FRONTIER ASSOCIATES, INC.
MANAGEMENT CONSULTANTS

Case Study #6
The Case of the Stymied StarLight

The Goals

The purpose of the StarLight mission at NASA's Jet Propulsion Lab (JPL) is to demonstrate technologies for the Terrestrial Planet Finder (TPF), a space telescope that will, for the first time, be able to detect Earth-like planets orbiting nearby stars and to examine them for signatures of life. The new telescope, planned for launch in 2015, will exploit the theory that habitable planets – those capable of supporting life -- will have atmospheres containing water vapor and carbon dioxide, and that those containing life will have atmospheres containing the important biomarkers of oxygen, ozone, and methane. Earth's atmosphere, for example, contains these molecules whereas the atmospheres of lifeless Venus, and (as far as we know) lifeless Mars consists almost entirely of carbon dioxide. The atmosphere of a planet reflects the light of the parent star. The atmospheric composition, and thus the possibility of life, can be inferred by analyzing the spectrum of that light – if only engineers could find a way to detect this very faint signal.

The Technical Details

Planet detection faces two major challenges. The first is to see the faint light reflected by a planet from a distance of dozens of light years (hundreds of trillions of miles). The second and more difficult challenge is to separate the reflected light of a planet from the much brighter light of its parent star. To discern such detail requires unprecedented angular resolution. The larger the diameter of a telescope, the better its angular resolution. A telescope constructed like the Hubble Space Telescope would have to be at least the size of a football field — far beyond our current ability to build, much less launch into space.

One way to surmount this obstacle is with interferometry. Using this approach, light simultaneously collected by two or more telescopes stationed at least 100 meters apart is reflected to a central location where the beams are combined (interfered) in such a way that the light from the star is cancelled out. Interferometry in space requires precision formation flying of spacecraft to 10 centimeters, and subsequent active control of the interferometer optics to an accuracy of a few nanometers (billionths of a meter, or thousands of times smaller than the diameter of a human hair).

The StarLight mission, planned for launch in 2006, is intended to demonstrate precision formation flying and long-distance interferometry in space. As originally envisioned, it consisted of three spacecraft: two spacecraft which collect light, and one spacecraft that combines the light from the two other spacecraft.

In 1998 the team projected that it would barely be able to keep the cost of the mission within their $180M budget.

The Crisis

In the summer of 1998 the project was notified that a significant portion of the non-NASA funding — nearly a third of the total budget — would not be available. The team unsuccessfully attempted to replace the missing $50M by enlisting other customers. The team then considered cost-saving alternatives such as reducing the inter-spacecraft distances to 20 meters (possibly using a boom, and giving up the formation flying demonstration) or using lasers instead of starlight for the interferometry demonstration. When none of these ways of descoping (settling for something less than the original goal) proved attractive to NASA, it appeared to the team that the objectives of the mission could not be met within the $130M budget, and that in about eight weeks, at the next briefing to NASA Headquarters, the mission would have to be cancelled.

The FAI Solution

Gary Blackwood, one of the project team managers, had recently participated in a Frontier Associates' Leader Workshop conducted at JPL. The purpose of this workshop is to "provide a technology for producing breakthrough results with others." One of the techniques presented in the workshop is for handling situations in which things don't go as planned and breakthrough solutions are needed.

Instead of looking forward from the present and asking, "How are we going to overcome this obstacle?" a team using the FAI technique looks backward from the future and asks, "How did we accomplish our goal?" Looking back from the future promotes creativity, often referred to as "thinking out of the box." Instead of a solution involving reduction of their goal, the team creates a breakthrough that generates a result better than their original goal.

In a few of the steps in the FAI approach, the team

- builds a powerful commitment
- gets clear about the real goals that forward that commitment
- brainstorms on how they fulfilled those goals

The StarLight team created a powerful commitment that they entitled "Forward the Search for Life in the Universe."

They saw that their real goals to forward that commitment were

- a breakthrough in formation flying to an accuracy of 10 centimeters
- a breakthrough that demonstrated the feasibility of interferometry in space requiring optical control to a few nanometers

They recognized the original mission scenario of three spacecraft flying in a linear formation was only one way of reaching these goals. Standing in the future and looking back, the team brainstormed about other ways they might have achieved their goals.

In brainstorming, no solution has to be feasible. Instead of just three alternatives (find $50M, descope, or cancel), by looking back from the future the team was free to come up with many pages of possible solutions. Then they analyzed for feasibility.

The Results

In reviewing the possibility of a 2-spacecraft solution, the team saw that they could put the combining instrument on one of the two telescopes rather than on a third spacecraft, and add a fixed delay line (an "optical detour") to compensate for the distance the light had to travel from the other telescope. By borrowing from 10th grade math, they saw that if the joint combiner-collector spacecraft were located at the focus of a parabola, and if the other collector spacecraft flew back and forth along the parabola, <u>all</u> NASA's original mission goals could be accomplished with only two spacecraft. In fact, the new solution was in many ways better than the original design. It would deliver the same results but was less expensive and likely to be more reliable. In acknowledgment of their ingenious solution, the team received an award from JPL.

By making this breakthrough, the team developed a new view toward obstacles, and they've since produced many other major breakthroughs. As with the first, these breakthroughs resulted from "thinking outside the box" rather than from exhaustive testing and experimentation. In addition, the StarLight team now saw itself as capable of producing breakthroughs as needed to successfully overcome any obstacle to the commitment they had built.

Summary

When faced with a difficult obstacle, a team usually focuses on solving the problem in front of them, which almost inevitably leads to descoping. The result typically costs more, takes more time, or produces less than originally planned. In using FAI's method for resolving difficult problems, including building a powerful commitment, being clear about the real success criteria, and asking "How did we accomplish the success criteria?" a team can reliably produce a breakthrough, a result <u>better</u> than originally planned.

