**Software Engineering - Margaret Hamilton**

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*“To produce a short biography of a key software engineer, discussing the work and impact of the individual”*

Margaret Hamiltion is the software engineer that I have chosen to write about due to her pivotal role, not only in the world of software engineering, but the ever evolving study of spaceflight technologies. In this essay I will discuss the early life, education, accomplishments and legacy of Ms Hamilton from her work as a mathematician to her role as lead systems designer for NASA.

Margaret Hamilton was born on the 17th of August, 1936 to Kenneth and Ruth Heafield. The family moved to Michigan where Margaret would graduate from Hancock High School in 1954. She would go on to study Mathematics and Philosophy at the University of Michigan in 1955. After transferring to Earlham College Margaret where her Mother was studying, Margaret graduated with a BA in mathematics and a minor in philosophy. With the inspiration she accredits to the head of the maths department at the time she went on to study abstract mathematics and become professor . These skills served as the essential foundation on which she would build her outstanding future career.

In the summer of 1959 Hamilton worked at MIT for Edward Norton Lorenz, an esteemed meteorologist, who established the theoretical basis of weather and climate predictability. During her time there she was first introduced to the world of software development. As computer science and software engineering were not yet established disciplines, to become a programmer young graduates such as Hamilton had to primarily learn through hands on experience and it was here where she would get that essential experience. Her work contributed to Norton Lorenz’ publication on chaos theory, a branch of mathematics which studies the underlying patterns within the apparent randomness of chaotic complex systems. She continued her work there until 1961 when she was recruited to work on the Semi Automatic Ground Environment (SAGE) project at the MIT Lincoln lab. Hamilton gained even more experience with software development as she worked on the software for a computer system that would go on to be developed for anti aircraft defense. This was primarily used to defend the United States against potential Soviet attacks during the Cold War. However that is not the most fascinating detail about her work there. Hamilton once wrote that upon entering the organisation as a beginner, she and other new software developers would be given a program deemed to be unsolvable and too hard to get to run. (["AGC – Conference 1: Margaret Hamilton's introduction"](http://authors.library.caltech.edu/5456/1/hrst.mit.edu/hrs/apollo/public/conference1/hamilton-intro.htm). *authors.library.caltech.edu*. [Archived](https://web.archive.org/web/20160131233720/http://authors.library.caltech.edu/5456/1/hrst.mit.edu/hrs/apollo/public/conference1/hamilton-intro.htm) from the original on January 31, 2016.). Not only is this an extremely daunting task but all of the comments written by the author of the code were in Greek and Latin. Now, as a developing software engineer I too can revel in the shared frustration of thrifting through pages and pages of documentation but I cannot imagine having to do something similar in a completely different language! Hamilton saw this as a challenge and (to the surprise of her colleagues) actually got it to run and not only this, got it to print out the answers in latin. It was these efforts and the skills she acquired during her early career which made her a prime candidate for a position at NASA as the lead developer for the flight software used in numerous Apollo missions.

After exploring Hamilton’s early life to see how she became experienced enough to take on such a formidable task at NASA, we can now delve into the truly remarkable accomplishments she attained during her time there. Hamilton was initially hired as a programmer but then moved onto work in systems designs until she eventually was put in charge of a team of software developers and engineers responsible for the in flight command module software for the Skylab and Apollo missions. Not only would her work make history in helping to design communications for the first United States space station (Skylab) but her work on the digital flight computer helped guide the Apollo 11 mission which saw mankind’s first landing on the Moon. Hamilton was tasked with leading the software development team to create a 1 cubic foot computer that could guide, navigate and control Apollo 11 during its mission. We must remember that this was the late 60s where computers filled entire rooms using primitive computational power. We can look at how the work of Hamilton’s team saved the mission by exploring what happened during the mission itself.

As the lives of the astronauts on the Apollo mission were at stake Hamilton had to devise a new way of programming. The software needed to quickly detect unexpected errors and recover from them in real time. However this type of programming was extremely difficult at the time since early software could only process jobs in a predetermined order. To overcome this the program was made to be asynchronous meaning the softwares more important jobs would interrupt less important ones. She then designed priority displays for emergency warnings that would interrupt the astronauts regularly scheduled tasks allowing them to respond to such emergencies instantaneously. To do this the astronauts would communicate directly with mission control after seeing these warnings allowing them to also work in an asynchronous environment. This proved essential during the lunar landing when Buzz Aldrin flipped a switch enabling the rendezvous radar which was not only essential for the return trip but was also prematurely draining the onboard computational resources. Thanks to the software developed by Hamilton and her team, during this overload of computation, the software restarted and only included the programs necessary for landing. Hamilton even commented on the perhaps misguided trust the organisation had put in the astronauts, “We had been told many times that astronauts would not make any mistakes. They were trained to be perfect.” - Margaret Hamilton. Just on the brink of descent onto the surface of the moon, the fail-safes implemented by Hamilton and her team made the mission a success and could have saved the lives of the crew on board.

Hamilton would go on to continue her legacy by founding Hamilton Technologies which used its unique universal systems language to create breakthroughs in systems and software. In 2003 she received the NASA Exceptional Space act award for scientific and technical contributions. This marked the largest monetary award given to any individual in NASA history, an accomplishment which reflects the value of her work during her time there. Hamilton is also heralded as the creator of the term “software engineer” as a way of giving legitimacy to the work of each man and woman who worked with her throughout her career. Margaret H. Hamilton “is the person who came up with the idea of naming the discipline, software engineering, as a way of giving it legitimacy.” (Tadre, Matti, 2014 - 12 - 03, *The Science of computing,* CRC press. p. 121). These are only some of the many awards given to Margaret Hamilton for her esteemed career in software engineering even during a time where even the term itself did not exist and it is because of the people like Hamiton that it is such a well founded study today. Clearly it can be seen that Hamilton was and still is today a key software engineer in the world of computer science and for that reason her work and its impact should be celebrated.

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