Margaret Hamilton:

The woman who put man on the moon

Margaret Heafield Hamilton is an American computer scientist, systems engineer, and business owner. She was Director of the Software Engineering Division of the MIT Instrumentation Laboratory, which developed on-board flight software for the Apollo space program. The computer system was the most sophisticated of its day. Her rigorous approach was so successful that no software bugs were ever known to have occurred during any crewed Apollo missions. I was inspired to write her biography given her immense contribution in building the field of software engineering itself and of course, helping humankind to take its first steps in space.

- ## Early Childhood

Margaret Elaine Heafield was born August 17, 1936, in Paoli, Indiana to Kenneth Heafield and Ruth Esther Heafield. She graduated in Maths with a minor in philosophy from Earlham College [in Indiana]. She was inspired by her father(a poet and philosopher) to take up philosophy. She married James Cox Hamilton in 1958, they had a daughter, Lauren. She briefly taught high school mathematics and French at a public school in Boston, Indiana, while her husband completed his undergraduate degree at Earlham. Later, she found a job at the nearby Massachusetts Institute of Technology (MIT). It was in the laboratory of Prof Edward Lorenz, the father of chaos theory, working on a system to predict weather and SAGE system software that searched for enemy airplanes . Her plan was to support her husband through his three-year stint at Harvard Law. After that, she wanted a graduate degree in math. But destiny had other plans. "*Lorenz's love for software experimentation was contagious, and I caught the bug*", Margaret remarked in a recent interview with the Guardian.

- **Early Career**

Prior to Apollo, beginning in 1959, she worked on her first software projects, and they were for a professor at MIT. During this time she learned several software languages on her own, but, she credits learning about systems and software from Professor Edward N. Lorenz.

The very first languages she programmed in were hexadecimal and binary. She also worked on the SAGE system at Lincoln Labs and wrote software for the XD-1, the first AN/FSQ-7 computer, whose job was to search for 'unfriendly' aircraft—a very early form of 'homeland security.' It was her efforts on this project that made her a candidate for the position at NASA as the lead developer for Apollo flight software.

She became interested in software reliability when she was working on SAGE. The only information the computer provided to the developer for debugging their program was to light up a very large register on the console of the computer, showing the address where the program halted.

- **Apollo Program**

Margaret was planning to resume graduate school when her husband saw a newspaper advert. The MIT Instrumentation Laboratory was looking for people to develop software to "send man to the moon". She was attracted both by the sheer idea and the fact that it had never been done before. She was the first programmer to join and the first woman they hired. Male engineers were already working on the project, but they were hardware engineers and it wasn't their thing.

Hamilton was initially hired as a programmer for this process but moved on into system designs. She eventually led a team credited with developing the software for Apollo program. Her team was responsible for developing in-flight software and error detection and recovery software such as restarts and the Display Interface Routines which Hamilton designed and developed. The man-in-the-loop priority-display-interface-routines gave the software the ability to communicate asynchronously in real time with the astronauts, the software and astronauts running in parallel within a distributed system-of-systems environment. With this as a backdrop, the priority displays warned the astronauts in case of an emergency by interrupting the astronauts' normal mission displays and replacing them with priority alarm displays, providing them with emergency related options from which to select.

- **Critical moments during the mission**

The error detection capabilities, thanks to Margaret and hundred of other software engineers saved the lives of many astronauts several times during the Apollo missions.

- Apollo 11

During Apollo 11 mission ,just before landing on the moon when the computer, as a result of the rendezvous radar switch having been left in the wrong position, became overloaded. The priority alarm displays were a reminder to the astronauts to put the radar switch back where it belonged. When the priority displays gave them the choice: "to land" or "not to land", because of their (and mission control's) belief in the integrity of the on-board flight software, they chose to land.

- Apollo 8

One day, Lauren(Margaret's daughter) was playing with the MIT command module simulator's display-and-keyboard unit, nicknamed the DSKY (dis-key). As she toyed with the keyboard, an error message popped up. Lauren had crashed the simulator by somehow launching a prelaunch program called P01 while the simulator was in midflight. There was no reason an astronaut would ever do this, but nonetheless, Hamilton wanted to add code to prevent the crash. However, this idea was overruled by NASA. They thought that it would never happen because the astronauts were trained to be perfect.

However, it did. During Apollo 8, astronaut Jim Lovell inadvertently selected P01 during flight. This led to all the navigation data being wiped out and the astronauts could not return home.

Hamilton and her team needed to find a solution and it needed to be perfect. After spending nine hours poring through the 8-inch-thick program listing on the table in front of them, they had a plan. Houston would upload new navigational data. Thanks to Hamilton—and Lauren—the Apollo astronauts came home.

Margaret with the code she wrote for Apollo 11

- ## Later Life

In 1976, Hamilton co-founded with Saydean Zeldin a company called Higher Order Software (HOS) to further develop ideas about error prevention and fault tolerance emerging from their experience at MIT working on the Apollo program.They created a product called USE.IT, based on the HOS methodology. It was successfully used in numerous government programs.

Hamilton was the CEO of HOS through 1984 and left the company in 1985. In March 1986, she founded Hamilton Technologies. The company was developed around the Universal Systems Language (USL) and its associated automated environment, the 001 Tool Suite, based on her paradigm of development before the fact for systems design and software development.

- ## Awards

In 1986, Hamilton received the Augusta Ada Lovelace Award by the Association for Women in Computing.

In 2003, she was given the NASA Exceptional Space Act Award for scientific and technical contributions. The award included $37,200, the largest amount awarded to any individual in NASA's history.

In 2016, she received the Presidential Medal of Freedom from Barack Obama, the highest civilian honor in the United States.

On April 28, 2017, she received the Computer History Museum Fellow Award, which honors exceptional men and women whose computing ideas have changed the world.

In 2017, a "Women of NASA" LEGO set went on sale featuring minifigures of Hamilton, Mae Jemison, Sally Ride, and Nancy Grace Roman.

In 2019, she was awarded The Washington Award.

In 2019, she was awarded the Intrepid Lifetime Achievement Award.

- ## Legacy

During the early days of Apollo, software was not taken as seriously as other engineering disciplines. Hamilton was the woman that came up with the term “software engineering” and gave the field legitimacy. Thanks to the work she led, she defined not only what humans could do in space but also her on the ground. Software engineers all around that world today can develop trustworthy software and test them via error detection tools thanks to the principles and the work of Margaret. However, her contributions go far beyond putting humans on the moon. She has been an inspiration to women all around the world who want to succeed in STEM fields. Even when her field

was hugely men driven, she succeed in becoming one of the greatest of her time.

At last I would like to quote former US president Barack Obama "***Our astronauts didn't have much time, but thankfully they had Margaret Hamilton***."

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