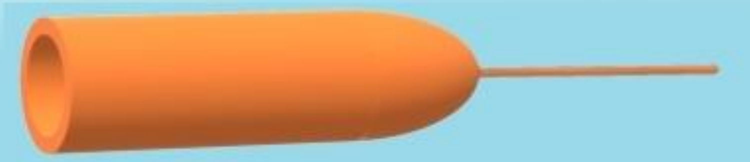
Space Travel and Christian Faith

Elder Exchange @ VMRC
June 13, 2019



Thanks!

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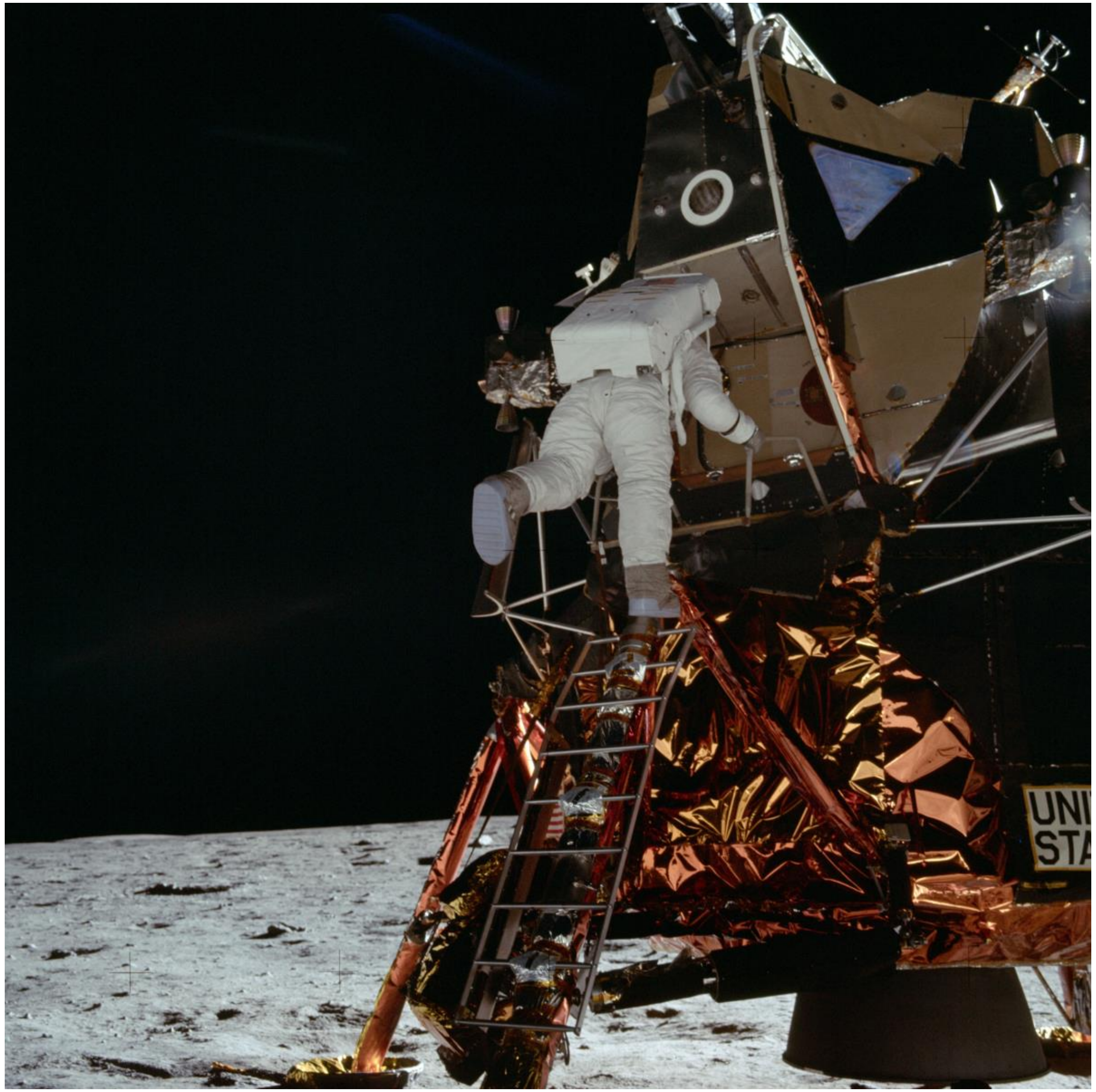
- Friends & Classmates
- Fellow Mission Workers
- Mission Administrators
- Other Church Leaders & Members

Edwin “Buzz” Aldrin
(Apollo 11; 20 July 1969)



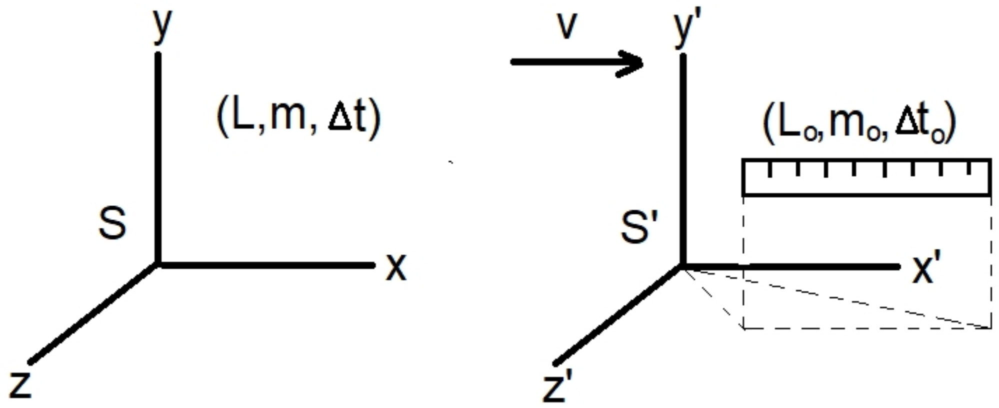
Earthrise
(Apollo 8: 24-Dec-1968)

I. Theory of Special Relativity

Two Concepts of Special Relativity

In 1905, Albert Einstein proposed two concepts as ideas that underlay his Special Theory of Relativity.

1. There is no preferred inertial frame of reference in the physical universe. The laws of physics are the same in all such reference frames.



2. The speed of light has the same value regardless of the motion of the source or the receiver as long as they have a constant velocity with respect to each other.

Consequences

- Length Contraction

$$L = L_o \sqrt{1 - \frac{v^2}{c^2}}$$

- Time Dilation

$$\Delta t = \frac{\Delta t_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

- Relativity of Mass/Energy

$$m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Cosmic Ray Muons

- Observations:

  Created at 6000 m above Earth.

  Reach surface of Earth at about $100/m^2/s$.
- Average lifetime at slow speeds (its perspective) (Δt_0): 2.2 μs
- Created with speed (v): 0.9983 c
- Distance it can travel (its perspective):

  $x_0 = v\ \Delta t_0 = \underline{660\ m}$
- But they reach the Earth surface in perfution

Cosmic Ray Muons (cont'd)

- Lifetime at high speed:

$$\Delta t = \frac{\Delta t_o}{\sqrt{1 - \frac{v^2}{c^2}}} = 38\ \mu m$$

- Distance it can travel (from our perspective):

$$x = v\ \Delta t = \underline{11{,}000\ m}$$

So, no wonder we see lots of them per second at sea-level.

- Conclusion: **Theory matches observation!**

Newton’s Second Law with a Constant Force

$$F_o = m\,a$$

$$F_o = \frac{d}{dt}(mv)$$

$$F_o = \frac{d}{dt}\left[\frac{m_o\,v}{\sqrt{1-\frac{v^2}{c^2}}}\right]$$

Solving Newton's Second Law of Motion

$$\int_0^t F_o\,dt = \int_{v_1}^{v_2} d\left[\frac{m_o\,v}{\sqrt{1-\frac{v^2}{c^2}}}\right]$$

$$\frac{F_o\,t}{m_o} = \left[\frac{v}{\sqrt{1-\frac{v^2}{c^2}}}\right]_{v_1}^{v_2}$$

Velocity as a Function of Time

$$v_2 = \frac{\left(\frac{F_o\, t}{m_o}\right) + \left(\frac{v_1}{\sqrt{1 - \frac{v_1^2}{c^2}}}\right)}{\left[1 + \left(\frac{F_o\, t}{m_o}\right) + \left(\frac{v_1}{\sqrt{1 - \frac{v_1^2}{c^2}}}\right)\right]}$$

Setting Up a Trip to a Close-by Star

The closest stars are in a system of three stars. The system is called Alpha Centauri and the closest star is Proxima Centauri (which also has an exoplanet orbiting it). These are at 4.37 and 4.24 l.yr from Earth.

At 5.97 l.yr is Barnard’s Star, and the next closest one at 7.78 l.yr is Wolf 359.

So, let’s contemplate a trip:
distance = 6.000 l.yr
constant force: $F_o = m_o 2g$ with $g = 9.80\ m/s^2$ is the acceleration on Earth acting for 1.00 yr on the spacecraft

A. Speed of Spacecraft after Accelerating

With 1 yr = 31 557 600 s, c = 299 792 458 m/s, g = 9.81 m/s^2
and starting with t = 0 at liftoff, we find:

$$v = \frac{2\,g\,t}{\left[1 + \left(\frac{2\,g\,t}{c}\right)^2\right]^{1/2}}$$

v = <u>0.900 c</u>

B. Distance Traveled (Earth Perspective)

<u>During Acceleration</u>

Recall the definition of velocity (or speed).

$$v = \frac{dx}{dt} \Rightarrow \int_0^x dx = \int_0^t v\, dt$$

Now substitute in the equation for the v we arrived at previously, integrate both sides, and solve for x.

$$x = \frac{c^2}{2g}\left\{\left[1 + \left(\frac{2gt}{c}\right)^2\right]^{1/2} - 1\right\}$$

x = <u>0.626 l.yr</u>

Units Measuring Astronomical Distances

Distance Sun to Earth: 1 AU = 1.496 X 10^{11} m = 93.0 million mi

Distance Sun to furthest known object (2015): 150 AU

Speed of light (vacuum): c = 299 792 458 m/s,

Long Time Unit: 1 yr = 31 557 600 s,

Light-year = distance light travel in one year

Therefore, 1 l.yr = 1 LY = 63 241 AU
= 9.461 X 10^{15} m = 5.88 X 10^{12} mi

Also, 1 parsec = 1 pc = 206 265 AU = 3.26156 l.yr

C. Time of Trip (Spacecraft Perspective) #1

<u>During Acceleration</u>

We can rewrite the time dilation equation as:

$$dt' = \sqrt{1 - \frac{v^2}{c^2}}\ dt$$

Then integrating and substituting in for the velocity function, we get:

$$\Delta t' = \left(\frac{c}{2g}\right) \ell n\left\{\left(\frac{2g\Delta t}{c}\right) + \left[1 + \left(\frac{2g\Delta t}{c}\right)^2\right]\right\} = \underline{0.714\ \text{yr}}$$

C. Time of Trip (Spacecraft Perspective) #2

During the coasting period:

The distance traveled as seen from Earth is:

6.000 l.yr – 2(0.626 l.r) = 4.748 l.yr

On Earth an observer sees the spacecraft moving at 0.900 c.

Therefore, the time that passes on Earth is:

Δt = dist./vel. = 4.748 l.yr/(.9c) = 5.27556 yr

Substituting this into the equation of time passing at a constant v gives:

$$\Delta t' = \sqrt{1 - \frac{v^2}{c^2}}\ \Delta t = \underline{1.583\ \text{yr}}$$

Summary

Observer on	Time (yr)	Distance (l.yr)
Earth: Acceleration	1.000	0.626
Earth: Coasting	5.275	4.748
Earth: De-acceleration	1.000	0.626
TOTALS	**7.275**	**6.000**
Craft: Acceleration	0.714	0.379
Craft: Coasting	1.583	1.424
Craft: De-acceleration	0.714	0.379
TOTALS	**3.011**	**2.182**

II. Applying the Values of Christian Faith

1. Human Life Is Sacred

“You shall not murder.” –Exodus 20:13

“I tell you, love your enemies and pray for those who persecute you, that you may be children of your Father in heaven. He causes his sun to rise on the evil and the good, and sends rain on the righteous and the unrighteous.” –Matthew 5:44-45

<u>Questions</u>: If we support a program in which human participants are very likely to lose their lives, is that how God would want us to act? Agreeing to cut a person’s life short, is that a form of murder? Is this equivalent to not letting persons have as long as possible to become a child of God?

2. God Desires All People to Be His Children

"The Lord is not slow in keeping his promise, as some understand slowness. Instead he is patient with you, not wanting anyone to perish, but everyone to come to repentance." –2 Peter 3:9

"For God so loved the world that he gave his one and only Son, that whoever believes in him shall not perish but have eternal life…. Whoever believes in him is not condemned, but whoever does not believe stands condemned already because they have not believed in the name of God's one and only Son." --John 3:16-18

Question: If there are no Christian believers among a crew on a mission that will likely end in death for one or more persons, are we limiting how long God's grace can be offered?

3. Seeking Human Knowledge Is Not the Most Important Pursuit

“Love never fails. But where there are prophecies, they will cease; where there are tongues, they will be stilled; where there is knowledge, it will pass away.” --1 Corinthians 13:8

“For this reason, since the day we heard about you, we have not stopped praying for you. We continually ask God to fill you with the knowledge of his will through all the wisdom and understanding that the Spirit gives,[e] **10** so that you may live a life worthy of the Lord and please him in every way: --Colossians 1:9-10a

<u>Questions</u>: In which pursuits would God want us to spend our time, money, and physical and emotional energy? Is excelling as a scientist [substitute your vocation] to be my highest and only priority?

4. Jesus Taught Us to Care for the Poor and the Suffering

“No one can serve two masters. Either you will hate the one and love the other, or you will be devoted to the one and despise the other. You cannot serve both God and money.” The Pharisees, who loved money, heard all this and were sneering at Jesus.” --Luke 16:13-14

“Jesus answered, “If you want to be perfect, go, sell your possessions and give to the poor, and you will have treasure in heaven. Then come, follow me.” --Matthew 19:21

<u>Questions</u>: Will human spaceflights help those hungry, homeless, suffering from war, and such? Or does this limit help for the poor?

[Note: The $2T human program to Mars could cover the food stamp program for 50+ yr.]

Sociological Considerations

- Crime and violence
  ‘Cosmonaut Valery Ryumin wrote in his journal during a particularly difficult period on board the Salyut 6 space station: "All the conditions necessary for murder are met if you shut two men in a cabin measuring 18 feet by 20 and leave them together for two months.“’ –Wikipedia “ISS”
- Sexual stresses
- Loneliness
- Isolation (greatly delayed communication)

III. Energy Considerations Are the End of the Matter?

Photon Engine

- There are large number of nuclear and elementary particle reactions in which energy is released as photons of light (usually as gamma rays).
- Einstein's famous $E = m c^2$ equation describes where these photos come from—some mass is converted into energy.
- In most reactions, only a small amount of mass is converted to energy.
- If we could find and harness a reaction where eventually all of the mass goes into energy (light), then we would have a photon engine.
- However, no such thing exists today (and probably never will).

Photon Engine: Conservation Laws

Let f = fraction of mass remaining after the burn.

Conservation of Linear Momentum (during acceleration)

$$\frac{m_o v_1}{\sqrt{1-\frac{v_1^2}{c^2}}} = \frac{E_{photon}}{-c} + \frac{f\, m_o v_2}{\sqrt{1-\frac{v_2^2}{c^2}}}$$

Conservation of Energy(during acceleration)

$$\frac{m_o c^2}{\sqrt{1-\frac{v_1^2}{c^2}}} = E_{photon} + \frac{f\, m_o c^2}{\sqrt{1-\frac{v_2^2}{c^2}}}$$

Photon Engine: Fraction of Mass Left After a Round Trip

After accelerating from v_1 to v_2:

$$f = \left[\frac{\left(1 + \frac{v_1}{c}\right)\left(1 - \frac{v_2}{c}\right)}{\left(1 - \frac{v_1}{c}\right)\left(1 + \frac{v_2}{c}\right)} \right]^{1/2}$$

To begin, $v_1 = 0$ and $v_2 = 0.900$ c. Therefore, $f = 0.2294$.

However, in a round-trip there are four acceleration (and symmetrical de-acceleration) periods. Thus,

$$f_{total} = (0.2294)\,(0.2294)\,(0.2294)\,(0.2294) = 0.00277$$

Photon Engine: Conclusion

1. There is no such thing as a photon engine that completely annihilates fuel into light (gamma rays) and no such engines are even at the conceptual stage today.
2. If such an engine was built, the amount of fuel needed would be very large.

Estimated mass of Orion + service module = 57,000 lb (26 metric ton)

Beginning mass = 57,000 lb/0.00277 =20,600,000 lb

Maximum payload for a 40-ft long shipping container is 58,400 lb

Thus this spacecraft mass would minimally fill: 352 containers

NOTE: This assumes the spacecraft is assembled outside of the Earth's gravity.

Conventional Engine: Conservation Laws

Generally one or two liquid fuels will burn expelling exhaust gases. Note that m is relativistic.

Conservation of Linear Momentum (during acceleration)

$$\frac{m_o v_1}{\sqrt{1-\frac{v_1^2}{c^2}}} = m_{exh} v_{exh} + \frac{f\, m_o v_2}{\sqrt{1-\frac{v_2^2}{c^2}}}$$

Conservation of Energy(during acceleration)

$$\frac{m_o c^2}{\sqrt{1-\frac{v_1^2}{c^2}}\ m} = m_{exh} c^2 + \frac{f\, m_o c^2}{\sqrt{1-\frac{v_2^2}{c^2}}}$$

Conventional Engine: Fraction of Mass Left After a Round Trip

After accelerating from v_1 to v_2:

$$f_{conv.} = \left[\frac{\left(1-\frac{v_2^2}{c^2}\right)}{\left(1-\frac{v_1^2}{c^2}\right)}\right]^{1/2}\left[\frac{\left(1-\frac{v_1}{v_{exh}}\right)}{\left(1-\frac{v_2}{v_{exh}}\right)}\right] \quad \& \quad v_{exh} = \frac{v_1 + v_{exh}^{craft}}{\left(1+\frac{v_1 v_{exh}^{craft}}{c^2}\right)}$$

This is iterated with $v_{begin} = 0$ and $v_{end} = 0.900$ c. Let $v_{exh}^{craft} = 0.100$ c. [Maximum value known today is ~(1.6×10^{-5}) c.].

Thus, $f_{conv.} = 1.13 \times 10^{-6}$

Therefore, in a round-trip

$$f_{total} = (1.13 \times 10^{-6})^4 = 1.63 \times 10^{-24}$$

Conventional Engine: Conclusion

At the end of the round-trip, the spacecraft (26 metric ton) needs to survive. Therefore, m_{end} = 26,000 kg (57,000 lb).

And $m_{begin} = m_{end}/f \Rightarrow m_{begin}$ = 26,000 kg/1.63 X 10^{-24}

Therefore, m_{begin} = 1.60 X 10^{28} kg

Remember that the mass of the Earth = 5.971 X 10^{24} kg

Thus to make this trip, we would need at least

= 1.60 X 10^{28} kg/5.971 X 10^{24} kg = 2680.

~<u>2700 Earth's full of pure rocket fuel</u>

This is not possible!!!!

IV. Travel to Mars and Christian Faith Values

Current Spacecraft Mission Data

<u>International Space Station</u>

Mass: 420 Mg (420 kilo-ton)

Full Crew: 6 persons

Current Age (2019): ~20 yr

Program Cost (1985-2015): $150 billion

<u>Rover Missions to Mars</u>

Opportunity (2004-2019) & Spirit (2004-2010): ~$1 billion

Curiosity (2012-??): $2.5 billion

Mars 2020 Rover (in 2020+): $2.1 billion

Data for Planned Manned Mars Mission

Orion – an interplanetary NASA crew module

Space Launch System – a heavy-duty space shuttle which can launch Orion to Mars

Orion Crew Size: 2-6

Proposed Total Trip Time: 400-450 days;
1040 days (with 500 days on surface of Mars)

Proposed Launch: 2035

Cost: Estimates from $20 billion to more realistic cost of $2 trillion for several missions

Artist sketch by NASA/Marshall Space Flight Center - https://www.nasa.gov/exploration/systems/sls/multimedia/gallery/SLS_Concepts.html, Public Domain,

Faith Issues with Supporting Missions to Mars

All of the concerns cited with interstellar missions still hold here.

1. Human Life Is Sacred.
2. God Desires All People to Be His Children.
3. Seeking Human Knowledge Is Not the Most Important Pursuit.
4. Jesus Taught Us to Care for the Poor and the Suffering.

Pathways to Exploration. (NAP, 2014)

"Human spaceflight is an extraordinarily challenging endeavor that is fraught with daunting technical, political, and programmatic hurdles and carries a high degree of physical risk to the explorers who push forward the boundaries of human presence."

"The frequently cited rationales for human spaceflight are self-evident to some and unconvincing to others, and there are unlikely to be novel rationales that are more potent."

Conclusion of *Pathways to Exploration* (I)

"Probably the most significant factors in progressing beyond LEO are the development of a strong national (and international) consensus about the pathway to be undertaken and sustained discipline to maintain course over many administrations and Congresses. Without that consensus and discipline, it is all too likely that the potential of the SLS will be wasted, human spaceflight to LEO will be increasingly routine (although still with risk to life), and the horizons of human existence will not be expanded—at least not by the United States."

Conclusion of *Pathways to Exploration* (II)

"With such a consensus, however, and with strict adherence to the pathways approach and principles outlined in this report, the United States could maintain its historical position of leadership in space exploration and embark on a program of human spaceflight beyond LEO that, perhaps for the first time in the more than half-century of human spaceflight, would be sustainable."

But why is it important that the US have the glory? Or why does any nation-state need to have the glory?

My Conclusions (I)

- If extending human exploration of space is enticing, then our experience demonstrates that robotic missions are cheaper than human missions.
- And, so far, robotic missions have gained more information than would human missions at the same (and often much less) level of funding and with a much lower level of risk.
- Let’s remember that human societies do not have infinite resources to solve all of their social ills and to pursue all knowledge about our universe (physical, chemical, biological and psychological).
- We have limited numbers of people and their minds, limited finances, limited time and limited physical resources.

My Conclusions (II)

- If national and international support for the idea of human missions to Mars can make it a success, then applying these same financial, intellectual, technological and creative resources to social problems can help us find answers to these perplexing concerns.
- Let's put our efforts into solving such problems as global hunger, inadequate educational levels, insufficient health care, and lack of global knowledge of the Good News of Christ as the way to God.