Analysis of the science in the film 2001: A Space Odyssey

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Introduction

This essay will investigate and analyse the science fiction technologies used in the above film. The film was released in 1968 and pre-dated both the Apollo moon landings and the modern silicon chip. The film was set mainly around the year 2001, although the exact dates for the different scenes were not significant. The film was based on three major technologies, which were space travel, space habitations and computers. However a number of other, minor technologies (in the context of the film) were also shown. In addition the film included scenes of alien technologies, as well as what might be termed scientific anomalies, where some events did not look scientifically correct. This essay will examine each of these areas separately.

Scientific Anomalies

Movement on the moon looked unreal. Even before Apollo, the lower gravity (1/6g) of the moon was known. However, in the film there was no attempt to walk in a low gravity manner, neither in the moon base nor on the surface. All walking looked like it was taking place in gravity of 1g.

The distance quoted for the trip to Jupiter was half a billion miles. The distance from Earth to Jupiter can be taken as about this figure (appendix A), for a straight line trajectory. In practice this would never be flown. It is far more likely that Discovery would have travelled in a Hohman transfer orbit or similar (NASA, 2004), in which case the distance would be much greater.

Minor Technologies

The space suits looked remarkably form fitting, especially when compared to those used by both Apollo and space shuttle astronauts. They gave the impression of being inspired by diving suits. However, with new materials the next generation of space suits may well be much slimmer, allowing more freedom of movement (NASA, 2008a, National Geographic, 2007). These new suits bear a remarkable similarity to the suits used in the film.

It would have been easy for Kubrick to 'invent' artificial gravity. Instead he has used two simple scientific principles. For the grip shoe, as used by the stewardess in the lunar shuttle, it is easy to imagine Velcro in this role nowadays. On board the space station and Discovery a different principle was used, namely that of centrifugal force by rotation of the craft. For the space station the entire craft was rotated, whilst for Discovery it was a section of the living accommodation.

Two scenes involving food were shown. In one the food was a liquid (lunar shuttle) and in the other it was a paste (Discovery). In practice astronauts eat a wide variety of solid foods although wet, sticky foods are preferred, since they stay attached to utensils more easily. Some foods are easier than others; tortillas can be used instead of bread with its associated crumbs (CSA, 2006).

Most of the crew of Discovery were shown in suspended animation or stasis. This was achieved by slowing their metabolisms down to almost nothing. The inspection plates on the chambers had a suggestion of ice on the inside, suggesting that this was achieved by freezing

the body. However, at present such a technique would kill the person, rather than preserve them (LJMU, 2008).

Major Technologies

1. Spacecraft

Three separate spacecraft were shown in the film, the differences arising from their contrasting duties. The first was the space station shuttle, where the aerodynamic surfaces implied atmospheric use and thus a surface lander. The sleek design was reminiscent of Concorde, the first prototype of which had been rolled out in 1967, although the research had commenced in 1956 (British Airways, no date). However, the technology now exists in the form of NASA's space shuttle, which is less sleek than Kubrick's version. Undoubtedly the cargo bay could be adapted to make it into a passenger-carrying spaceliner. Similarly, Alan Bond's HOTOL concept (Reaction Engines, 2006a) and its later development, Skylon (Reaction Engines, 2006b) also show less streamlining than envisaged by Kubrick.

The second spacecraft was the lunar shuttle. The globe-like body was presumably built for strength and compactness, since aerodynamics was not a consideration. Operating costs must have been low, since in the film it only had two passengers. However, an ion drive would not have had sufficient thrust to lift the vessel off the lunar surface and, in any case, there were no signs of solar panels to provide power for the engines (ESA, 2005). Therefore it was likely to be a chemical rocket, which is generally not cheap to operate. Furthermore the fuel would have to be lifted from Earth first. The operating economics of the craft appear dubious.

The final vessel to consider is Discovery. The long, slender structure would have been too weak to land on a surface and hence Discovery would have spent her life in space. Similarly her acceleration must be low otherwise the structure would buckle. From the information given, her acceleration was $0.078ms^{-2}$, or very approximately 0.01g. (appendix B). An ion drive would probably give this type of performance. The distance between the crew habitation and the engines suggested a drive system giving out something harmful, such as radiation. Hence an ion drive powered by a nuclear reactor would have been appropriate, as Discovery moved away from the Sun and could not rely on solar power (ESA, 2005).

2. Habitats

Two space habitats were shown; the space station and the moon base. Space stations are now a reality and the International Space Station (ISS) was preceded by the Russian Mir station. However, the 'hotel style' in the film jarred in the light of the much less sophisticated ISS. Moon bases are still in the future, although it is worth noting that NASA expects to return to the moon by 2020 to establish an outpost (NASA, 2007), which is still a far cry from the moon base as portrayed. One of the stumbling blocks is the need for a reliable lunar shuttle, which is still under development within NASA's Constellation program (NASA 2008b). NASA is not the only organisation moving in this direction. For example, the Space Frontier Foundation has the objective to "...establish a large scale, economically viable, permanent human settlement on the moon within the next 20 years." (Space Frontier Foundation, 2008). There is also the position of the Chinese and Russians to consider.

3. Computers

With HAL, Kubrick avoided the usual cinematic images of cabinets with tape drives and a command line operating system, with about four lines to the screen. Nevertheless HAL's data banks had the appearance of an old mainframe, rather than a modern computer with

silicon chips. HAL would no doubt have passed the Turing test, something that had not been achieved at the turn of this century (Saygin et al, 2000).

Computers that monitor and run complex machines such as Discovery are commonplace nowadays. However, the trend is to use several computers, rather than a single unit. NASA's space shuttle uses this approach (Sklaroff, 1976). This enables redundancy management techniques, so that a failure such as HAL's would be recoverable, since a single computer can be 'out-voted' by other computers working together.

Alien Technologies

The first alien technology to be considered is the monolith, which seemed to be some kind of radio signalling device, although with other properties. The Dawn of Man monolith may have triggered the thought processes that resulted in the use of a bone as a club. The lunar monolith had a power source that survived four million years of being buried, whilst the Jupiter monolith appeared to initiate Bowman's final journey after leaving Discovery.

The trip through space by Bowman after leaving Discovery seemed, at the very least, to be at relativistic speeds, judging by the smearing of light. It may even have been faster than light, judging by some of the other scenes on that trip.

In a number of scenes, two Bowmans appear, but of different ages, suggesting either time travel or a trick of the mind. In addition, Bowman's mind seemed to have been read and provided the basis for the 'hotel room' in which he lived, before his resurrection as the star-child. Whilst all the other alien technologies are, at least, understandable to us, even if we cannot replicate them, this final resurrection technology is beyond our understanding.

Conclusions

Considering it was made just before the first Apollo moon landing, the film has turned out to be a good indicator of future technologies. It has really only wrong on the time scale, by maybe fifty to hundred years. However, when projecting technology into the future it is always a mistake to ignore other factors such as politics and commerce, which are issues Kubrick never considered. The future may lie with private enterprise, such as Virgin Galactic (Virgin, 2008). Finally, given how space travel has evolved since Apollo, with the proliferation of unmanned space probes, it is interesting to consider what might have happened if Kubrick had foreseen this and sent a robot probe to Jupiter instead, rather then Bowman? Would we now be watched over by a star-robot, instead?

Appendix A: Distance from Earth to Jupiter

Orbital semi-major axes (McBride and Gilmour, 2004):

Earth = 149.6×10^6 km

Jupiter = 778.4×10^6 km

Distance, *d*, from Earth to Jupiter at closest approach:

$$d = 778.4\times10^6 - 149.6\times10^6 = 628.8\times10^6 \text{ km} = 390.7\times10^6 \text{ miles} \approx 0.5 \text{ billion miles}$$

Appendix B: Acceleration of Discovery

We are told that the ship is three weeks into the voyage and has covered 80 million miles. It is assumed that it started with zero velocity.

Initial velocity, $u = 0\ \text{ms}^{-1}$
Final velocity, v = unknown
Acceleration, a = unknown
Distance, $s = 80\times10^6$ miles $= 128\times10^9$ m
Time, $t = 3$ weeks $= 1.81\times10^6$ s

$$s = \frac{1}{2}(u+v)t \Rightarrow v = \frac{2s}{t} - u$$

$$\Rightarrow v = \frac{2\times128\times10^9}{1.81\times10^6} - 0 = 1.41\times10^5\ \text{ms}^{-1}$$

Thus:

$$v^2 = u^2 + 2as \Rightarrow a = \frac{v^2 - u^2}{2s}$$

$$\Rightarrow a = \frac{\left(1.41\times10^5\right)^2 - 0^2}{2\times128\times10^9} = 0.078\,\text{ms}^{-2}$$

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