Interview with Dr John Houbolt

"**With the nature of man being what it is, there appears to be no way to bring people together in a committee fashion and have them agree unanimously when dealing with such unexplored frontiers [as LOR]"**

Dr John Houbolt, 8th of April, 2005

Introduction

President Kennedy's speech on 25 May, 1961, was the official start of the Apollo-program. The programs mission was to "before this decade is out, of landing a man on the moon and returning him safely to the earth."[1] Any project of this magnitude requires many decisions, and officially starting such a project requires confidence that the responsible organization, NASA in this case, is able to make the decisions and reach necessary technical and management capabilities for fulfilling the mission. In Apollo-program the single most important decision[2] was the selection of the mission mode, or the way of going to the Moon. There were three alternatives: direct flight, earth-orbit-rendezvous (EOR), and lunar-orbit-rendezvous (LOR). We will later discuss the modes in more detail (see chapter "The mission modes"). At this point all we need to know is that it took NASA several years to reach consensus and make the decision.

One man, doctor John Houbolt, is widely credited for playing central role in this decisions process. Some contemporary persons[3] even state, that without John Houbolt NASA would not have made the mission mode decision in time, and that Apollo-program could not have reached its goal in 1960's.

[1] See e.g. http://www.presentationhelper.co.uk/kennedy_man_on_the_moon_speech.htm
[2] Confirmed by Robert Seamans in interview on Friday, 1st of April 2005. Interview by Bill Simmons, with help of Matti Kinnunen.
[3] by Robert Seamans in interview on Friday, 1st of April 2005.

This essay is based on an interview[4] with John Houbolt. Since we also interview Robert Seamans, NASA's associate administrator at the time, on the same topics, we reflect also Seamans' recollections together with those of Houbolt.

The structure of this essay is as follows. First, we present the biography of John Houbolt, Houbolt's career in NACA and NASA, and his organizational position at the time of making the mission mode decisions. Second, we shortly explain the different mission modes, and the sequence of events which lead to choosing LOR and Houbolt's role in this sequence. Fourth, we take a quick look at another important decision: the size of the crew of Apollo. This simpler, and earlier decision provides a good comparison for the making the mission decision. Finally, we discuss briefly the future of space exploration and conclude the essay.

Biography of John Houbolt

John Houbolt was born in Altoona, Iowa, on April 10th, 1919[5]. He received his B.S and M.S in civil engineering from the University of Illinois (1940 and 1942, respectively), and his Ph.D. in Technical Sciences from ETH, Switzerland, in 1957. Houbolt joined the Langley Research Center of NACA in 1942, and worked there until 1963. At the same time, Houbolt held teaching positions in University of Virginia and Virginia Technical Institute. Houbolt left NASA in1963 and worked as senior vice president and senior consultant at Aeronautical Research Associates of Princeton until 1975. Houbolt returned

[4] By email, on 3rd -9th of April, 2005, by Matti Kinnunen (with help of Bill Simmons)
[5] This chapter is based on "An Inventory of the John C. Houbolt Papers at the University of Illinois Archives", at http://web.library.uiuc.edu/ahx/ead/ua/2620117/2620117b.html .

to NASA in 1975 and worked for NASA until he retired in 1985. Houbolt lives in Scarborough, Maine together with his wife Mary.

Houbolt started his career in NACA as a researcher in the structures research division in 1942 doing research in stability and dynamics of aircraft structures. From 1949 to 1961 he was the associate chief of the dynamic loads division researching aeroelasticy, and from 1961 to 1963 he was the chief of theoretical mechanics division. It was in these two later roles that Houbolt played important role in choosing the mission mode.

The mission modes

In this chapter, we briefly introduce[6] the three competing mission modes: the direct-flight mode, the earth-orbit-rendezvous mode, and the lunar-orbit-rendezvous mode[7].

In the direct-flight mode, a single large launch vehicle places a spacecraft to a earth-to-moon trajectory. The spacecraft would then land on the Moon, and after the Moon-mission was done, would take off from the Moon for the journey to Earth. Back at Earth, a small command module would land through the atmosphere. The main disadvantage of this mode was the large launch vehicle needed. Even though there were plans for building such a vehicle, called Nova, getting Nova ready in time was not likely.

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[7] Based on "Why Lunar-orbit Rendezvous" by Brainerd Holmes, Astronautics, November 1962

The earth-orbit-rendezvous mode would eliminate the need for building Nova by launching several smaller vehicles from the Earth. These vehicles would then meet each other in earth-orbit and make up a single spacecraft, which would launch to the Moon, and land more or less as in the direct-flight mode. The main disadvantage of this mode was the fact that it required launching a space-craft and a fuelling vehicle separately, and then fuelling the spacecraft in the earth orbit. This was considered feasible, but hard. The advantage was the possibility to return to the Earth if something went wrong.

The lunar-orbit-rendezvous would eliminate the need for launching several vehicles form the Earth. In this mode, the spacecraft would fly from the Earth to the lunar orbit. A part of the spacecraft, the command module, would remain in the orbit. The other part of the spacecraft, the lunar lander, which would consist of descent and ascent stages would land on the Moon. After completing its mission on the Moon, only the ascent stage would take off from the Moon and rendezvous with the command module. The command module would then return to Earth. The advantages of LOR would be the smaller required total energy budget, since only part of the spacecraft would land on and take off from the moon, and the need for only one launch vehicle. The main disadvantage would be the rendezvous in the moon-orbit: if it would not succeed, the astronauts in the lunar module could not return to Earth.

The study of different mission modes had started well before Kennedy's speech. The group of von Braun had started to study EOR already in 1958. Von Braun and his group at Marshall, and they continued to support EOR until the decisive meeting on June 1962[8].

At the same time, researchers in Langley, including John Houbolt, were also studying mission modes. They became convinced, that LOR would be the best mode. Houbolt himself says that he became convinced about LOR's preference in 1959[9].

The LOR-decision and its consequences

NASA finally decided to choose LOR in an all-day meeting on 7th of June, 1962. When asked for the most important early decisions in the Apollo-program, Houbolt replied[10]:

> *"The most important was the decision to use LOR. Without that decision, I firmly believe we still would not be on the moon. "*

Seamans[11] also ranked this decision as the most important decision in the Apollo-program. The final decisive factor in making this decision was von Braun's unanticipated "reversal of opinion"[12], which was, according to Houbolt[13]:

> *"A pivotal decision was when von Braun changed his mind and adopted LOR"*

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[8] See e.g. http://www.hq.nasa.gov/office/pao/History/SP-4205/ch3-2.html , page 2
[9] In interview, on 3rd -9th of April, 2005, by Matti Kinnunen (with help of Bill Simmons)
[10] Ibid, interview
[11] Ibid, interview
[12] von Braun himself claimed that he had not reversed his opinion, since before the meeting he had not had a strict opinion on the mission more. This discussion is beyond the scope of this essay.
[13] Ibid, interview

Making the mission mode decision took NASA more than 3 years. The first committee to discuss the issue was Jastrow's committee[14], which was established in February, 1959. There were in total, at least 12 committees, which were working, among other issues, on the mission mode.

Houbolt was a member of, or give advice to, many of these committees. Since the committees did not consider, in Houbolt's opinion, LOR seriously enough, Houbolt wrote his two famous letters to Seamans[15]. Houbolt considers his own decisions to send the letters as one of the important early decisions in the Apollo-program:

> *"My decision to write to Seamans was an important early decision, and his decision to pass my letter along to Management was significant, also."*[16]

In his first letter, on 19th of May, 1961, Houbolt states, that the state of the booster program is "deplorable" and that NASA should therefore pay more attention to rendezvous studies. He also gives some arguments for the claim that even if a big booster, for example a Nova, would be available, the probability of mission success using it would be rather low. This argumentation is in line with the answer by Houbolt, when asked whether the existence of Nova would have changed his opinion about mission mode: "*Absulutely not"*.

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[14] see http://history.nasa.gov/SP-4308/ch8.htm
[15] The letter are available at http://www.hq.nasa.gov/office/pao/History/monograph4/foreword.htm by choosing "Key documents"
[16] Ibid, interview

In his second letter, on 15th of November, 1961, Houbolt again requests NASA to pay more attention to LOR when studying the mission modes. He gives various reasons, why LOR is much better, safer, and faster way to get to the moon that building a large booster. Given the fact that von Braun's group seems to have been concentrating in studying and advocating EOR at the moment[17], Houbolt's preoccupancy of arguing against NOVA seems a bit strange.

Houbolt's preoccupancy and letters seem even more strange, if Seaman really got convinced of LOR during his and Houbolt's first meeting in September, 1960. In our interview, Seamans told that he went to Langley during his first week in NASA. He met Houbolt and two other local engineers, who briefed him about LOR. Seamans claims that while he became convinced[18], the organization was not convinced, and that the task was to convince the organization. It seems, that one of Houbolt's main roles in the mission mode decision has been keeping LOR in the discussion and defending it, which Seamans, as the assistant administrator, could not do.

Houbolt himself was not aware of that Seamans was convinced. When we asked him for his understanding of Seamans' opinion in the mission mode decisions, Houbolt answered:

> "*When I wrote my first letter to Seamans, I knew I had to get in touch with someone on an individual basis, and I picked Seamans because he had worked on a project*

[17] See e.g. http://www.hq.nasa.gov/office/pao/History/SP-4205/ch3-2.html
[18] See e.g. http://www.hq.nasa.gov/office/pao/History/SP-4205/ch3-2.html , page 2, which hints to the same direction, and tells the story of the meeting in Langley.

called "Saint"[19] which I believed had possibly dealt with rendezvous aspects in general (though not with LOR in particular). Therefore, I felt he might listen to me, might be somewhat sympathetic to the idea, and then force management under him to give LOR due consideration. "

and continued

"I didn't know his specific opinion, but after I wrote to him and in answer to my letter, he wrote and assured me around May of 1960, that Management was working on it. "

So, Houbolt wrote to Seamans, because he thought Seamans would consider a rendezvous a possibility, and because of Seamans' organizational positions. We may also assume, that having met Seamans face-to-face at least twice[20], Houbolt felt encouraged enough to write to him directly.

According to Seamans, NASA could make the mission mode decision only after the whole agency reached a consensus about it. This happened with von Braun's speech on 7th of June 1962, as explained earlier. Another interesting question is when the LOR-decision became irreversible. According to Houbolt is became irreversible "*on the date LOR was chosen".* Seamans claims that it was a bit later, namely at the moment of

[19] SAINT, Satellite Interceptor Project, was a project, on which Seamans had worked in RCA. It was later cancelled, but it later RCA got contract on rendezvous and docking in Apollo. See http://www.nasm.si.edu/research/dsh/TRANSCPT/SEAMANS4.HTM .
[20] At Langley and in Washington in December 1960. See e.g. http://www.hq.nasa.gov/office/pao/History/SP-4205/ch3-3.html , page 1.

accepting the budget for 1963, in which the allocations for Nova were moved to other projects. Another interesting questions is whether NASA maintained any alternative, or backup plans ("Plan Bs") in addition to LOR. Seamans says clearly, that there were no alternative plans. Houbolt is a bit more hesitant and says

> *"some consideration was still given to the Direct Flight Mode by the skeptics."*

The space program of USA stalled after the Apollo-program. It has been argued, that choosing LOR, which (according to this argument) prevented building a permanent space station, would have caused stalling. Houbolt does not agree with this argument, saying

> *"There was a lot of haggling before and after the LOR decision was made by those who were fighting for the big booster vehicles, but I don't think that Apollo caused the space program to stall. "*

and that

> *"I do not believe Apollo caused the decline of NASA. I believe Apollo enhanced NASA."*

Seamans claims that the reasons for the stalling was the difficult budgetary situation at the time. In his opinion, building a space station with the Apollo-equipment would have been easy.

The size of the crew

The size and weight of the lunar spacecraft depend on the number of astronauts and the length of the mission. It is interesting to take a look at how the decision to have 3 astronaut crew came about.

According to Cox and Murray[21] "the choise of three-man crew turned out to be perfect". The reasons for this was that 2 men were needed for lunar exploration activities, and one the third man was needed to operate the command module. This explanation is, however, post-hoc, since the size of the crew was chosen before the mission mode. This is evident from Houbolt's letter to Seamans on November 15th, 1961. In his letter, Houbolt protests of the ground rules of the Golovin committee[22]. He writes *"three ground rules are worth mention: three men, direct landing, and storable return. These are very restrictive requirements. If two men can do the job, and if the use of two men allows the job done, then why not do it this way?"*

So, where did this "ground rule" come from? According to Seamans[23] no real studies were done on this. Seamans thinks that the 3 astronaut crew was necessary for having back-up persons in case of sickness or accidents. This is not a good reason, since the lunar spacecrafts had many other single points of failure. Seamans himself argued[23] for against the apparent risk of LOR by pointing out the numerous single points of failure of the spacecrafts.

Cox and Murray just refer to some designers who "just figured that they [astronauts] would run the duty shift as Have did, four hours on, eight off, which meant that they

[21] Cox and Murray: *Apollo,* South Mountain Books, 2004. See page 91.
[22] Formed in July 1961 to plan the launch vehicles.
[23] Ibid, interview

would need 3 astronauts to ensure that an astronaut would be on duty all the time".

Houbolt offers yet another explanation[24] :

> "*In one of our informal, roundtable sessions, it was discussed that there had to be at least two. You needed a pilot in the orbiter, and you needed someone in the lander. With an airplane, there is usually a pilot, a co-pilot, and a navigator; so, arbitrarily, we picked a crew of three.".*

This would suggest, that sometime after writing his second letter to Seamans, Houbolt got convinced about the necessity, or at least feasibility of a crew of three.

Based on these quotations, we really cannot know how and by whom the crew size got decided. It may have just been a common consensus, which happened to be suitable, if not even correct, as Houbolt stated in our interview:

> "*[the crew size of] three was perfect".*

For the future manned missions to the Moon and the Mars, the choice of crew size cannot be made this haphazardly. For the first, the necessary tasks during such a missions may not reflect those in the Navy or in airplanes, which, by the way, now usually have just a pilot and a co-pilot. For the second, some current research suggests that

> "Overall, larger crews were less dysfunctional than smaller ones. The crew which demonstrated the least deviance, conflict, and dysfunction of all was one that numbered about nine persons."[25]

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[24] Ibid, interview

Of course, if the purpose is the establish a colony in the Mars, as Joe Gavin suggested[26], a larger crew is a necessity anyway.

Conclusions

Let's us conclude by discussing the future of space exploration. First, let's consider, what Houbolt thinks about Joe Gavin's claim. Houbolt says

> *"I'm pretty much in agreement with Joe Gavin about the future of the space program. People don't seem to realize that for man to go to Mars is a monumental task and may not even be possible because of distance and time involved. For example, consider the logistics of carrying oxygen, food, water, heat, electricity and return fuel for a year-long, round-trip to Mars along with particle protection against meteorites and such for one person let alone for a crew of two or three."*

Second, Seamans says that he believes in human space exploration, but according to him, we should first do as much as possible by using robots before sending humans. Seamans also says, that we cannot prove the necessity of sending men to Mars. Instead, justifying the necessity requires an act of faith[27].

If we were to make such an act of faith, and decide to establish a colony in Mars, the two decisions we have discussed in this report suggest two lessons for us to learn.

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[25] Dudley-Rowley et al: "Crew size, composition, and time: implications for explorations design", AIAA Space Architecture Symposium 10-11 October 2002, Houston, Texas
[26] During his guest lecture, Apollo-class, April 2005
[27] Ibid, interview

First, we should be extremely vary of unstated assumptions. In Apollo, using 3 astronaut crew proved to be the correct decision, even though it was made without explicit studies. Next time, it is not likely that the crew size is among the unstated assumptions, but we can be sure that there are others. Since some of them may well be incorrect and unwarranted, we should strive for finding and evaluating them.

Second, we should consider Houbolt's opinion about making complex decisions seriously. Houbolt claims that

> *"With the nature of man being what it is, there appears to be no way to bring people together in a committee fashion and have them agree unanimously when dealing with such unexplored frontiers."*[28]

If this is true, we should expect having the need of characters like Houbolt in all large scale pioneering projects. We need to have and to tolerate individual champions of novel ideas, and we should build our organization and management structures in such a way, that the champions' energy, determination, and courage is not in vain. Of course, individual champions may well be wrong, and for this reason we need ways to manage the totality of problems in a project. Since the projects are large, we must also agree with Seamans, who claims that no single person can manage the decisions space of large programs, and that we need tools for getting our minds around the issues.

[28] Ibid, interview

Therefore, in the next programs, we need to be more aware of our assumptions, to make it easier for individual champions to exists, and to make sure, that we have the necessary tools for supporting our reasoning.