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 the in-flight software for the Apollo space program. The computer software was the most complex of its day. Her thorough software programming was so successful the Apollo missions never encountered a bug in their time.. 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 on 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. 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 taught mathematics in a high school and her husband finished 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 complete his degree 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.

- ## **<u>Early Career</u>**

Before working to Apollo, beginning in 1959, she worked on her first software projects for a professor at MIT. She learned many software languages on her own, but, she credits learning about software systems 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 work on this project that made her a suitable candidate for the the head developer for Apollo flight mission software.

She became interested in software reliability when she was working on SAGE. There was very little information for a debugger to get. All, the computer provided was a huge console light, ringing bells and the address where the program halted.

- ## **<u>Apollo Program</u>**

Margaret's husband saw an advert in the newspaper. The MIT Instrumentation Laboratory was looking for people to develop software to "send man to the moon". She was attracted to this idea as it was a new concept and an interesting one. Margaret was the first programmer and the first woman to join the project. There were male engineers working on the project before but they specialized in hardware.

 Hamilton was first hired as a programmer but advanced onto 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 display interface routines gave the system ability to transmit messages asynchronously in real time with the astronauts. In case of an emergency the priority displays warned the astronauts, by interrupting the normal ongoing mission displays and displaying them with priority alarm displays, giving them options on what they would like to do next.

• **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

The rendezvous radar switch had been left in the wrong position just before landing and as a result the computer became overloaded. The priority alarm displays reminded the astronauts to put the switch in its correct state and gave them options to land or not. The astronauts chose to land because they believed in the integrity of the system.

• Apollo 8

Lauren(Margaret's daughter) was one day playing with the MIT command module simulator's display-and-keyboard unit. During this time an error message showed up. Lauren had somehow crashed the simulator when she pressed a program called P01 midflight. Normally a highly trained astronaut would never do this but Hamilton wanted to add code to prevent this from happening. 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 mistakenly 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 perfect solution in a short amount of time. After nine hours of going through the 8-inch-thick program listing on the table in front of them, the engineers decided to upload new data. Houston uploaded this new navigational data and it worked. Thanks to Hamilton , her team and most importantly Lauren, the astronauts came home.

Margaret with the code she wrote for Apollo 11

- ## <u>Later Life</u>

In 1976, Hamilton co-founded Higher Order Software (HOS) to advance her ideas about error prevention and fault tolerance.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 to 1985. In 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.

- ## <u>Awards</u>

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.

- ## <u>Legacy</u>

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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