Space: An Exciting Place to Work!

Working in Space
(without ever leaving Earth?)

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NASA
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STEM Presentation
Herzogenaurach, Germany
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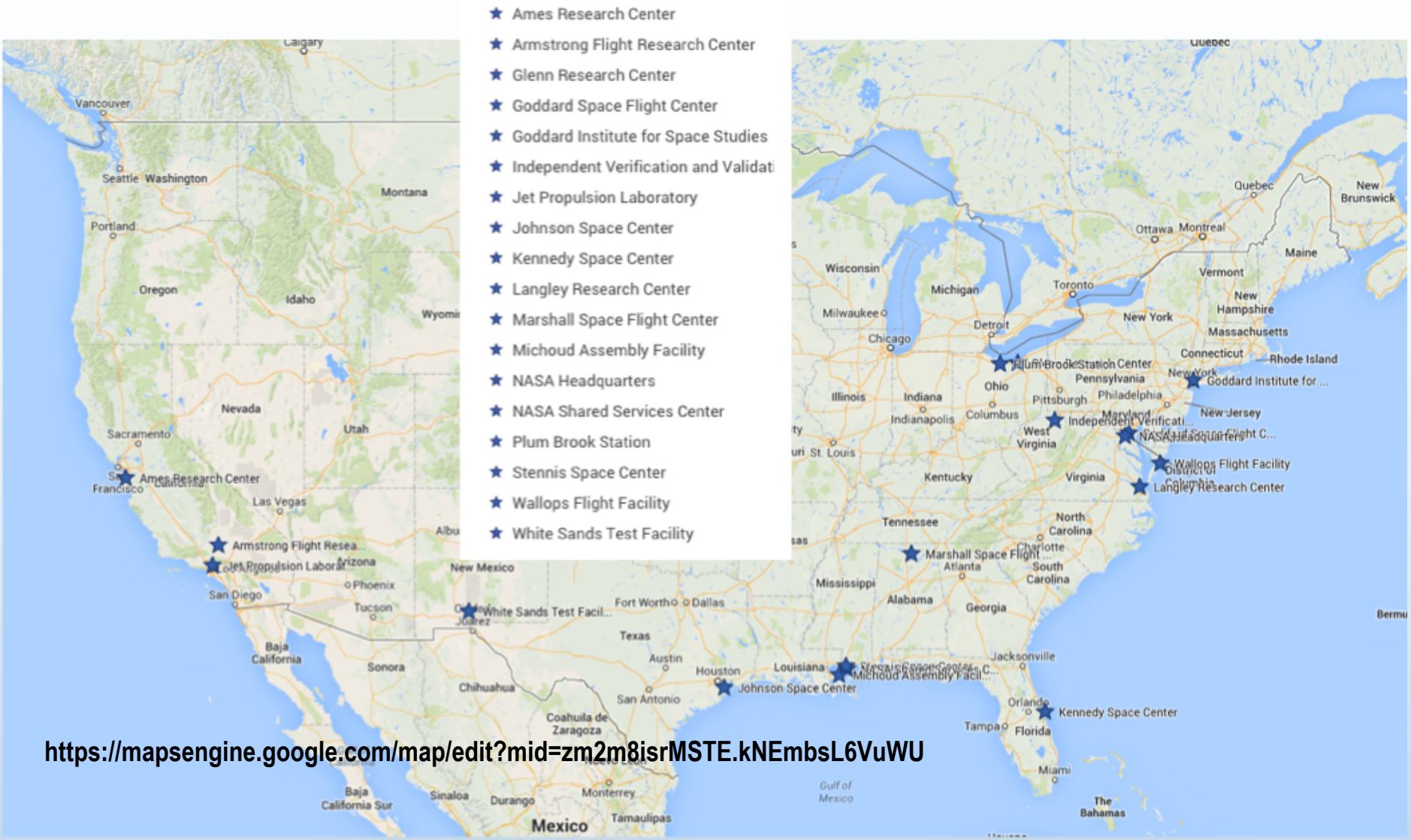
NASA: Not just “Houston” and “Kennedy”



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Space Careers: Astronaut

- Astronaut Career Facts:
  - Today, there are ~50 astronauts on the ISS or ready to launch. Since 1961, 533 astronauts have flown in space.
  - NASA currently has 18,000 employees.
  - In 2014, 9 year old children said: Video game designer, scientist, teacher, veterinarian, doctor, nurse are most desired careers.
  - In 1970: Astronaut, fireman, sports star.

Space Careers: Astronaut

- New NASA astronaut class Facts:
  - In June, 2017, 18 300 people applied to become an astronaut.
  - NASA selected 12.
  - Astronauts also work for ESA
  - Are you a future astronaut?

Astronaut Requirements:

Succeed in a Medical test:

- Excellent vision (eye glasses are ok)
- Height between 62 and 75 inches (157-190cm)
- Low blood pressure

Learn to fly a jet:

- Engineering or science degree.
- Physically fit
- Mentally alert and stable
- Tolerate airplane acrobatics (spins, high-g's)

ESA Astronaut: Germany

Alexander Gerst:

- *Born* [redacted] *on* [redacted]
- *Technical High School in Öhringen, 1995*
- *Univ. of Karlsruhe, Geophysics (Diploma)*
- *Victoria Univ. (NZ), Earth Sciences (Masters)*
- *Univ. of Hamburg, Geophysics (Doctorate)*

Space Experience:

- Joined ESA, 2009.
- ISS Expedition 40 & 41, 2014
- Summer 2018 return to ISS.

Could Dr. DellaCorte be an astronaut?

Succeed in a NASA Medical test:

- Excellent vision (eye glasses are ok)
- Height between 62 and 75 inches (157-190cm)
- Low blood pressure

Learn to fly a jet:

- Engineering or science degree.

- Physically fit
- Mentally alert and stable
- Tolerate airplane acrobatics (spins, high-g's)

Alternative Careers: Stay on Earth

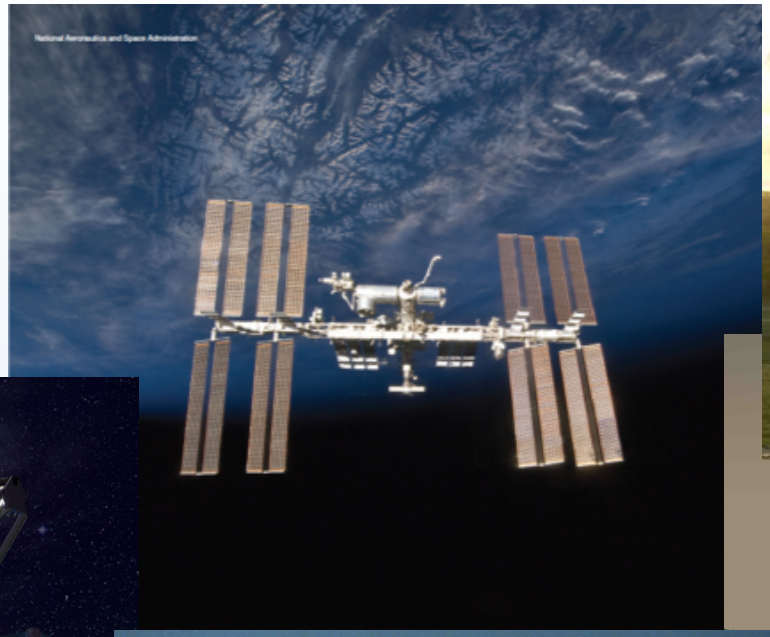
NASA's other 17 950 employees:

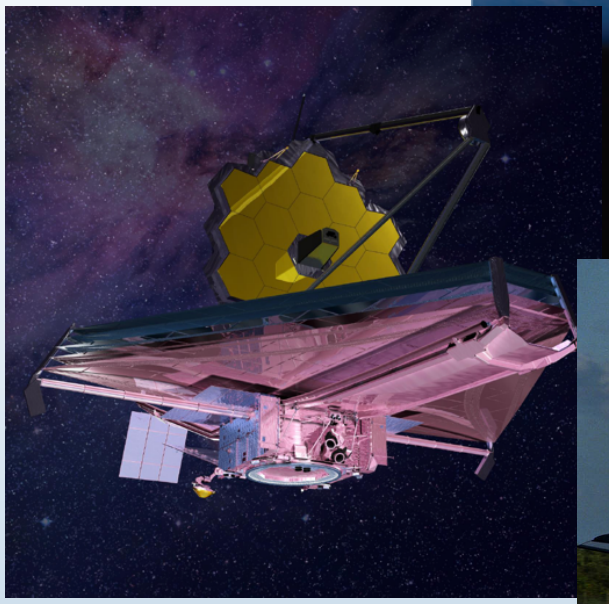
- Design and build space vehicles
- Operate (Mission Control) space vehicles
- Study the earth (satellites, climate change, etc.)
- Explore deep space (probes, rovers, space telescopes, etc.)

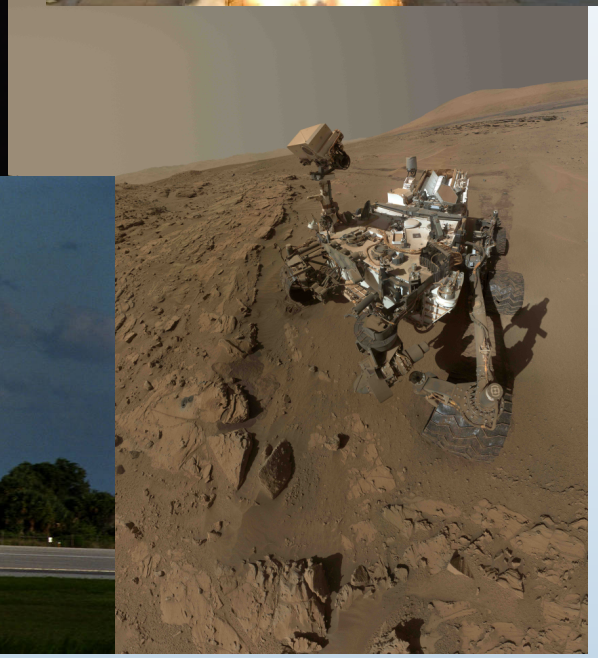
Hidden and unseen careers:

- Develop new technologies
- Help repair broken spacecraft

Expanding Boundaries: NASA tries new things that are hard







Expanding Boundaries: Problems Happen

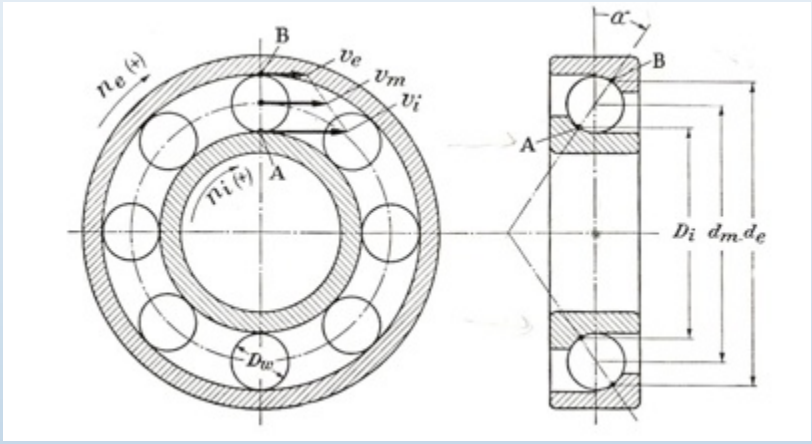
- **Mars Curiosity Rover:**
  - Dust storms
  - Shock load landing
  - Extreme cold temperatures
  - Nuclear radiation power
- **Technical Problems:**
  - Dirt damages bearings and blocks solar power and cameras
  - Bearings and moving parts freeze
  - Rocks damage wheels

ISS Technical Challenges: All Disciplines

- **Major Spacecraft Systems:**
  - Electrical Power
  - Life support (water, air, food)
  - Propulsion (thrusters)
  - Materials and structures
  - Mechanisms (bearings, hatches, exercise machines)
- **Technical Problems:**
  - Mechanical Engineering
  - Electrical Engineering
  - Chemistry
  - Computer Science
  - Materials Engineering
  - Biology and Medicine

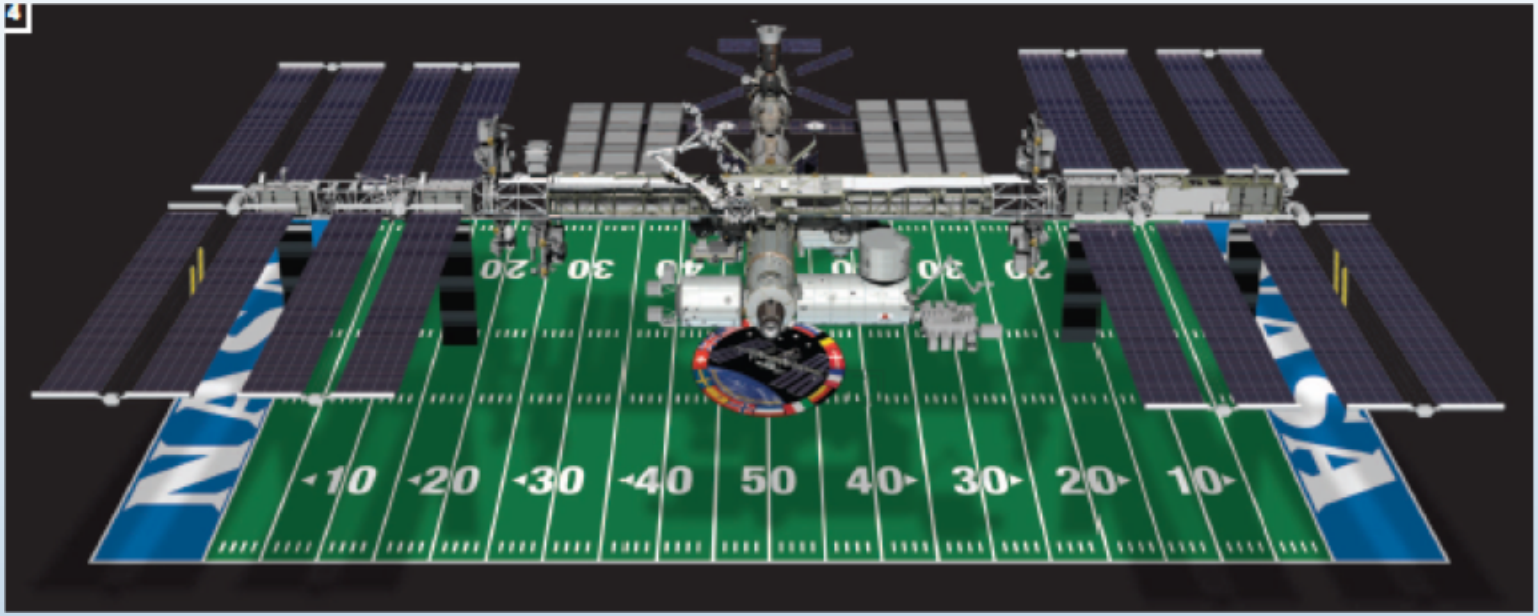
Bearings: Common mechanical challenge

- **Definition: A bearing is a device that allows free movement between two connected machine parts.**
  - **Allows one part to turn while the other remains stationary (e.g. wheel vs. car frame, propeller vs. airplane wing).**
  - **Must operate with low friction and no wear.**
  - **Be able to withstand severe loads.**
  - **Used everywhere (cars, planes, washing machines, spacecraft, pumps, fans, computer disk drives, roller skates and bicycles).**
- **Usually have balls and races (inner and outer rings).**
- **Made locally by Schaeffler.**



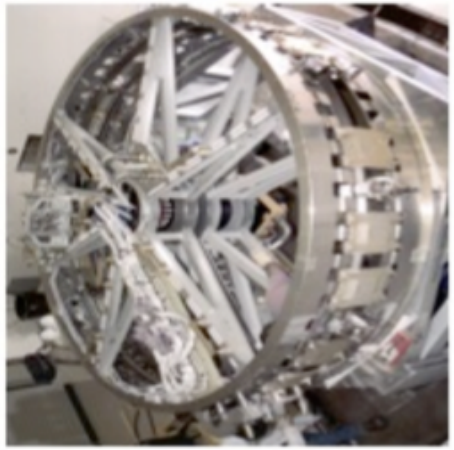
ISS: Laboratory in space

- Large, ~100 meters long
- Solar Panel (PV) array “wings”.
- Many moving mechanisms and systems.
- Lots of engineering “challenges” (problems)

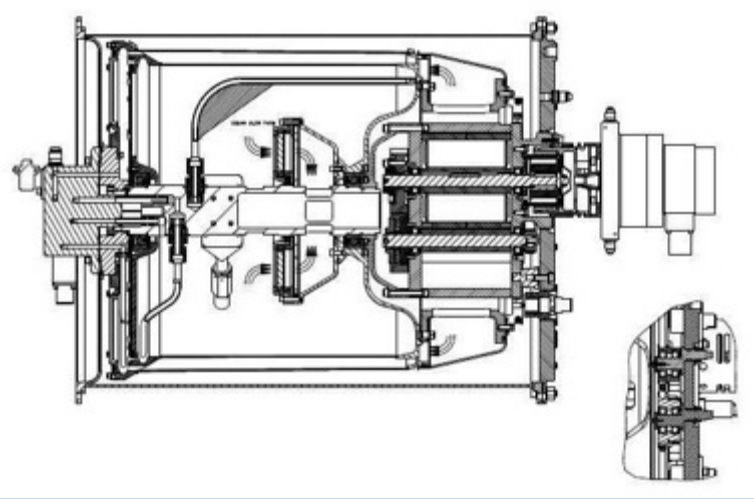


ISS: Two Bearing Challenge Examples

- SARJ Bearing Failure:
  - Solar panel wing bearing.
  - Continuous slow rotation
  - Vital to ISS operation. Failure not an option.

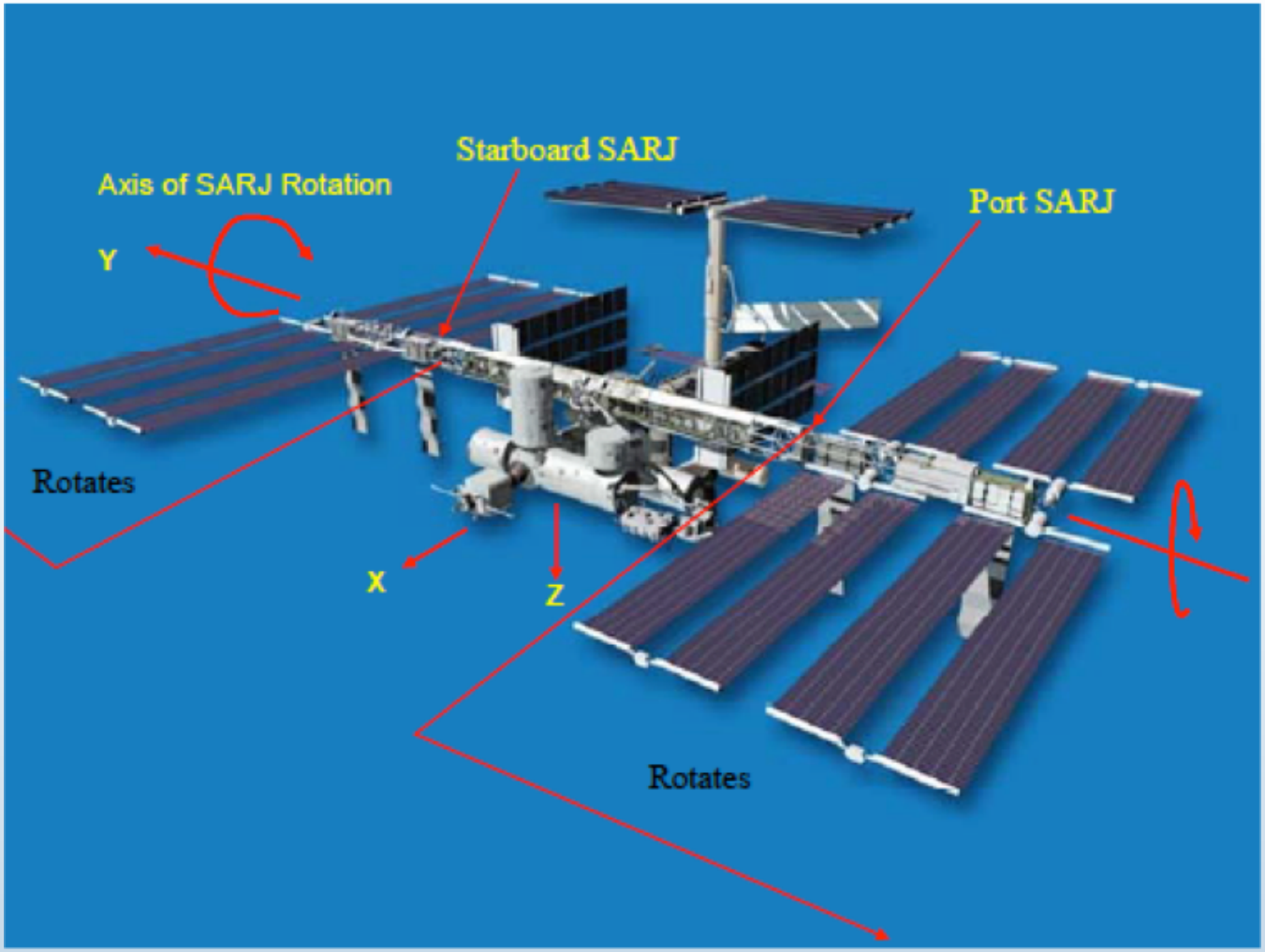


- ECLSS Distillation Assembly:
  - Purifies dirty water.
  - Bearings spin in hot acid water.



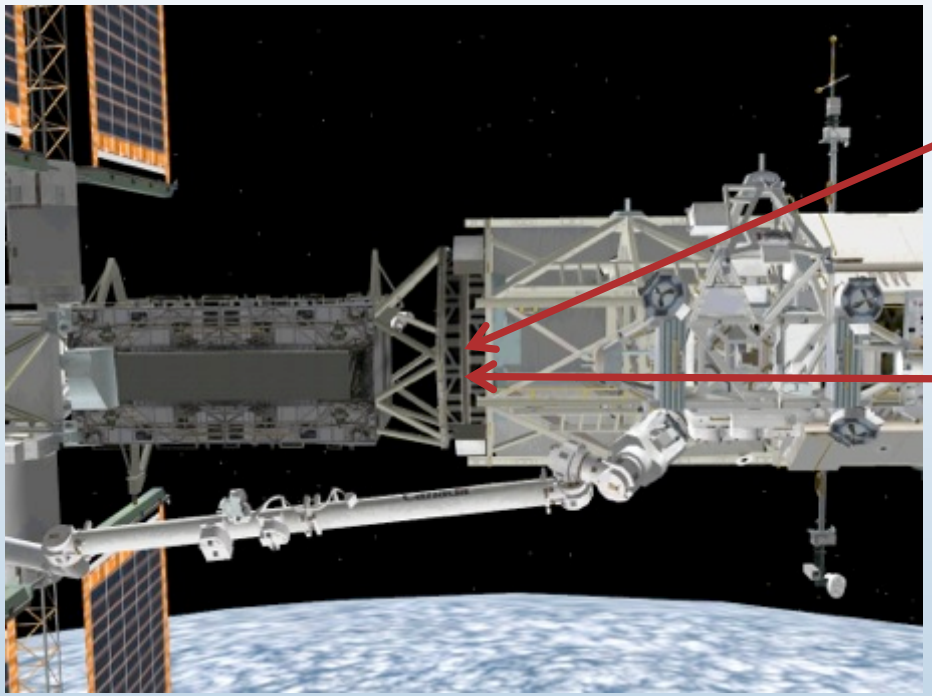
ISS: Solar Alpha Rotary Joint (SARJ)

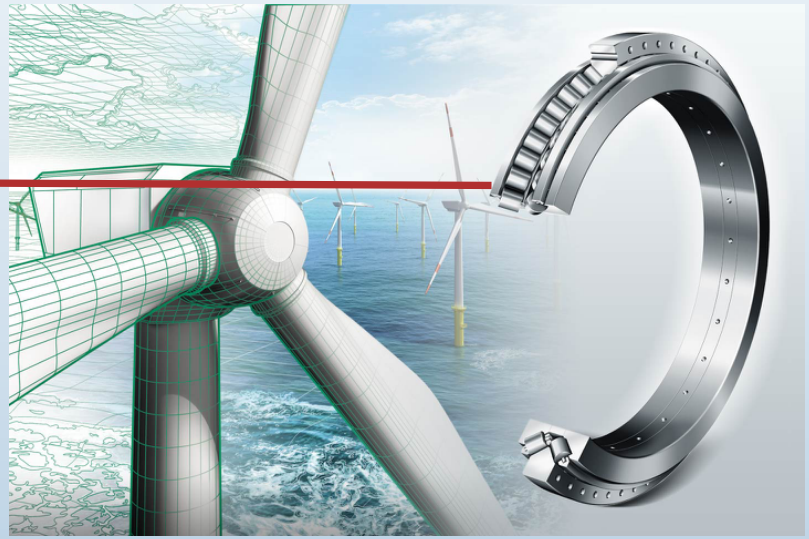
- Big bearing allows solar panels to follow sun.



SARJ Bearing: Like Wind Turbine Bearing

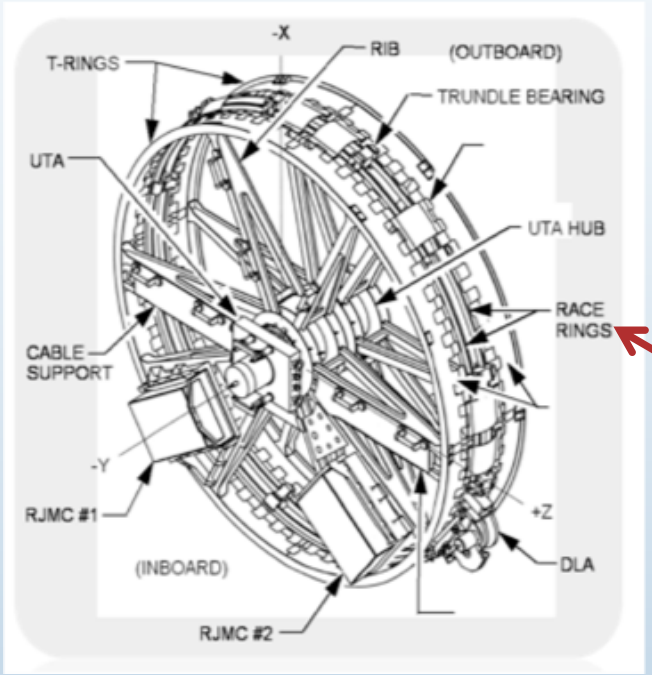
- 3 meter bearing
- Turns slowly and must be smooth
- Similar to large wind turbine bearings made by Schaeffler

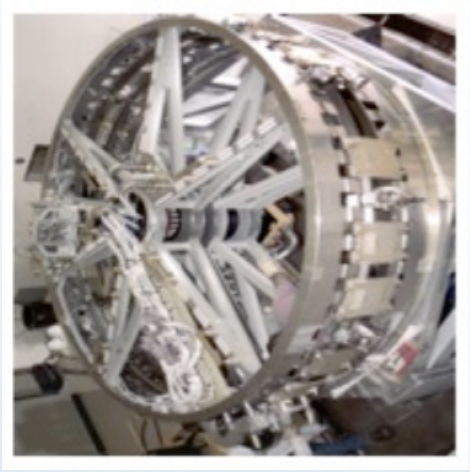


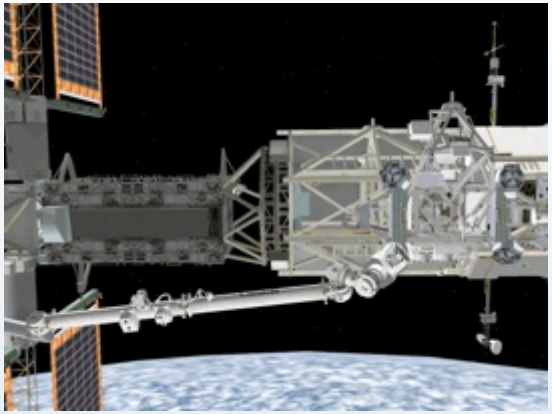


SARJ Hardware

- SARJs:
  - Design complex.
  - Can be replaced or repaired in space



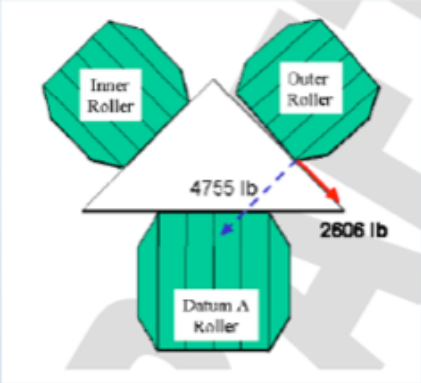




Bearing made for long-life, but designed to allow replacement by astronauts (never proven before).

SARJ Bearing (Close up view)

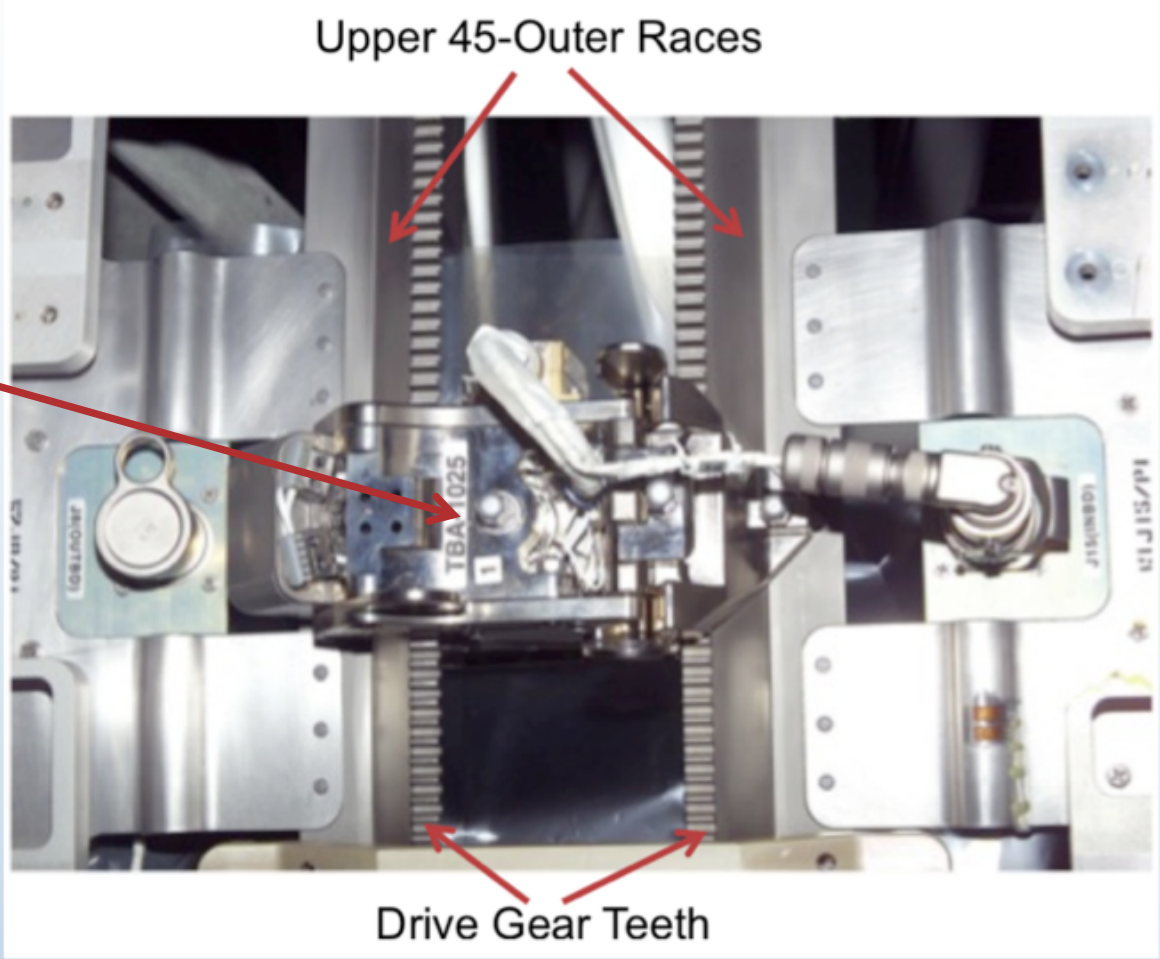
- Bearing race rings are triangle cross-section (shape).
- Races turn inside three rollers.
- Each roller contains a small ball bearing.



SARJ: When new on ISS

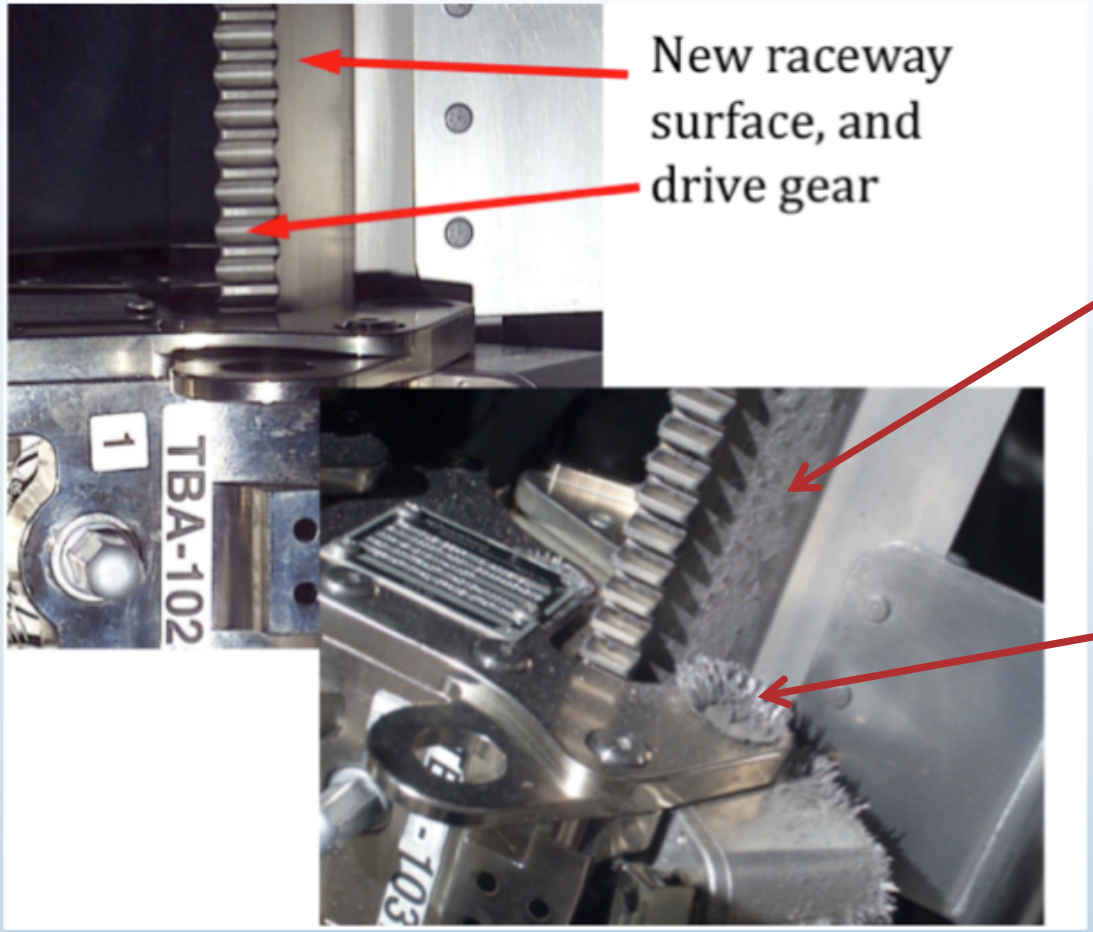
- Race surfaces are smooth and clean.
- Rollers (hidden under trundle) allow races to turn easily.

Trundle (rollers underneath)



SARJ: Bearing stopped turning?

- Astronaut Extra Vehicular Activity (EVA-spacewalk)
  - Race was not smooth and clean any longer.
  - Wear debris was everywhere…samples collected.

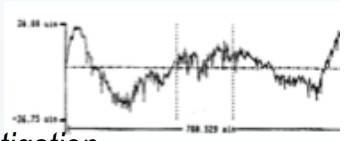


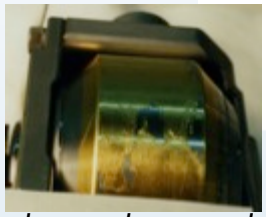
Investigation: “how did it break?”

Inadequate lubrication of the roller-race contact, combined with a kinematic mechanism design that is vulnerable to roller tipping and high friction, led to damaging high roller-race surface forces and stresses.

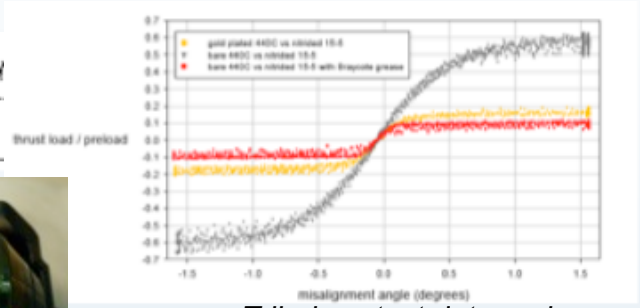
Problem

Investigation



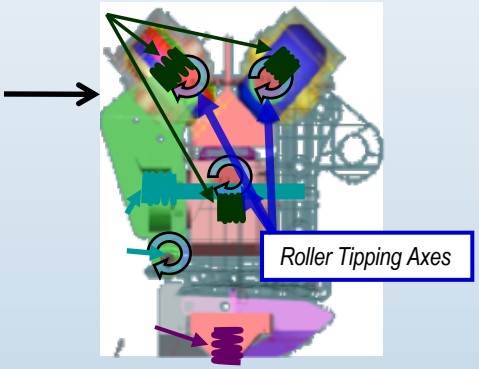


Design analyses and records search



Tribology test data and expertise

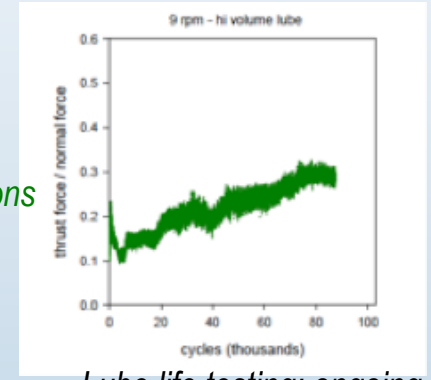
Root cause determination



Understanding

T. Krantz and C. DellaCorte (RXN)

Recovery-Operations



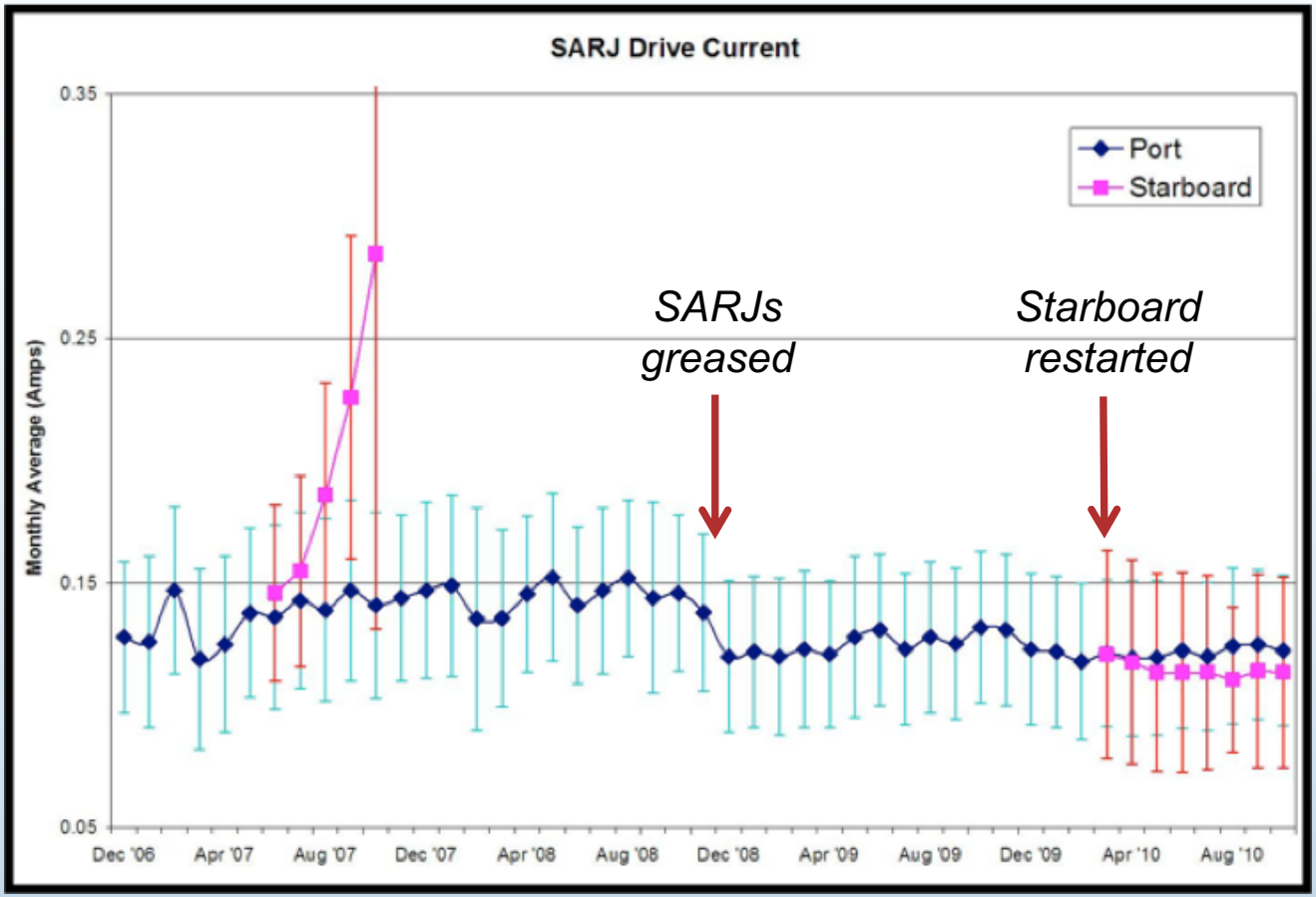
Lube life testing: ongoing

Repair: "How can we fix the SARJ?"

- Ground tests and analyses showed that grease reduces friction is needed.
  - STS-126 trained for SARJ repair and recovery.

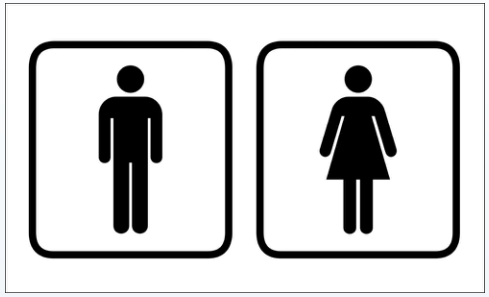
SARJ Repair: “It worked!”

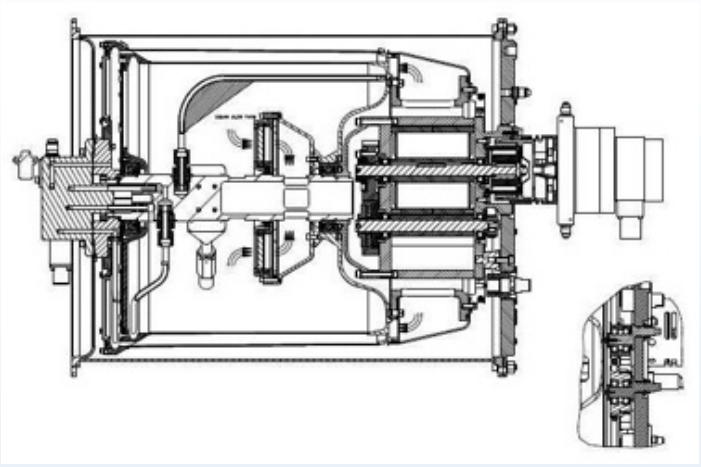
- Grease lubrication added November 2008.
- NASA watches SARJ friction every minute, 24/7.
- Nine years later the SARJ bearings are ok.



ISS: Water Recycling

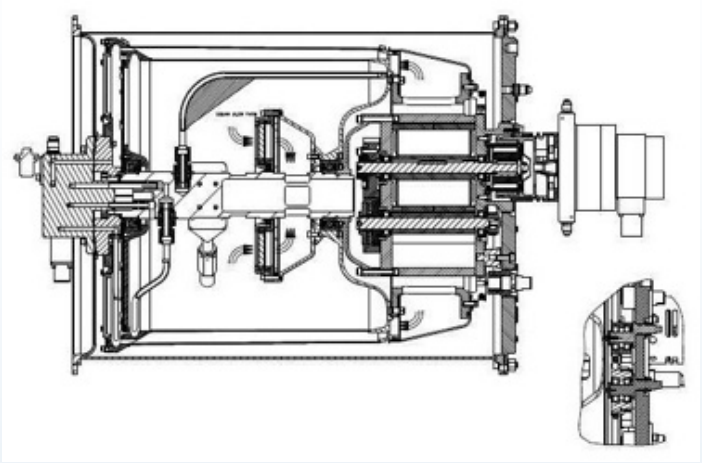
"Toilette" → *"Distillation Assembly"* → *"Wasser"*



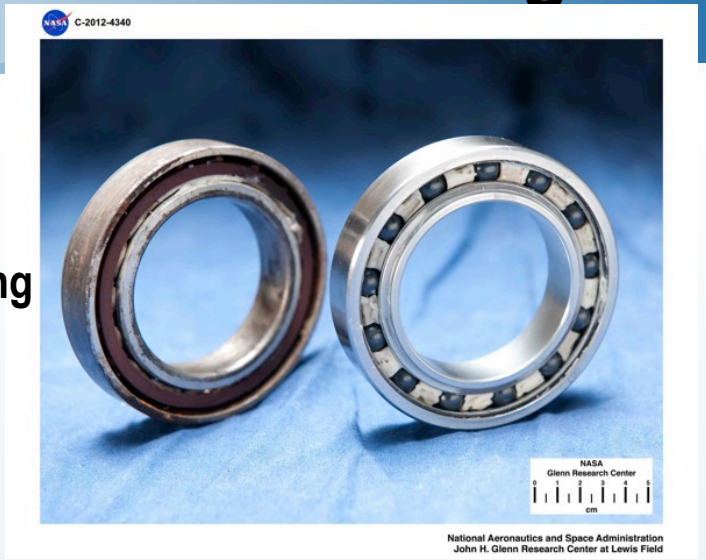


- **<u>ECLSS Distillation Assembly</u>:**
  - **Rotating drum is heated to boil dirty water and create steam.**
  - **Steam is cooled, condensed and filtered to produce clean water.**
  - **Inside ISS, warm, wet, corrosive environment.**

Water Recycler: Needs new bearings



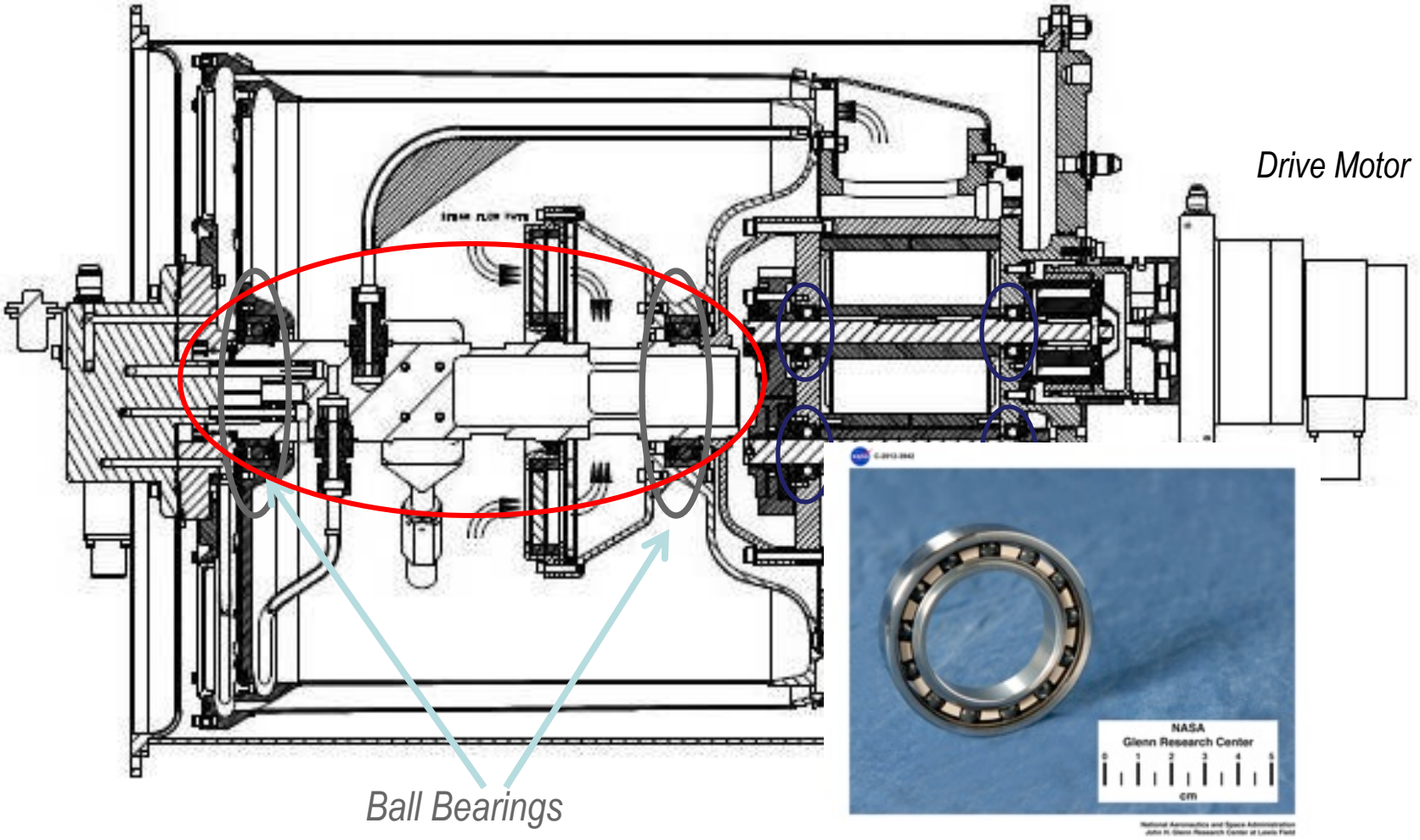
Steel Bearing (rust)



NiTi Bearing (rust-proof)

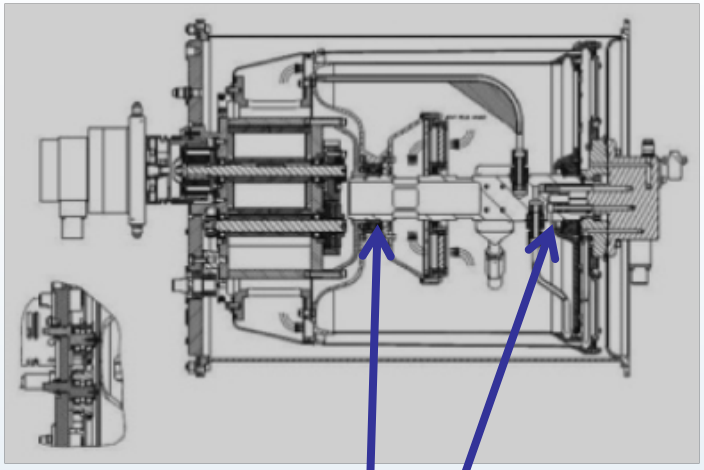
- <u>ECLSS Distillation Assembly</u>: Bearing problems
  - Original steel bearings rusted and failed.
  - Cobalt alloy bearings were too soft and failed
  - NASA invented new NiTi alloy that is hard and does not rust. Could it work?

New Technology: NiTi Bearings

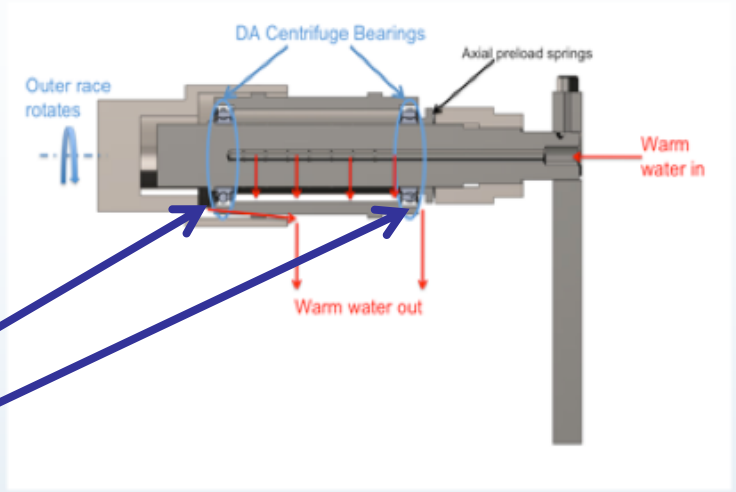


Bearing Testing: NASA lab
(Warm, wet, slow conditions)

DA Cross Section



DA Urine Processor Simulator

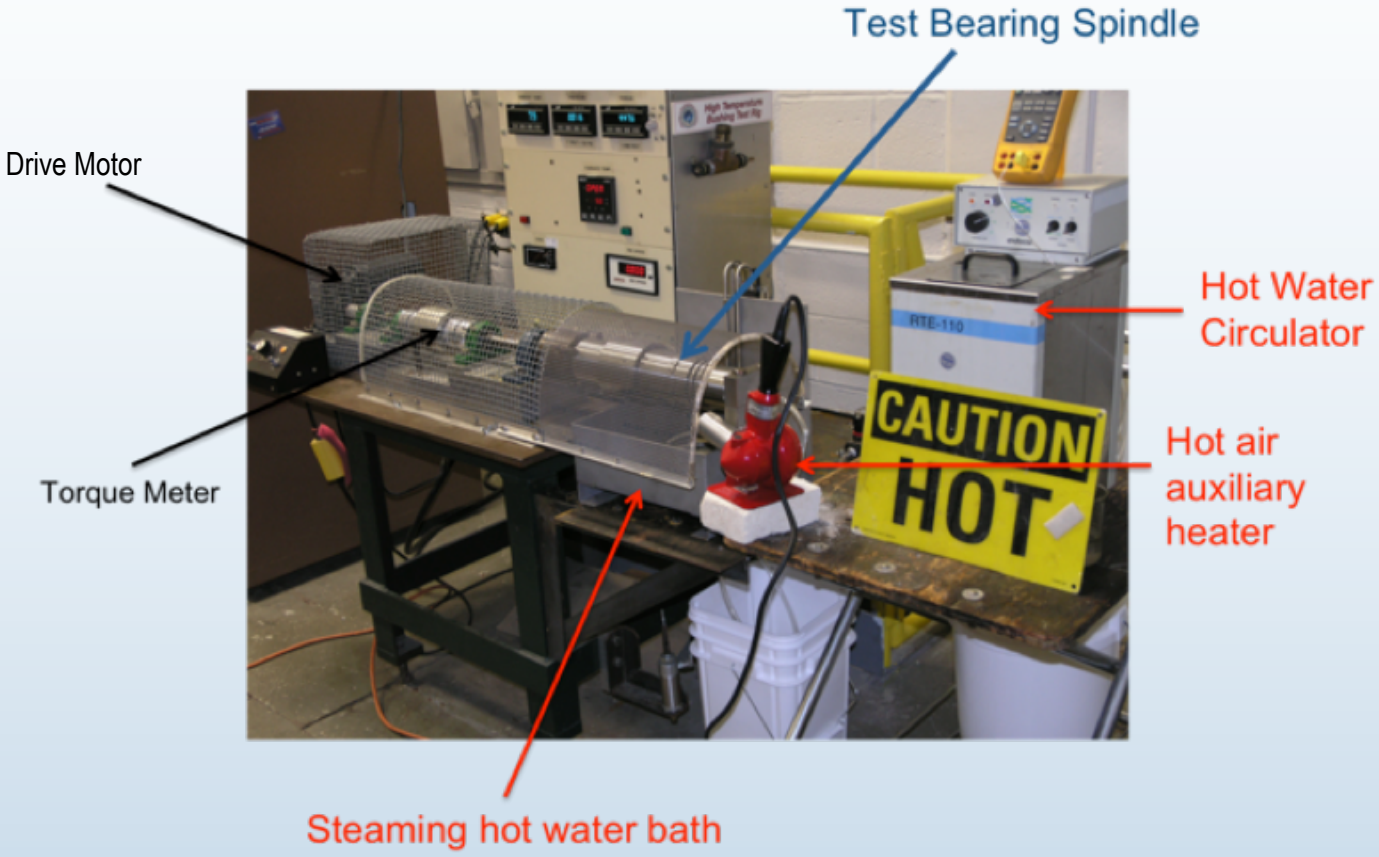


DA Centrifuge Bearing Test Rig
Spindle Components

Speed, load, configuration, temperature and moisture match ISS application.

Bearing Testing:
(Warm, wet, slow conditions)

Lab Configuration of DA Urine Processor



Long tests (10 000 hours) prove that NiTi bearings work well.

Current Status: NiTi technology

- **Problem**: NASA bearing failures in ISS water recycling machine.
  - Steel bearings rust and fail rapidly.
  - No materials known that are hard and corrosion-proof for bearings.
- **Solution**: Develop new alloy (NiTi) that cannot rust and is hard
- **Plan: Transfer knowledge of NiTi to industry**
  - Schaeffler has developed processes for NiTi and NiTi-Hf bearings.
  - Schaeffler is now making NiTi bearings for NASA missions and use on earth.

Thoughts: Many opportunities in space

- Space is an exciting business!
- The astronauts do great things well and face real problems.
- Thousands of engineers, scientists and technologists stand behind the astronauts.
- They design new systems, develop new technologies and move them into mainstream industries.
- All engineering, science and technological disciplines are needed in space.
- **Not everyone can be or needs to be an astronaut to make a contribution.**

Thank You!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