50 Years Beyond the Giant Leap: Spacecraft Navigation from Apollo to the 21st Century
Stephen Volante, CT

Talk given at the American Translators Association 2019 Conference
https://www.atanet.org/conf/2019/

References

Books:
David Mindell: *Digital Apollo: Human and Machine in Spaceflight* – a great general history of the Apollo program

Don Eyles: *Sunburst and Luminary: An Apollo Memoir*
The 2018 memoir by a software engineer who wrote much of the code for the lunar landings. A good read for a general audience, but rather technical in parts.

Video-audio:

1. The best media resource I've found on this topic is:
   13 Minutes to the Moon, episode 5: *The Fourth Astronaut*
   https://www.bbc.co.uk/programmes/w13xttx2/episodes/downloads

   This a comprehensive, 50-minute podcast on developing the Apollo navigational system and how it performed. It features interviews with:

   - Margaret Hamilton: Director of Apollo On-Board Flight Software Development
   - Don Eyles: Software Engineer
   - Eldon Hall: AGC Lead Designer
   - David Mindell: Author of *Digital Apollo: Human and Machine in Spaceflight*

2. Apollo Flight Journal YouTube channel - *Apollo 11: The Complete Descent* (20 minutes)
   https://www.youtube.com/watch?v=xc1SzgGhMKc&t=494s

   This shows the view from the LM as it descended to the lunar surface. Communications between the astronauts and Mission Control appear as captions at the bottom of the screen. Explanations of computer operation and astronaut action appear on the right.

3. CNN films: *Apollo 11*
   Available on various platforms: iTunes, YouTube, Google Play, Vudu
   There is a lot of nostalgia and film of the astronauts and Mission Control, but there is also an excellent four-minute sequence leading to the landing (sped up) with communications and the sound of the 1201-1202 program alarms

4. NOVA: *Apollo's Daring Mission*
   https://www.pbs.org/wgbh/nova/video/apollos-daring-mission/

   Broadcast in December 2018 for the 50th anniversary of Apollo 8. This episode covers the development of three critical systems - the Saturn V rocket, the AGC, and the command module redesigned after the 1967 fire that killed three astronauts - then the first flight to the moon.

5. *Moon Machines episode 3: Navigational Computer*
   https://www.youtube.com/watch?v=xQ1O0XR_cA0&t=490s

   A 2009 Science Channel documentary, 45-minutes, on inertial navigation and developing the AGC and software

6. AeroAstro MIT Youtube channel:

   MIT's Department of Aeronautics and Astronautics has a Youtube channel that features talks by:

   Neil Armstrong: https://www.youtube.com/watch?v=FD0jUvcMoD4&t=4079s
   (Armstrong begins at 35 minutes)

   Jim Lovell: https://www.youtube.com/watch?v=wUUgTavzgSk

   Apollo 50+50 series

   Apollo astronauts Walter Cunningham and Charlie Duke and MIT staff members Don Eyles and Walt Widnall discuss developing the Apollo guidance system and the lunar missions
   https://www.youtube.com/watch?v=spTrlbHFc6w&t=1779s

7. Gyroscope spinning: Science Online
   https://www.youtube.com/watch?v=cquvA_IpEsA&t=73s

8. Vintage Space Youtube channel
   Space historian Amy Shira Teitel has been posting videos to Youtube for several years, many of them explaining details of the Apollo missions:

   How Apollo Astronauts Didn't Get Lost Going to the Moon:
   https://www.youtube.com/watch?v=X-O3Uu4DuLw

   Hal Laning: The Man You Didn't Know Saved Apollo 11
   https://www.youtube.com/watch?v=LELUXyVDOKk

   Verbs, Nouns, and the Apollo Guidance Computer
   https://www.youtube.com/watch?v=b8S_T772H1c

   Apollo 11's 1202 Alarm Explained
   https://www.youtube.com/watch?v=kGD0zEbiDPQ&t=336s

   What Happened When Apollo 12 Was Struck by Lightning?
   https://www.youtube.com/watch?v=9i6yD2c2Jho

   Gimbal Lock and Apollo 13
   https://www.youtube.com/watch?v=9i6yD2c2Jho

   Why Apollo Flew in a Figure 8
   https://www.youtube.com/watch?v=xnXdEMtU_DE

9. InSight Landing on Mars
   A NASA engineer explains all the challenges of landing on Mars:
   https://www.youtube.com/watch?v=PDSbUpmRksI

Print media and websites:

Your Smart Toaster Can't Hold a Candle to the Apollo Computer:
https://www.theatlantic.com/science/archive/2019/07/underappreciated-power-apollo-computer/594121/

Apollo 11 and Other Screw-Ups: Tales from the Lunar Module Guidance Computer
https://www.doneyles.com/LM/Tales.html

Can you navigate a spacecraft to Mercury? Interactive Smithsonian site that lets you plan and execute a flight to the planet Mercury
https://timeandnavigation.si.edu/navigating-space/challenges/navigate-in-space-activity

wehackthemoon.com
This website is dedicated to the Apollo program and focusing on the work of engineers and scientists at the MIT Instrumentation Laboratory, now Draper.

Norm Sears on Apollo Software 101
https://wehackthemoon.com/people/norm-sears-apollo-missions-software

Math That Made the Moon Landing
httpst://wehackthemoon.com/missions/math-made-moon-landing

Margaret Hamilton's letter to the editor of a magazine dispels misconceptions about the LGC, the 1201-1202 alarms, and the lunar landing
https://wehackthemoon.com/people/margaret-hamilton-computer-got-loaded

Four woman besides Margaret Hamilton who contributed to Apollo at MIT:

1. *Elaine Denniston: the woman who corrected Apollo's code*
   https://www.bbc.co.uk/programmes/p07grnn6

   https://wehackthemoon.com/bios/elaine-denniston

   After working on Apollo at MIT, Elaine Denniston earned degrees at Harvard and Boston University Law School, then practiced law for 35 years (she also has a great Boston accent).

2. Phyllis Rye, Software Engineer:
   https://wehackthemoon.com/bios/phyllis-rye

3. Saydean Zeldin, Software Engineer and Programmer
   https://wehackthemoon.com/bios/saydean-zeldin

4. *Jane Goode: Software Engineer and Astronaut Trainer*
    https://wehackthemoon.com/bios/jane-goode

Don Eyles and Peter Volante on Apollo 14:
https://wehackthemoon.com/people/don-eyles-apollo-14

https://wehackthemoon.com/people/peter-volante-apollo-14

Peter Volante 94-second podcast:
https://wehackthemoon.com/audio/peter-volante-apollo-14