# Bridging the Gap Between Man and Machine

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Robonaut B's upper body can attach to a Segway-built robotic mobility platform (RMP) in order to drive on Earth.
CREDIT: NASA/JSC

Crew cooperation will always be vital in any manned space exploration mission, even if som of those crewmembers aren't human.

With a current mandate to return human explorers to the moon no later than 2020, then push on to Mars, NASA researchers are developing better robots for the humans who will work alongside them on space missions.

"It's just enough time if we're very aggressive," said Illah Nourbakhsh, robotics group lead at NASA's Ames Research Center in California, of the 2020 deadline. "If we're able to really focus on robot perception and manipulation, yes, I believe we can have robots build habitats on the moon."

The goal of using robots in conjunction with human astronauts on lunar and planetary missions is to free up the living members of the crew for exploration and science. The two astronauts aboard the International Space Station (ISS), for example, spent the bulk of their time just maintaining the orbital facility, researchers said.



"Humans could end up speeding a massive amount of time just dealing with upkeep [in future missions]," Nourbakhsh said. "We can't afford to do that, you'd need more humans to be there, eating food, breathing air."

At Ames Research Center, scientists and engineers are constructing an indoor laboratory designed to mock a manned moon or Mars base, with an inner control room looking out over simulated lunar surface where humans and robots will cooperate to build structures, test equipment and use digging tools In November, researchers will use the site to test their system with NASA's wheeled humanoid-like automaton Robonaut B and other robots.

Nourbakhsh and his team hope their tests will lead to space-flying assistants capable of taking instruction from human astronauts, responding in a

human-like manner or even offering suggestions and asking for help when needed. They envision robots that can be both controlled remotely and function autonomously.

"That doesn't mean the robot will be as smart as a human, but it has to be able to ask questions and you have to be able to answer it," Nourbakhsh told *SPACE.com*.

***Complex communications***

***Streamlining communications between humans and robots is a first step towards building a better space team.***

***"Human teams use very colloquial language," Nourbakhsh said, adding that air traffic controllers, for example, have their own set vocabulary designed specifically to direct pilots and aircraft. "Robots are not first-class citizens and they won't necessarily understand every word."***

***Ames researchers are focusing on enhancing robot spatial reasoning skills to ease routine tasks, such as handing off tools and equipment, and allow automatons to understand hand signals and gesture on their own during communication with human astronauts.***

***Nourbakhsh said his project works in tandem with other robotics research with similar goals of developing smoother human-robot cooperation.***

***NASA researchers led by Ames scientist Bill Clancey, for example, have developed intelligent computer software called mobile agents to work as a data management bridge between human astronauts, rovers and base computers during a moon or planetside extravehicular activity (EVA).***

***"What we do is give the [robotic assistant] another computer running the agent system," Clancey has told SPACE.com. "It brings the robot into the voice network, and it can speak to astronauts."***

***Instilling robotic instincts***

***One of the major challenges facing robot-human cooperation is safety, project researchers said.***

***"When you have robots and humans working side-by-side, there have to be safeguards," Nourbakhsh explained. "It's not just a piece of software anymore."***

***A spacesuit-clad astronaut working in the vacuum of space or on the lunar surface is already in a potentially dangerous situation, and the addition of a robot working in close quarters could prove disastrous if the automaton is not equipped with measures to prevent injury or accidental damage.***

***"It's like [Isaac] Asimov's laws," Nourbakhsh said. "[The robot] should never endanger the human being."***

***Lunar and Mars robots must also be able to multitask, not only to adapt to their surroundings but also to increase utility.***

***"We need robots that can be team players, and switch to a different role as needed," Nourbakhsh said. "You want a robot that can see an object once and recognize it in the future, robots that dig through regolith, and robots that can create oxygen on the moon."***

***Conditioning humans for robots***

***Changing how humans and robots interact does not solely depend on developing better machinery and ever-more sophisticated machinery. Humans will have to adjust, too.***

***"It will be a challenge for humans to work down at a specific robot's level," Nourbakhsh said. "Humans tend to either decide that the robot is sort of perfect and I can trust it, or the robot is unbelievably stupid and I shouldn't use it."***

***Built in responses to indicate confusion and understanding in a robot can act as audio cues for human operators to adjust their directions, Nourbakhsh said, adding that developing the proper mental models for humans to use when addressing robot helpers can be reinforced through field tests.***

***Tens of small field trials and up to four major simulations in the Utah desert will likely be required before the first robotic astronaut partners are ready for a space mission, but the automatons won't fully supplant human explores, researchers said.***

***"We as explorers, as scientists, are always going to want to have situations where we want to scrape that rock, or hand drill that sample," Nourbakhsh said. "We're not going to always go to a robot, we want that first-hand experience."***

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