**REMAKING NASA**

The first difference is the preferred shape. A vehicle meant to pluck astronauts from the international space station—particularly in an emergency—should be able to maneuver upon reentry so that it can land in a suitable spot. If astronauts have to leave the station in a hurry, that maneuverability, something known as cross-range, can mean the difference between landing at a well-equipped U.S. airbase and the middle of Siberia. In contrast, a capsule like the ones used by the Mercury, Apollo, or Soyuz astronauts depends on a carefully timed runway to land close to its target—a luxury that an injured astronaut might not have.

But the wings that gave the shuttle its distinctive shape and large cross-range aren’t needed for a mission out of Earth orbit because they can’t function in a vacuum or in a very thin atmosphere. “You don’t need wings to go to Mars or the moon,” says Michael Mott, vice president of Boeing NASA Systems. The current designs for the OSP included both planelike and capsulelike variants, anticipating the CEV’s dual missions to ferry astronauts to the space station and take them out of Earth orbit. “I don’t think that there’s a serious change in direction for the CEV that NASA wants,” says Mott.

A big difference between the OSP and the CEV, however, is the sheer amount of propellant that’s needed to get the craft to its goal. A low-Earth-orbit spacecraft such as the Soyuz capsule need only carry enough fuel to knock itself out of orbit. A moon vehicle must have an extra engine and fuel to leave Earth’s orbit and enter a moon-bound or Mars-bound trajectory, as well as enough propellant to break out of its new orbit and return to Earth.

A twin at NASA says that what the Soyuz capsule need only carry enough fuel to knock itself out of orbit. A moon vehicle must have an extra engine and fuel to leave Earth’s orbit and enter a moon-bound or Mars-bound trajectory, as well as enough propellant to break out of its new orbit and return to Earth.

Apollo engineers solved this problem by building an enormously powerful rocket. The Saturn V could lift about 120,000 tons to low Earth orbit, more than enough thrust to handle a large Apollo complex of spacecraft, extra engine, fuel, life support, and lunar lander. Thirty years of technological improvements will allow the CEV payload to be much lighter than the Apollo complex. “In wiring alone, you eliminate hundreds of pounds of wiring used in the Apollo mission,” says Mott. Even so, NASA will need to think creatively: The launchers tapped for the OSP, the Atlas V and Delta IV medium, can’t lift more than approximately 20 tons into orbit in their present configuration. As a result, the space plane, engine, and lander may have to be launched separately and then brought together in orbit, or NASA may even use existing Russian or European heavy launchers to get heavier components into orbit.

So far, nothing has been ruled out. “No-body’s said anything about the launch vehicle,” says John Logsdon, a space expert at George Washington University in Washington, D.C. NASA Administrator Sean O’Keefe has suggested that there are no plans to design a new launch vehicle from scratch, although he suggested that NASA will study how to get the required cargo into space with slight modifications of existing launchers. Current OSP designs show it sitting on top of a launcher, which would allow a small rocket to second the pad.

The most striking difference between a moon mission and an orbital mission is the lander. Although the designs are very preliminary, there are hints that they will look like beveled Apollo landers, which were known as lunar excursion modules (LEM). “Yeah, you see a lot of LEM-like designs,” says Mott. “The physics hasn’t changed, and the Mercury/Gemini/Apollo people got it right.”

To satisfy those intractable physical laws, a CEV needs to be light, relatively simple, and able to link up with a lander, an engine, and a fuel source. It must also ferry astronauts on and off the space station under all conditions. This one-craft-does-all approach frightens Launius, who draws a parallel with a U.S. fighter-bomber intended to fulfill many roles for the Army, Navy, and Marines. First used in Vietnam, it was phased out in the 1980s. “The F-111 in the 1960s was supposed to do everything,” he says, “but it couldn’t do anything very well.”

If history is any guide, NASA is likely to face similar pitfalls in building the CEV. Many consider the shuttle itself a failure; with a $400 million cost per launch, it never came close to fulfilling NASA’s promise of cheap access to space. And several attempts to design a shuttle replacement or crew rescue vehicle have gone awry, most notably the X-33. This experimental vehicle swallowed $1 billion before the program was cancelled a few years back. That level of performance, all agree, simply isn’t good enough for NASA.

—CHARLES SEIFE

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**From Bean Counter to Visionary: A Space Odyssey for NASA Chief**

Two years after his arrival and 1 year after the Columbia tragedy, Sean O’Keefe is trying to take NASA back where it’s been—and beyond

It wasn’t too long ago that a senior Republican lawmaker blasted Sean O’Keefe’s vision for NASA as “timid and anemic.” Not anymore. Although many people are skeptical of the president’s new direction for NASA, none is accusing the space agency’s top administrator of being faint-hearted.

It is an astonishing transformation. As a Pentagon comptroller and second-in-command at the White House Office of Management and Budget, O’Keefe was known as a bean counter rather than a visionary. His arrival at NASA headquarters in December 2001 was greeted with dread by those who feared that his job was to keep expensive visions at bay.

Yet today the 48-year-old O’Keefe is at the helm of an ambitious effort to remake the U.S. space exploration program with the promise of billions of new dollars. What happened? “He’s gone native,” grouses one former Pentagon colleague, who complains that O’Keefe gradually was seduced by the glamour of the astronaut culture and swallowed up by the realities of directing a federal agency. Others say it was the Columbia disaster last February that forced O’Keefe to reckon with

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**Highlights.** NASA Administrator Sean O’Keefe (left) rejoices with Cornell’s Steve Squyres after the 3 January landing of the martian rover Spirit, which later developed communications problems.
the agency’s future. But John Marburger, the
president’s science adviser, believes the re-
thinking began when O’Keefe was appoint-
ed to the job amid concerns about space
station cost overruns. “That’s when space
policy began to change,” he says.

In retrospect, the administrator’s early
push to develop nuclear power and propul-

sion systems, build a shuttle alternative, and

drop the taboos on discussing human mis-
sions beyond the space station were obvious
clues to what lay ahead. In the wake of Co-
lumbia, O’Keefe surprised the White House
by asking for a massive spending increase—
on the order of $27 billion over 5 years—to
speed up and expand work on these efforts.
Administration officials say. The White
House balked at the cost and insisted on a
clear destination. O’Keefe came back this
fall with plans to send humans to Mars; ulti-
mately the president chose a lunar base as a
more immediate goal that was less likely to
cause sticker shock.

An ambitious and loyal Republican,
O’Keefe is rumored to lust after a senior Pen-
tagon post, a rumor he strenuously denies.
Regardless, his political future may hinge on
how well he runs the congressional gauntlet
in coming months. He must convince skepti-
cal lawmakers that his prescription for NASA
will cure the ailing human space flight effort
without hurting the healthier space and earth
sciences. Gaining that support may prove
tougher than getting face time with the presi-
dent or vice president, a longtime patron.
O’Keefe is respected on Capitol Hill, but he
has a tendency to speak at length and say lit-
tle. “He wouldn’t know how to speak a
straightforward sentence if you paid him,”
says one frustrated congressional aide.

O’Keefe spoke with Science just prior to
the president’s 14 January speech and, thus,
decided to discuss details of the exploration
plan. But he appeared relaxed and forthright
in a wide-ranging discussion in his office
overlooking the Potomac River and the Pen-
tagon. His edited remarks on various topics
follow.

—ANDREW LAWLER

On the Mars Spirit rover:
How things have changed in a year! There is
a very thin margin between great success and
great failure, and I’ve seen both ends of it. On
the Spirit landing, we didn’t know how dense
the atmosphere of Mars was. Had we [started
the parachute firing sequence] a few seconds
later, it would have crashed and might even
have buried itself about 5 feet [1.5 meters]
straight down. Holy cow—this could have been
a disaster. And we might not have known why.
That’s the hairline difference between succes-
s and failure. It’s razor thin. [Spirit’s troubles as Science went to press
painfully reinforce that notion.]

On the science behind exploration:
It will be a significant driver. The story of
Spirit is both science and exploration. There’s
the theory and the tools. And then we’re go-
ing to put the pedal to the metal and go ex-

dplore, and figure out what is on the other side
of that ridge. It’s all about both. But . . . if you
have to demonstrate every exploration goal
with an exclusive scientific theoretical con-
text, you are not going to capture the
imagination—except for the community in-

On what drives discovery:
Neil Tyson, the head of the Hayden Planetar-
i um in New York City, has traced the [un-
pinnings of] seminal exploration achieve-
ments. First is national defense. Second is
an economic advantage—such as going to
the New World. Third is a national objective,
such as the current Chinese motivation [for
space flight]. And a fourth is human expan-
sion based on knowledge and interest and
desire. There are pitifully few of these
achievements, but they do occur. And when
they happen they are interesting, such as
Chinese [ocean exploration] in the 14th cen-
tury. Tyson argues that the Chinese [ulti-
mately] made a determination that every-
thing available elsewhere was of lesser
value. They made that determination at their
peril and to their detriment.

On George H. W. Bush’s failed vision:
There are people who even in the last
several months have asserted that all that is
necessary is for the president to proclaim a
vision and we’re on our way. I said, “You
think so?” If 1989 wasn’t a demonstration of
why that theory is wrong, then we didn’t
learn much! The articulation of a vision and a
set of goals and aspirations is insufficient
to really propel this [new initiative] any-
where. Our mantra all the way through has
been: “Here’s the direction, and here are the
dollars to carry it out.” Anything that re-
quires a leap of faith, an invention, a sus-
pension of the law of physics—any of those
things—are disqualified. Those aren’t vi-
sions, those are fantasies.

On completing the space station:
I think the scientific community thought [par-
tial completion, dubbed core complete] was
the goal, and that wasn’t what was intended.
We’re looking at something on the order of
half a dozen flights to reach core configura-
tion once we return to flight and probably 25
thereafter to assembly complete.

On “going native”:
You have to adapt to what the circumstances
require. The history of the last 2 years is at-
tention to cost consciousness. I think any
objective observer would say NASA is pro-
foundly and fundamentally different than it
was 2 years ago. If that is going native, then
it is a native instinct that wasn’t present at
this agency 2 years ago. The attitude when I
walked in the door here by most senior folks
was that something costs what it costs. I
said, No, you better have a better idea than
that—or else it’ll cost nothing, because we
won’t bother doing it. If we are going to
promulgate a policy it better be realistic, it
better have goals and objectives, and we bet-
ter have the capacity to really do it.

Low point. NASA’s Steve Altemus (right) shows O’Keefe wreckage from the space shuttle Columbia, which disintegrated 1 year ago.