Neutral Buoyancy Laboratory: Astronauts from the Pool to Spacewalks

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Kurt Otten is the Operations Manager for NASA’s Neutral Buoyancy Laboratory (NBL) in Houston, Texas which is a 6.2-Million-gallon pool. He is also the owner of The Pool Company which he started in 1983 while still in high school. He earned his Bachelor of Science in Electrical Engineering from the University of Houston. Kurt began his career at NASA as a Safety Diver at the Weightless Environmental Testing Facility (WETF) while attending college. He has always had a love for all water so being able to work at the NBL was a perfect fit to allow him to use his Engineering degree and swimming pool knowledge.

**Abstract**

NASA’s Neutral Buoyancy Laboratory (NBL) is one of the world’s largest indoor pools that can support multiple large scale operations utilizing both underwater and topside assets simultaneously. The NBL’s pool, measuring 202 ft (61.5 m) long by 102 ft (31.1 m) wide and 40 ft (12.2 m) deep, is outfitted with full-sized mock-ups of the International Space Station, including working model of the robotic arm. Its volume is 6.2 million gallons, chlorinated fresh water and maintains a water temperature of 84°-86°F (28.9°-30°C). The NBL is utilized for mission planning, procedure development, hardware verification, astronaut training, and refinement of time-critical operations necessary to ensure mission success during spacewalks. The facility is also used for commercial applications such as Subsea Oil and Gas working ROV trainings, Off-shore Safety & Survival Training, Underwater Systems: AUVs, ROVs, ADSs, Underwater Testing: Systems Tests, Integration Tests, Commercial Space: Mockup Support, Ground Tests, and Orion Spacecraft Recovery Training. All of this has to be strategically programmed using multiple areas such as safety divers, camera divers, topside crews and test directors ensuring that all customer needs are met.

This session will discuss how a facility of this size is able to have multiple foreign objects in the pool keeping perfectly balanced water while using a turnover rate of only 18 hours. We will discuss the design of the facility and how we were able to meet the challenging requirements that were above a standard indoor aquatic facility and how the daily operations of the facility are programmed and managed. This session will give you a behind the scenes look at one of NASA’s most vital facilities, how we train our Astronaut’s from the pool to spacewalks and view some actual hardware that is used to perform these spacewalks. Feel free to ask questions in the Q&A session.
Astronauts from the Pool to Spacewalks

How we teach astronauts to spacewalk

International Space Station (ISS)

- Only scientific laboratory orbiting 250 miles above the Earth
- International collaboration between 5 space agencies representing 15 countries
- Assembly started in 1998; Crewed since 2000
- Currently have 6 people living and working there
- Habitable volume of an average 5 bedroom house
- Including solar arrays, size of a football field

How we built ISS

37 Space Shuttle Flights and ~150 EVAs to assemble and maintain
Extravehicular Activities (EVA)

Extravehicular Mobility Unit (EMU)

Provides basic life support functions to protect astronauts while working in the extreme environment of space:
- PLSS – Primary Life Support System, delivers oxygen to breathe and maintain suit pressure, scrubber, water tank, regulates suit pressure
- HUT – Hard Upper Torso, fibreglass upper part of the EMU to which the helmet, arms and waist attach
- TMG – Thermal Micrometeoroid Garment, white layer that provides protection to the suit bladder from thermal extremes and small micrometeoroids
- DCM – Display and Control Module, has a digital display and mechanical pressure gauge to allow you to check out your suit’s performance
- LCVG – Liquid Cooling and Ventilation Garment circulates water around the astronaut’s body for cooling
- DIDB – Disposable In-suit Drink Bag holds 32 ounces of water to drink
- SAFER – Simplified Aid For EVA Rescue, N2 “jet pack” to allow you to fly back to ISS if you become separated
- Helmet lights for when it’s dark and a sun visor for when it’s sunny
- Radio to talk to Mission Control and your partner, also to downlink suit parameters to Mission Control

EVA TOOLS
How to Train to Work in Space

New astronauts learn the basics of EVA including how the EMU works and how to perform basic tasks during an EVA.

Once assigned to an ISS Increment, astronauts spend ~22 months learning all about life on the ISS, including more in-depth EVA knowledge.

EVA Training facilities include:

- Neutral Buoyancy Lab (NBL)
- Virtual Reality (VR) Lab
- Space Station Airlock Test Article (SSATA) Vacuum Chamber
- Space Vehicle Mock-up Facility (SVMF)
- Airlock
- Partial Gravity Trainer (POGO)
- Active Response Gravity Offload System (ARGOS)
- Flight Hardware Lab
Neutral Buoyancy Laboratory (NBL)

- Astronaut training
- Mission Planning
- Procedure Development
- Hardware verification
- Time-critical operations
- Mission success

- Over 150 EVAs Trained
- 148 ISS
- 13 Hubble
- Over 327,000 Dive Hours
- Over 95 million cu. ft. Nitrox (EAN46%) produced (NRG stadium is 90 million cu. ft.)
- Over 20,800 Space Suit Training Hours
- Over 3,500 Space Suit Training Events

Multiple Integrated Control Rooms
Clean Climate Controlled Environment
Armature Test Audit & Instrumentation Capabilities
Multiple Cage Systems for Equipment Handling
SCUBA and surface-supplied dive systems
ISO Level 8 Clean Rooms

Ellington Runway Access

Classroom, Meeting, & High-Bay Work Areas
On-Site Engineering and Technical Services
Medical Staff, Hypobaric Altitude & Hyperbaric Chambers
World Class Safety Culture

Co-located Logistics & Manufacturing Facility
Logistics and Mockup Facility (LMF)

- Vertically Integrated Design and Manufacturing
  - Mockup Fabrication and Repair
  - Machine shop
  - Sheet Metal Shop

Neutral Buoyancy Laboratory (NBL)

- Remotely Operated Vehicle (ROV) Operations
- Hardware Testing and Demonstration
- Safety and Survival Training
- Vehicle and Crew Recovery
- Diving Center of Excellence

Facility Design

- Construction
  - Building built in 1991 as processing facility for Space Station Freedom
  - Repurposed in 1995 for NBL pool
  - Took 30 days to fill and 30 days to clean the water after filling
  - HVAC 1,560 Tons (1-400T/4-290T)
  - 10M BTU Boiler System
  - Exhaust 144K cu. ft
The Pool

- Length: 202 ft (61.5 m)
- Width: 102 ft (31.1 m)
- Depth: 40 ft (12.2 m)
- Volume: 6.2 million gallons
- Water temperature: 84°-86°F (28.9°-30° C)
- 2 Overhead Bridge Cranes (20.6 Tons each)
- 22+ Video P/T/Z Cameras

Water Treatment System (WTS)

- Complete Automatic Control System
- Heated at 86°F (2M BTU Boiler)
- 4 sand filters with 18 hour turnover rate
- Uses filtered water for backwash
- Fill water fed upstream of filters
- 10,000 Gal NaOCl annually for sanitizer
- 1,000 Gal Muriatic Acid annually
- Backwash ~15,000 Gal weekly
- Over 5,000 Gal water loss due to evaporation weekly

Diagram:

- Automated Control System
- Sand Filters
- Backwash Tank
- BOILER
- Chemical Addition
- Filtration Pumps
- Water Analysis
- Makeup Water
- Pool Treatment Water Loop
Programing the Facility

Personnel, Tests and Reconfiguration
• Facility Utilization Requests for Users
• Custom MS Excel spreadsheets that post to web and various monitors
• Pre-dive Calendar for programming (Long Range and Weekly Planning meetings)
• Project Web Application

ISS Airlock (NBL)

ISS Airlock (Actual)
Questions?

• Thank You for this great opportunity
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