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Countdown to 2013...

building the James Webb Space Telescope

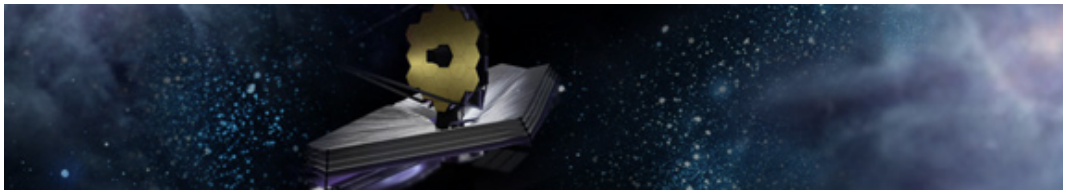
When the Webb Telescope takes off for its perch in space, a million miles away, it will be operated by some 200,000 lines of software code. One of its goals will be to search for faint signs of infrared light to help us better understand the origins of the universe. Since a system failure would involve a space shuttle mission to repair, the software needs to be right the first time.

NASA chose an IBM Rational systems development solution to be used by its three international space agency partners in building the Telescope. The solution will act as a blueprint for the entire multi-decade project, allowing different development organizations to "drag and drop" software code directly into the blueprint, where it is then automatically populated across the entire project. Such modeling can accelerate software development by almost 30 percent, with quality checks built in at every step.

It's a long way from the development of the Hubble Telescope nearly 20 years ago. Hubble was a mix of proprietary applications. When a fix was needed, engineers had to identify not only which software application would solve the problem, but sometimes track down the very same developer who wrote the original code years earlier.

About the James Webb Space Telescope

(Source: www.jwst.nasa.gov)



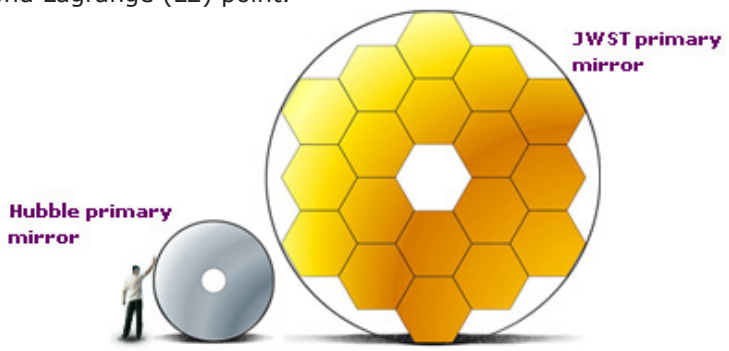
What is the James Webb Space Telescope?

This large infrared space telescope is scheduled for launch in 2013, replacing the Hubble Space Telescope. It will serve as the premier observatory for thousands of astronomers worldwide over the next decade. The Webb Telescope will seek out traces of visible and infrared light from the very first stars, to offer clues to the formation of the Universe.

How is the Webb Telescope different from Hubble?

There are some similarities—both Telescopes are (or will be) in space. They both seek to improve our understanding of processes like star birth and the evolution of galaxies. However, there are many differences.

To start, the Webb Telescope will primarily look at the Universe in the infrared, while the Hubble studies it at optical and ultra-violet wavelengths. The Webb Telescope also has a much bigger mirror than the Hubble. This larger light-collecting area means that it can peer farther back into time than the Hubble is capable of doing. The Hubble is in a very close orbit around the earth, while the Webb Telescope will be one million miles away at the second Lagrange (L2) point.



Specifically, what will the Webb Telescope do?

It has four scientific goals:

The End of the Dark Ages: First Light and Reionization seeks to identify the first bright objects that formed in the early Universe, and follow the ionization history.

The Assembly of Galaxies will determine how galaxies and dark matter, including gas, stars and active nuclei evolved to the present day.

The Birth of Stars and Protoplanetary Systems focuses on the birth and early development of stars and planets.

Planetary Systems and the Origins of Life studies the physical and chemical properties of solar systems (including our own).

Where will it orbit?

The Webb Telescope will be situated at the second Lagrange point (L2) of the Sun-Earth system, about one million miles from the Earth. The combined gravitational forces of the Sun and the Earth can almost hold a spacecraft at this point, and it takes relatively little rocket thrust to keep the spacecraft near L2. The cold and stable temperature of the L2 point will allow it to make the very sensitive infrared observations needed.

How large is it?

The Webb Telescope is about the size of a school bus and has a large mirror, 6.5 meters (21.3 feet) in diameter and a sunshield the size of a tennis court. Both the mirror and sunshade won't fit onto the ship fully so both will fold up and open only once the Telescope is in outer space.

Who is developing the Telescope?

The Webb Telescope is an international collaboration between NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA). NASA has overall responsibility and its Goddard Space Flight Center is managing the development effort. Over 1,000 people in more than 17 countries are working on the project.

Who is James Webb and why does he have a telescope named for him?

James Webb is a former NASA Administrator who laid the groundwork for the Apollo missions to the moon.

Highlights of IBM's space flight chronology

1944
IBM helps to design and build the Automatic Sequence Controlled Calculator for Harvard University. It is used by Navy scientists to prepare ballistic tables.

1957
Two IBM 704 computers are used to track the Soviet Union's Sputnik I, the world's first artificial satellite.

1959
The United States accelerates its satellite launching program, including the first U.S. flight of monkeys (Able and Baker) into outer space. An IBM 709 data processing system is used in this effort.

1962
Mercury Astronaut John Glenn in Friendship 7 becomes the first American to orbit the Earth. His historic four-hour, three-orbit flight is monitored in real-time by IBM computers.

1968
A two-ton, three-foot high, 21-foot diameter, IBM-assembled Instrument Unit guides the Apollo 8 astronauts in the first manned circumlunar flight.

1969
The Apollo 11 astronauts make the first manned landing on the Moon with the help of IBM computers.

1970
IBM computers in Houston assist flight controllers in the dramatic rescue of the Apollo 13.

1971
IBM computers help guide the Apollo 14 and Apollo 15 Moon landings. Photographs taken by Mariner 9, the first spacecraft to orbit Mars, are enhanced by IBM computers.

1982—85
IBM technology supports successful flights of the Space Shuttles Columbia, Challenger, Discovery, Atlantis and Endeavour, respectively.

1993
The IBM ThinkPad 750C becomes the first modern notebook computer to fly in space, as part of the Space Shuttle Endeavour's mission to refurbish the Hubble Telescope.

1997
NASA's Pathfinder, equipped with IBM RS/6000 technology for its onboard computer, lands on Mars.

2002
IBM collaborates with NASA scientists to analyze tele-robotic data during the 2003 Mars Exploration Rover (MER) expeditions.

2006
NASA uses IBM software to develop the software and systems that will operate the James Webb Space Telescope which will look much closer to the beginning of time and hunt for the unobserved formation of the first galaxies.

Podcast transcript:
IBM and NASA: the James Webb Space Telescope

LANINGHAM: You're listening to developerWorks interviews where we feature conversations with technical luminaries and thought leaders from a variety of disciplines on topics of interest to technology professionals. I'm your host, Scott Laningham.

Our guests today are Sky Matthews, Senior Manager of Rational Industrial Systems Solutions, and Swati Moran, go- to-market manager for Systems Development, Aerospace and Defense, also with IBM Rational. Thank you both for making time for this today.

MORAN: Thanks, Scott. It's a pleasure to be here today.
MATTHEWS: Thank you, Scott, and it's great to be here.

LANINGHAM: Now, we know that NASA's Hubble Space Telescope which is orbiting around the earth is near the end of its life cycle, and has of course been an enormously valuable tool for astronomers.

We also know that systems development efforts have come a really long way since Hubble went up back in 1990. Tell me about the James Webb telescope if you could, a little bit, and what is the end goal of all the collaborative efforts around this and the replacement of Hubble?

MORAN: Sure, Scott. So the James Watt Space Telescope—or, JWST—is basically a large infrared space telescope to find the first galaxies that formed the early universe. And the capability of this telescope is going to be to see stars that formed the planetary system that connects the Milky Way to our solar system.

And it's scheduled to launch in 20-13, so 2013. And the James Watt Telescope is going to reside in an orbit that's one million miles from the earth. So that's just some background on the telescope itself.

And this is an international collaboration effort that involves NASA. And the develop-

ment specifically is occurring at Goddard Space Flight Center with multiple systems integrators—so, contractors who are building this with NASA.

It also involves the European space agency and the Canadian space agency. So as you can see, it's an international collaborative effort between space agencies to build this next-generation space telescope.

LANINGHAM: Wow, a whole lot of coordination to do there then, right?
MORAN: Yes, absolutely.
LANINGHAM: Did you say a million miles from the earth, the orbit will be?
MORAN: Yes.
LANINGHAM: Wow, so it's outside of the moon; it's pretty far out, then.
MORAN: It is pretty far out.

LANINGHAM: Sky, how would you describe the distance between the old approach with Hubble and this new systems development approach with the James Webb Telescope in terms of generations that we've come since that old route?

MATTHEWS: Well, in particular in the software development, you know, as you can imagine, you really only get one chance to get things right in developing a space system like this. And the cost of errors and failures is huge.

So NASA is taking great steps to try to improve the quality of their software, and that's where our industrial systems solution comes into play, because it can help them get, you know, an order-of-magnitude improvement in quality.

LANINGHAM: Yes, and you know, I was reading the press release and they talked about the challenges they faced with Hubble at times when things would break down, and they were having to track down people who wrote the original code to solve problems and they weren't even working at NASA anymore. I mean, that must be pretty common with old space systems like that, then.

MATTHEWS: Yes, that's a huge problem. And one of the reasons that the government is very interested in moving towards more open-standards-based development is so that they, you know, they have a much easier time maintaining the system down the road. And that the skills to maintain these systems are more widespread.

LANINGHAM: So with this new approach at least and certainly more than this it will not be proprietary to an individual [LAUGHTER] and their knowledge, right?

MATTHEWS: No, absolutely. And there's a much more disciplined approach to capturing the architecture of the system so somebody else can step in. Also, the other agencies can collaborate much more easily. There's this shared sort of view of the system architecture.

LANINGHAM: Now, could you and or Swati talk a bit about the benefits of a systems development solution? I mean, how will it enhance the development and the maintenance process for NASA with the James Webb Telescope?

MORAN: Sure, Scott. So basically an integrated systems development solution, IBM Rational Systems development solution, will help NASA and the James Webb Space Telescope program architect, build and govern these complex systems of systems.

So often on these projects the challenge is hardware and software co-development of these systems. So NASA used Rational Requisite Pro to implement basically systems requirements for the James Webb Space Telescope. In Rational Rose RealTime, they implemented the full systems model using the Unified Modeling Language which allowed them to communicate and reuse their models and code across this project or program.

And that helped to increase predictability and reliability of these systems and the quality of these systems. The quality is extremely important especially in something that's a national treasure here, which is the James Webb Space Telescope.

And then finally, they also used [Rational] ClearCase and ClearQuest to facilitate collaboration between the agency and the contractors—so the systems integrators that are building this James Webb Space Telescope allowing for asset reuse of the artifacts across the project.

LANINGHAM: How big is the extended team of people and parties working on this project? Do you have some sense of that?

MORAN: I know that there are several agencies. As mentioned there's the NASA Goddard Space Flight Center who is the prime, and it has several systems integrators like Northrup Grumman and other smaller integrators.

And then finally the European Space Agency and the Canadian Space Agency. So multiple...multiple contractors, many people building this telescope.

LANINGHAM: It's probably hundreds, even thousands of people involved I'm sure.
MORAN: Yes, possibly.

LANINGHAM: It makes you wonder how on earth they ever did something like this before real systems development solutions, doesn't it?
MORAN: Yes, exactly. So there's a lot of distributed development that's involved, and governance of these systems are extremely important.

MATTHEWS: The complexity of the software I'm sure in the James Webb Space Telescope is much, much greater than that that was in the Hubble, you know, and probably orders of magnitude more complicated, a lot more people working on it.

LANINGHAM: So trying to do it the old way would probably be impossible then, wouldn't it?
MATTHEWS: Yes, it just wouldn't work. Exactly.

LANINGHAM: Well, it's got to be a very exciting project to be a part of, and I'm sure you're both enjoying your involvement with it, I would assume.

MATTHEWS: Oh, it's very exciting. I've always been a big fan of NASA, and it's tremendous to be a part of something that is going to play such an important role for so many years.

LANINGHAM: And it's supposed to be launched into orbit in 2013, is that correct?
MATTHEWS: That's right.
MORAN: That's correct, yes.

LANINGHAM: Well, thank you both for your time on this. This has been very interesting. We appreciate it.
MATTHEWS: Thanks very much, Scott.
MORAN: Thank you, Scott. Appreciate the time.

LANINGHAM: Our guests again have been Swati Moran, Rational go-to-market manager for Systems Development, Aerospace and Defense; and Sky Matthews, software engineer and senior manager with IBM Rational.

Find out more about developerWorks podcasts or subscribe to our syndicated feeds at ibm.com/developerworks/podcasts. I'm Scott Laningham. Talk to you next time.
[END OF SEGMENT]

IBM Corporation
1133 Westchester Avenue, White Plains, New York 10604, USA