THE SPACE SHUTTLE
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Part 1
Origins and Authorization

The conquest of space began when the V2 started entering it at hypersonic speed, meeting many functional problems. Wernher von Braun is on record as insisting that successful component functioning was not enough; all phenomena must be noted and analysed with reporting directly to him. These methods resulted in success, and many V2s were launched in WW2 with high reliability. One damaged my own home in England. The Russians captured the V2 development site at Peenemunde but von Braun and his key staff had already fled towards the West and gave themselves up to the Americans.

The atomic bomb ended the Japanese war but interest soon arose in its direct delivery by long range rocket. A sharp difference arose between the Americans, who favoured larger rockets, and the Russians who favoured clusters of smaller rockets based on the V2.

Into Space

The Russian approach gave initial dominance of Space, beginning with longer range rockets carrying heavier payloads. It was soon followed by the first Earth-orbiting space satellite which, for a while, the Americans were unable to match. At this time I met von Braun and his team who were engaged on the medium range Redstone missile while the Americans were heading for long range missiles. The other Americans failed to achieve earth orbit but von Braun succeeded. The Russians drew ahead by orbiting first a dog and later a man, Yuri Gagarin. I, and hundreds of others, were invited to meet him through the Soviet Embassy in London. They were also able to send a payload to the vicinity of the moon, while American Astronauts were beginning to orbit the Earth.

After the Apollo programme finished I witnessed the American launch of the Skylab. This was nearly a failure because of damage to the solar cell arrays which astronauts were able to repair just in time.

The main American effort had turned to the Space Shuttle. It was intended not only for astronauts to orbit the earth, but also for the larger scale carriage into low earth orbit of space satellites with rockets to carry them further to geostationary orbit, where communication satellites were being placed.

The Space Shuttle Vehicle

The intended missions of the Shuttle included astronauts, scientific missions, launch and maintenance of low earth orbit satellites, and geostationary satellites with upper stage boosters (both civil and military).

NASA encouraged international collaboration in several ways: participation in the design of the Space Shuttle, development of a Space Laboratory and a partially reusable Space Tug to take satellites to higher orbits of the earth.

Some European governments decided to participate in the Space Shuttle design. The British Aircraft Corporation was one of these, and I was appointed Director in Charge because by then I was the only Corporation engineer who had weapons, space and supersonic aircraft experience.

The Military Aircraft Division had published a study of a smaller Space vehicle intended for some of the proposed missions, the feasibility of which I had discussed with them. My Concorde experience had warned of the problems which arise when a supersonic vehicle is designed for too low a target weight. (The Concorde was designed for too low a target weight four times before it could cross the Atlantic with a payload.)

I led a mission to decide which prime American contractor we should join; the choice proved easy. At the first one we visited there were strong signs of staff dissatisfaction with the management. At Rockwell we met an enthusiastic team led by good leaders. We agreed with Rockwell to design the payload bay doors, the fin and rudder with air brakes, and the central instrumentation system.

The teams for these would be partly in America and partly at Bristol and Weybridge. The conditions of working were novel and the effects on families were considerable, so I arranged information courses for potential members of the team with their wives. International communication would involve space satellites. All team members were volunteers and the collaboration was set up.

Part 2
Working on the Space Shuttle

Our teams had no problem settling in with Rockwell. The wives met good friends and the children found their English education put them a year ahead of the American children. The husbands were respected at work, as I was, because there was respect for the guided weapons and aircraft projects they had worked on in England. We found a German team was working there on another aspect of design.

The Managing Director had come from the world famous Rockwell mining division and was generally called "the last gentleman in the business". We became great friends with him and his wife and I greatly respected what he did when the space shuttle design work ended.

Buz Hello, the team leader, gave a fortnightly talk to staff on how things were going. I was impressed by the way he arranged carefully prepared evidence for the many review meetings on particular aspects of performance. Each team also worked to a weight target and a cost target for their part of the Space Shuttle (well ahead of most English practice.)

The capsule fire which had killed three astronauts had left a big change in behaviour on design. Enormous care was given to detail design to ensure that no safety problem could arise.

One of Buz's mottos was "The Devil's in the Detail", and in the drawing office an equally senior engineer, Charlie Felz, was looking at and discussing the detail drawings with the draughtsmen.

I also visited NASA to make sure they understood that our British team could do the design and manufacture for half what it would cost in America. He joked by offering me a free bowl of soup on a subsequent visit. I also had discussions with NASA staff, particularly on the degree of risk in the Moon landing programme. The opinion was that the moon landing programme had probably ended just in time to avoid another bad event.

As a result, enormous care went into every aspect of the Shuttle programme. For the Moon landings an independent group had the job of examining what NASA did

and planned, and I was interested in how its members were chosen. They came from widely different backgrounds. One of them, whom I met, was a farmer!
I was able to enjoy two very realistic simulator experiences. One was to fly a shuttle re-entry into the atmosphere as assistant to a NASA pilot doing it with a roll system failure, using yaw to get roll. We made it all right.

The other was as co-pilot on an automatic lunar landing in the previous lunar module of the Apollo programme. The simulation was extremely realistic and included the blurred scene as we approached due to the rocket efflux followed by the impact of the three feet on the Moon's surface and the dying of the rocket jet.

Space Shuttle Design
When we started, the Space Shuttle was a hypersonic aeroplane on top of a supersonic aeroplane, both air breathing. The NASA aerodynamicists had been working on both for years.

During the first year the independent NASA group came up with a simpler, less costly and more practical idea. A rocket propelled vehicle capable of lunar orbit and Earth return, driven by a liquid fuel rocket motors with auxiliary semi-reusable propellant tanks.

Fortunately this had little effect on our parts of the Shuttle and Rockwell was quickly ready for a NASA programme review of it at which our presenters used three projection screens at once.

In our second year I became concerned lest NASA encounter the multiple redesigns and weight growth which had plagued the Concorde, and they readily agreed that I make them a presentation on this as the payload was only about 7% of the take-off weight. So I lectured them on the Concorde history and proposed that there be secret weight and thrust margins available when the sub-assembly mass targets were exceeded. They did this and the payload of the first Shuttle came only a little below the design aim.

We had taken out patents on some features of our designs; near the end of design Rockwell demanded we give them full rights on these. After a very difficult discussion they agreed to use their best endeavours to ensure our participation in the manufacture and operation.

Our team returned to U.K. to await an announcement on the winner.

Space Shuttle Contract
We were pleased to see that Rockwell won the contract. They immediately brought in an entirely different team to engineer the shuttle; the people with experience of development and launching of the Moon exploration programme.

And what of Buz's team which had won the contract? Joe Macnamara ensured that the senior members all got good jobs elsewhere in Rockwell; Buz was to lead the B1 supersonic bomber aircraft. Those made redundant were told that they could be re-engaged on the next major project, as had been the case with the Apollo project when many returned for the Space Shuttle.

We discovered, however, that NASA had developed more advanced technology for much of the portion we had designed and intended to cut us out. I revisited America to try to reverse this with the contractor's help, but NASA would not change.

Our team was re-absorbed into British Aircraft Corporation, though some of them later joined the European Space Organisation in which I was to be a British candidate for a top position (soon hijacked by the French) so I left the aircraft industry.

Space Shuttle Manufacture and Operations

For the next stage of this history we have to go on twenty five years when my wife and I were cruising from Leningrad to Moscow. We happened to lunch with an American and his wife, with whom we found much in common. I had led the team which found that no airline would buy the Concorde, and had to leave the aircraft industry as a result, ending up as a University professor.

He, as Financial Director of Rockwell, had predicted (on the basis of Apollo experience) that to cover all the planned Shuttle missions NASA would have needed six establishments the size of Cape Canaveral. Forced to leave, he too ended up in education in charge of all schools in New York.

He told me how Rockwell had won the manufacturing contract but only by agreeing to subcontract manufacture to every State which had an important vote in the Senate.

Shuttle missions

Many of the planned missions started to vanish. Firstly it proved too difficult to create a partially reusable rocket to take payloads on to geostationary orbit (which greatly pleased the Shuttle crews!). Secondly the military largely withdrew to use cheaper expendable rockets, which in the end could launch a smaller cheaper space shuttle.

In the same way, the shuttle was not used for communication satellite launch. Its main success was the launch and repair of the Space Telescope, and the subsequent building of the International Space Station, but expendable rockets later took this over.

The yearly number of Shuttle launches from Canaveral almost exactly fitted the prediction by Rockwell's financial Director which lost him his job.

Accidents

The way in which two Shuttles were destroyed with the loss of fourteen lives clearly showed that NASA had failed to follow up the rigorous safety measures with which it had started. An historical record in Wikipedia[1] states:

"On January 28, 1986, *Challenger* disintegrated 73 seconds after launch due to the failure of the right SRB, killing all seven astronauts on board. The disaster was caused by low-temperature impairment of an O-ring, a mission critical seal used between segments of the SRB casing. The failure of a lower O-ring seal allowed hot combustion gases to escape from between the booster sections and burn through the adjacent external tank, causing it to explode. Repeated warnings from design engineers voicing concerns about the lack of evidence of the O-rings' safety when the temperature was below 53 °F (12 °C) had been ignored by NASA managers.[95]

"On February 1, 2003, Columbia disintegrated during re-entry, killing its crew of seven, because of damage to the carbon-carbon leading edge of the wing caused during launch. Ground control engineers had made three separate requests for high-resolution images taken by the Department of Defense that would have provided an understanding of the extent of the damage, while NASA's chief thermal protection system (TPS) engineer requested that astronauts on board

Columbia be allowed to leave the vehicle to inspect the damage. NASA managers intervened to stop the Department of Defense's assistance and refused the request for the spacewalk, and thus the feasibility of scenarios for astronaut repair or rescue by Atlantis were not considered by NASA management at the time"

The management at NASA would rather not make decisions that would jeopardize their jobs. Further complicating things, certain members of Congress, which is the regulatory oversight body for NASA, have no desire to make decisions that would jeopardize the NASA centre in their district. Unfortunately these are some of the hardest obstacles in the path of NASA's organizational change.

There needs to be a mechanism for engineers to be able to bypass the bureaucracy and hierarchy, especially in the pre-launch process. What would have been the alternative if the engineers had succeeded in getting their point across in the case of Challenger? Probably Challenger would have had to been taken off of the launch pad and the SRBs disassembled to replace the damaged O-rings. This would have been expensive but not nearly as costly as the loss of crew and vehicle. As well, if an engineer has a special request for a certain type of data, there should be a way to request exceptions to formal bureaucratic procedures to focus on getting the data. Engineers have many intuitions and hunches that take time and resources to translate into analysis and data. These intuitions need to be respected, given credence, explored and welcomed by upper management.

What has happened since?
Strong forces ensure the opposite. The Reith radio lectures in the 1970s "The unimportance of being right" has been summarised as follows:
The ruling nostrum of the Civil Service is the unimportance of being right. Calamities come and go. Ministerial careers are ruined. Civil servants who challenged accepted wisdom of their political masters are usually sidelined. Their careers wither. Those who collaborate with political calamities survive and they progress inexorably into top jobs and honours.

The author was a senior civil servant who categorised the Concorde as an economic disaster. He was right . He lost his job.He was delighted to meet me with my similar history. The Financial Director of Rockwell also lost his job by being right about the Space Shuttle.

It is time for those who were right about important things to be appropriately honoured.

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[1] Space Shuttle
https://en.m.wikipedia.org/wiki/Space_shuttle_in_popular_culture#In_culture