td>Formal</td>
<td>± 0.10 mg/l</td>
<td>Complete, see AIC-SS-1253</td>
</tr>
<tr>
<td>CO₂ Detector</td>
<td>± 10 ppm CO₂ (derived)</td>
<td>Formal</td>
<td>± 8 ppm CO₂</td>
<td>In process, see AIC-SS-1258</td>
</tr>
<tr>
<td>UV Reactor</td>
<td>Oxidation ≥ 90% with a &lt;2 mg Cl/l sample (derived)</td>
<td>Formal</td>
<td>95%</td>
<td>In process, see AIC-SS-1258</td>
</tr>
<tr>
<td>TIC/GLS</td>
<td>Residual &lt; 30 μg/l with a 5 mg Cl/l sample (derived)</td>
<td>Formal</td>
<td>&lt;20 μg/l</td>
<td>In process, see AIC-SS-1258</td>
</tr>
<tr>
<td>0.04 Inch Temperature</td>
<td>± 2.5 °F (derived)</td>
<td>Formal</td>
<td>0.36 °F by similarity</td>
<td>Complete, see AIC-SS-1220</td>
</tr>
<tr>
<td>0.04 Inch Conductivity</td>
<td>± 10.0 μS/cm (derived)</td>
<td>Formal</td>
<td>&lt; ± 7.9 μS/cm</td>
<td>Complete, see AIC-SS-1241</td>
</tr>
<tr>
<td>High Calibration Module</td>
<td>± 0.1 pH units over operational life</td>
<td>Formal</td>
<td>± 0.25 pH units over operational life</td>
<td>Complete, see AIC-SS-1265</td>
</tr>
<tr>
<td>Low Calibration Module</td>
<td>± 0.1 pH units over operational life</td>
<td>Formal</td>
<td>± 0.1 pH units over operational life</td>
<td>Complete, see AIC-SS-1265</td>
</tr>
<tr>
<td>Solid Phase Acidifier</td>
<td>pH &lt; 4.0 for 2,880 hours (211.1 liters)</td>
<td>Formal</td>
<td>&gt; 25 liters</td>
<td>In process, see AIC-SS-1284</td>
</tr>
<tr>
<td>TOCV Module</td>
<td>± 50 μg Cl/l over operational life</td>
<td>Formal</td>
<td></td>
<td>December 1993</td>
</tr>
</tbody>
</table>

---

3.14.1
PROCESS LOOP TEMP./CONDUCTIVITY SENSOR

REQUIREMENTS

The process loop temperature/conductivity sensor design results in the following derived functional requirements:

- Conductivity measuring range = 1 - 30 \( \mu S/cm \) compensated to 25 °C using standard solution SRM 3190 as a reference

- Conductivity sensitivity/tolerance = \( \pm 1.0 \mu S/cm \)

- Temperature measuring range = 50 - 150 °F

- Temperature sensitivity/tolerance = \( \pm 1.0 °F \) (\( \pm 0.56 °C \))

- Operating flow rate = 15 - 17 lb/hr (100-130 ml/min)

- Supplied water shall be gas free
Requirements

The PCWQM-SEU requires iodine measurement with the following specifications:

- Iodine measuring range = 0.1 - 6.0 mg/l
- Iodine sensitivity/tolerance = ± 0.2 mg/l at iodine-iodide equilibrium in pure water and constant pH for accuracy during process
- Operating temperature range = 50-150 °F
- Operating flow rate = 15-17 lb/hr (100-130 ml/min)
- Supplied water shall be gas free
- Operating pH range = 5 - 9 pH units
The iodine detector design results in the following derived functional requirements:

- Optical path length $\leq 18$ cm
IODINE DETECTOR

IODINE DETECTOR BLOCK DIAGRAM
pH MEASURING SUBSYSTEM

REQUIREMENTS

The PCWQM-SEU requires pH measurement with the following specifications:

- pH measuring range = 5 - 9 pH units
- pH sensitivity/tolerance = ± 0.5 pH units
- Operating temperature range = 50 - 150 °F

The pH sensor design results in the following derived functional requirements:

- Operating flow rate = 1 - 5 ml/min
The Solid Phase Preconditioner (SPP) design results in the following derived nominal operating requirements:

- Flow rate = 1 ml/min
- Conductivity range = 1 - 30 μS/cm
- pH range = 5 - 9 pH units
- TOC range = 50 - 1000 μg/l
- Iodine range = 0.1 - 6.0 mg/l
- Temperature range = 50 - 150 °F
- TIC range = 0 - 5 mg/l
The Low Solid Phase Calibration Standards design results in the following derived functional requirements:

- Preceded by a Solid Phase Preconditioner (SPP)
- Effluent pH range = 3 - 5 pH units
- pH stability over operational life = ± 0.1 pH units
- Operational life span = 300 20 minute cycles
TOC MEASURING SYSTEM

REQUIREMENTS

The PCWQM-SEU requires TOC measurement with the following specifications:

- Measuring range = 100-1000 µg/l
- Sensitivity/tolerance = ± 50 ppb
SOLID PHASE ACIDIFIER

REQUIREMENTS

The solid phase acidifier design results in the following derived functional requirements:

- Effluent $< 4.0$ pH units
- TOC contribution $< 10 \mu g$ C/l
- Operational life span $= 2880$ hours (Equivalent to 211.2 liters throughput)
SOLID PHASE ACIDIFIER

REQUIREMENTS

The solid phase acidifier design results in the following derived nominal operating requirements:

- Flow rate = 1 and 5 ml/min
- Conductivity range = 1 - 120 \( \mu \)S/cm
- pH range = 3 - 10.5 pH units
- TOC range = 50 - 1000 \( \mu \)g/l
- Iodine range = 0.1 - 6.0 mg/l
- Temperature range = 50 - 150 \( ^\circ \)F
- TIC range = 0 - 5 mg/l
The Total Inorganic Carbon/Gas Liquid Separator (TIC/GLS) design results in the following derived requirements:

- TIC residual < 30 \( \mu g \) C/l at a TIC influent \( \leq 5 \) mg C/l
- TIC operating range = 0 - 5 mg C/l
- Provide oxygenation greater than 20 mg O\(_2\)/l at 1 atmosphere
- Influent pH < 4.0 pH units
- Operational flow rate = 1 ml/min
- Operating temperature range = 50 - 150 °F
- Operational performance insensitive to orientation (simulated zero G)
- O\(_2\) influent flow rate = 20-50 sccm
UV REACTOR

REQUIREMENTS

The UV reactor design results in the following derived requirements:

- Oxidation $\geq 90\%$ with TOC sample of urea $\leq 1.5$ mg C/l
- Operational influent pH $< 4.0$ pH units
- Operational flow rate $= 1$ ml/min
- Operating temperature range $= 50 - 150^\circ$ F
UV BALLAST

REQUIREMENTS

- UV REACTOR STEPUP, HIGH VOLTAGE OUTPUT TRANSFORMER
  - Envelope and mechanical interface defined in SK683-20929 of April 9, 1993
  - Two primary coils rated for 100 volts max.
  - Two secondary coils rated for 4000 volts max (40:1 turns ratio each)
  - Encapsulated; Electrical terminals are MIL-T-55155/15C
  - Qualified to MIL-STD-981 Class S consistent with MIL-STD-975J

* Specifications are to change per October 27, 1993 UV Ballast PDR Telecon
CARBON DIOXIDE DETECTOR

REQUIREMENTS

The CO₂ detector design results in the following derived operating requirements:

- Temperature range = 50-104 °F
- Flow rate = 1 ml/min ± 0.01 ml/min
- Inlet sample pH ≤ 4
- Inlet TIC residual ≤ 30 µg C/l
- 90% of sample TOC in the form of CO₂ (minimum)
- CO₂ detector cell surface ≥ 1 °C above inlet temperature of sample
- O₂ flow rate = 0-275 sccm
MOUNTING PLATE ASSEMBLY

REQUIREMENTS

- Change in front panel attachment points from center plane to top of front panel from ICD resulted in redesign. Requires more rigid (heavier) front panel due to cantilevered mounting of front panel.

- Front panel shall meet human factors of NASA-STD-3000 for rounded corners, connector spacing, attachment points

- Mounting plate assembly shall be self aligning, require no complex actions, unable to be installed in the wrong orientation

- Support PCWQM-SEU component assemblies during launch vibration, acceleration, and crew induced loads

- 1-g installation/removal force shall be less than 35 lbs

- Provide conduction path for heat rejection from components to integral heat exchanger

- Fasteners removable on orbit must be captive
MOUNTING PLATE ASSEMBLY

DESIGN

ALIGNMENT BUSHINGS

LABEL RECESSES

CAPTIVE FASTENERS

FASTENER COVER

TYPICAL CROSS SECTION

FRONT VIEW

ROUNDED Corners
PER NASA-SID-3000

RIGHT SIDE VIEW

4.10.3.1
The motor/pump design results in the following derived requirements:

- Flow rate = 1 and 5 ml/min
- Pressure rise = 10 - 25 psig
- Flow stability = ± 0.01 ml/min @ 1 ml/min
- Flow stability = ± 0.25 ml/min @ 5 ml/min
SAMPLE MANIFOLDS

REQUIREMENTS

- Minimize the requirement for tubing runs by grouping components onto manifolds
- Reduce the risk of leakage by mounting interconnected components on opposite sides of the manifold and by using drilled holes
- Reduce sensitivity to variation on multi-port components by using static face seals against the manifold
- Minimize manifold size and weight
- Locate heat generating components as close as possible to the avionics air heat sink
- Profile manifolds where required to maintain clearance to other subassemblies
SAMPLE MANIFOLD

DESIGN - SAMPLE MANIFOLD 2

SECTION A-A

316L STAINLESS STEEL MANIFOLD

TEMPERATURE/CONDUCTIVITY ASSEMBLY

TEMPERATURE SENSOR
SAMPLE MANIFOLD

DESIGN - SAMPLE MANIFOLD 4

316L STAINLESS STEEL MANIFOLD

3-WAY SOLENOID VALVE
SENSOR/EFFECTOR ADDRESS DECODER

REQUIREMENTS

SEAD ANALOG SIGNAL FUNCTIONAL REQUIREMENTS:

- 32 channels of single ended analog inputs with range of -10 to +10 volts dc
- Static input voltage accuracy of $\pm 0.003\%$ of Full Scale Range (FSR) at a 1 kHz sampling rate
- Static input voltage resolution accuracy of at least 610 $\mu$V/Least Significant Bit (LSB)
- Dynamic error $< \pm 0.0224\%$ FSR at a signal slew rate of 0.5 volts per second at a 10 kHz sampling rate
- Provide interface to firmware controller via 2 wire/line RS-422 balanced receivers/drivers
- Cabable of receiving or transmitting 16 bit wide data bus signals
- Cabable of storing, semipermanently, minimum 2K x 8 bit sensor calibration coefficients
SEAD DIGITAL SIGNAL FUNCTIONAL REQUIREMENTS:

- 16 Transistor-Transistor Logic (TTL) channels of digital input with the following characteristics:
  - Minimum high level input voltage is $V_{IH} = 2.0$ volts
  - Maximum low level input voltage is $V_{IL} = 0.8$ volts

- 32 channels of digital output with the following characteristics:
  - Minimum high level voltage $V_{OH} = 2.4$ (Min) with an output current of $I_{OH} = -4.0$ mA
  - Maximum low level voltage $V_{OL} = 0.45$ (Max) with an output current of $I_{OL} = 8.0$ mA
SENSOR/EFFECTOR ADDRESS DECODER

REQUIREMENTS

SEAD SAMPLE RATE FUNCTIONAL REQUIREMENTS

- Maximum sample rate frequency of 10 kHz
- Sample rate accuracy of ± 50 Hz
- Sample rate stability of ± 1% of the setting

SEAD BIDIRECTIONAL DATA BUS COMMUNICATION FUNCTIONAL REQUIREMENTS

- The input command yields the appropriate output effector command 100% of the time
SEAD VALVE DRIVER CIRCUIT FUNCTIONAL REQUIREMENTS

- Provide PWM drive to valve with 0.14% duty cycle after initial drive of
  +28 volts for 50 ms.

SEAD CONDENSATE DETECTOR CIRCUIT FUNCTIONAL REQUIREMENTS

- Convert the condensate detector's analog signal to a 1 bit digital signal
ICSAS Program Design Status

• Boeing directed change from PCWQM-SEU to ICSA configuration effective March 31, 1995

• Deliverables:
  ▶ 1 Pre-Production prototype Unit [PPU]: A) work out any layout bugs; B) built w/Class B EEE parts or parts from Class S lot being tested; C) verify calibration and test procedures; D) Boeing planned to ultimately deliver to Hamilton Standard to assist in WP integration.
  ▶ 1 Protosflight Unit [PFU]: A) supposed to be 100% Class S EEE parts; B) reduced Qual Test levels; C) intended to be used for Flight.
  ▶ STE: Automated test system designed for calibrating and performing ATP for PCWQM and ICSA.
ICSA Flow Diagram

LEGEND:

- QUICK DISCONNECT COUPLING SELF SEALSING
- IODINE DETECTOR
- TEMPERATURE/CONDUCTIVITY SENSOR
ICSA Mechanical Interface Components
Temperature/Conductivity Sensor - Process Loop
ICSAS Program Design Status

- Open Issues/Status:
  - PPU meet objectives stated above. \( \therefore \) no issues (Not for Flight!)
  - Boeing directed ZALC to complete build of PFU with some non-Class S EEE parts (upscreened DESC parts; red LED; AD590 temp sensor)
  - Calibration was performed as required
  - ATPs were modified to reduce Schedule: no thermal cycling; limited full range temperature sensor performance verifications; no Vibe; no EMI; no pressure or vacuum.
  - Boeing’s plan was to take PFU apart, install correct Class S parts, re-calibrate, execute PFU Qual ATP using STE
ICSA Program Design Status

ICSA Design considered a success that exceeded performance requirements (60 hour ATP):

- "Temperature sensitivity/tolerance of $\pm 1.0^\circ F$ over range of 50 to 150$^\circ F$"
  
  ATP data: $\pm 0.12^\circ F \{\pm 0.61^\circ F (3 \sigma)\}$

- "Conductivity sensitivity/tolerance of $\pm 1.0 \mu S/cm$ over range of 1 to 30 $\mu S/cm$ compensated to 25$^\circ C$ using SRM 3190 as reference standard"
  
  ATP data: $\pm 0.12 \mu S/cm \{\pm 0.88 (2 \sigma)\}$
ICSAS Program Design Status

- "Iodine Sensor sensitivity/tolerance of ±0.2 ppm over range of 0.1 to 6.0 mg I₂/L at iodine-iodide equilibrium in WP H₂O and constant pH"
  
  ATP data: ±0.11 mg I₂/L over range (1 σ)
- All ICSA hardware & documentation and PCWQM-SEU documentation shipped to Boeing April 25, 1997
  
- ZALC assumes current plan is to recover PPU & PFU ICSAs for use within PCWQM where appropriate
- ZALC also assumes STE will be recovered for use by PCWQM Program
1997 PCWQM Program Development

- ION Associates funded further development work towards PCWQM under “lessons learned” from Stage 10.
- Conclusions of Studies done for ION:
  - ZALC-SS-1601: GLS membrane material is available from alternative vendors
  - ZALC-SS-1600: “membrane failures” were not failures of membrane material: 2 caused by spacing shims (subsequent design has eliminated them); 1 caused by defective o-ring (subsequent assembly procedures call for microscopic inspection prior to incorporation into unit)
1997 PCWQM Program Development

- Conclusions of Studies done for ION (continued):
  - ZALC-SS-1602: Recommend further life testing to justify >1 yr life for ISFET probe (ORU3); or could replenish electrode gel on-orbit
  - ZALC-SS-1603: baslined Honeywell (nee Leeds & Northup) pH probe still available and no problems in future procurement expected; alternative vendors available, but design impacted.
  - ZALC-SS-1606: UV Ballast power supply subcontractors do exist and could cost effectively design/manufacture to Class B type requirements.
1997 PCWQM Program Development

- Conclusions of Studies done for ION (continued):
  - ZALC-SS-1607: Suggest incorporation of 254 nm solid state detector into UV Lamp Assembly to monitor intensity.
  - ZALC-SS-1608: TOC measurement range extension to 5000 ppb TOC can happen with virtually no impact if accuracy requirement set to ±5% of reading over 1 to 5 ppm range.
  - ZALC-SS-1605: Modeling and packaging study drawings follow, with recommendation that PCWQM incorporate power supplies and firmware controller for a true “turn key” instrument eliminating complex integration.
PCWQM Program Technical History

- PCWQM-SEU is a "dumb" assembly relying on external command and control of effectors and sensors.
- Baseline design results in two (2) large connectors:
  \[ J1 = \text{Power: } +5, +28, \pm 15 \text{ and associated returns} \]
  \[ J2 = \text{Signal: } 32 \text{ twisted, shielded pairs} \]
- Boeing to provide cabling up to PCWQM-SEU front panel. . . significant weight
- PCWQM Integration Nightmare:
  - PCWQM-SEU to External DC Power supplies
  - PCWQM-SEU to third party External FWC
  - PCWQM-SEU to third party software
1997 PCWQM Program Development

- Advantages of "self contained" PCWQM:
  - Improves significantly likelihood of successful higher level integration
  - Significantly reduces testing problems
  - Instrument provides a serial data stream (re: Stage 9 and Stage 10 PCWQM) with data already converted to scientific values (calculations already performed, PCWQM state and FDI status provided, overrides available, etc.)
  - Weight delta negligible: compare FWC weight -vs- 32 twisted pairs w/shields, connectors, multiple power lines, etc.
1.3A @ +120 Vdc

151.8 W = Total Load on +120 Vdc Supply

4.5A @ 28Vdc
AFL12048SXCA
83% eff

9.4 W

9.4 W

51.3 W

0.3A @ +15Vdc
-15Vdc
80% eff

7.5 W

7.5 W

40.0 W

8.0A @ +5Vdc
ATR286SFXC/CH
78% eff

126.0 W = Total Load on +28 Vdc Supply

Two Step Down Power Distribution Approach

PCWQM Program & Design Status

November 20, 1997
1.1A @ +120 Vdc

136.2 W = Total Load on +120 Vdc Supply

67.5 W

2.0A @ 28Vdc

28Vdc

83% eff

56.0 W

9.4 W

0.5A @ +15Vdd

-15Vdd

80% eff

7.5 W

40.0 W

8.0A @ +5Vdc

80% eff

Single Step Down Power Distribution Approach

POWEREF1.0.3, Scenario #2
<table>
<thead>
<tr>
<th>Description:</th>
<th>Ref.</th>
<th>Channel Count (wrt SEAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Digital Out</td>
</tr>
<tr>
<td>Conductivity</td>
<td>TC1</td>
<td>0.5</td>
</tr>
<tr>
<td>Iodine</td>
<td>I1</td>
<td>1</td>
</tr>
<tr>
<td>Motor, Metering</td>
<td>PM1</td>
<td>1</td>
</tr>
<tr>
<td>Motor, TOC Stepper</td>
<td>IG1</td>
<td>1</td>
</tr>
<tr>
<td>pH sensor</td>
<td>PH1</td>
<td>1</td>
</tr>
<tr>
<td>Pressure Xdcr PT1-1</td>
<td>C7</td>
<td>1</td>
</tr>
<tr>
<td>Pressure Xdcr PT1-2</td>
<td>B5</td>
<td>1</td>
</tr>
<tr>
<td>Pressure Xdcr PT2-2</td>
<td>D3</td>
<td>1</td>
</tr>
<tr>
<td>Pressure Xdcr PT2-4</td>
<td>B6</td>
<td>1</td>
</tr>
<tr>
<td>Pressure Xdcr PT3-1</td>
<td>B4</td>
<td>1</td>
</tr>
<tr>
<td>Pressure Xdcr PT3-2</td>
<td>C4</td>
<td>1</td>
</tr>
<tr>
<td>Pressure Xdcr PT3-3</td>
<td>C5</td>
<td>1</td>
</tr>
<tr>
<td>Pressure Xdcr PT4-2</td>
<td>C6</td>
<td>1</td>
</tr>
<tr>
<td>Temperature TC1, T</td>
<td>B7</td>
<td>0.5</td>
</tr>
<tr>
<td>Temperature TT1-1</td>
<td>C4</td>
<td>1</td>
</tr>
<tr>
<td>Temperature TT1-2</td>
<td>C4</td>
<td>1</td>
</tr>
<tr>
<td>Temperature TT1-3</td>
<td>C5</td>
<td>1</td>
</tr>
<tr>
<td>Temperature TT1-4</td>
<td>C5</td>
<td>1</td>
</tr>
<tr>
<td>Temperature TT1-5</td>
<td>C6</td>
<td>1</td>
</tr>
<tr>
<td>Temperature TT1-6</td>
<td>C4</td>
<td>1</td>
</tr>
<tr>
<td>TOC (CO2 Detector) IG1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SPA Heater HT1</td>
<td>C7</td>
<td>1</td>
</tr>
<tr>
<td>IR/GLS Heater HT2</td>
<td>C4</td>
<td>1</td>
</tr>
<tr>
<td>UV Drive UV1</td>
<td>C2</td>
<td>1</td>
</tr>
<tr>
<td>Valve, 3-way TV1-1</td>
<td>B5</td>
<td>1</td>
</tr>
<tr>
<td>Valve, 3-way TV1-4</td>
<td>C7</td>
<td>1</td>
</tr>
<tr>
<td>Valve, 3-way TV1-5</td>
<td>C4</td>
<td>1</td>
</tr>
<tr>
<td>Valve, 3-way TV1-6</td>
<td>C3</td>
<td>1</td>
</tr>
<tr>
<td>Valve, 3-way TV1-9</td>
<td>B6</td>
<td>1</td>
</tr>
<tr>
<td>Valve, 3-way SV1-2</td>
<td>S7</td>
<td>1</td>
</tr>
<tr>
<td>Valve, 3-way SV1-3</td>
<td>S7</td>
<td>1</td>
</tr>
<tr>
<td>Valve, 3-way SV1-4</td>
<td>D4</td>
<td>1</td>
</tr>
<tr>
<td>Condensate Detector  CD1</td>
<td>D4</td>
<td>1</td>
</tr>
</tbody>
</table>

Total Channel Counts¹: 19 : 22 : 20

¹ Per Flow Diagram 7330168 Rev. G
² not shown in Rev. G, to be added
³ baseline assumes full position mitigation
PCWQM Bottom Rear Left Panel View
ORU3 = pH and Cal Standard Assembly
ORU2 = Solid Phase Acidifier Assembly
Assumed Firmware Controller Volume
ORU3 Interface Manifold Assembly
Oxygen Manifold Assembly
PCWQM Future Technical Development

- Must establish Technical Baseline and Program Requirements!

- This directly impacts Cost & Schedule!

- Examples:
  - Class S -vs- Class B EEE Parts
  - Analyses detail (to what level(s), safety factors, etc.)
  - Testing -vs- Analyses
  - Amount of “Flow down” requirements that would have to be levied on our vendors
  - HSD/DCMO involvement in Assembly and Testing
  - MRB Responsibility