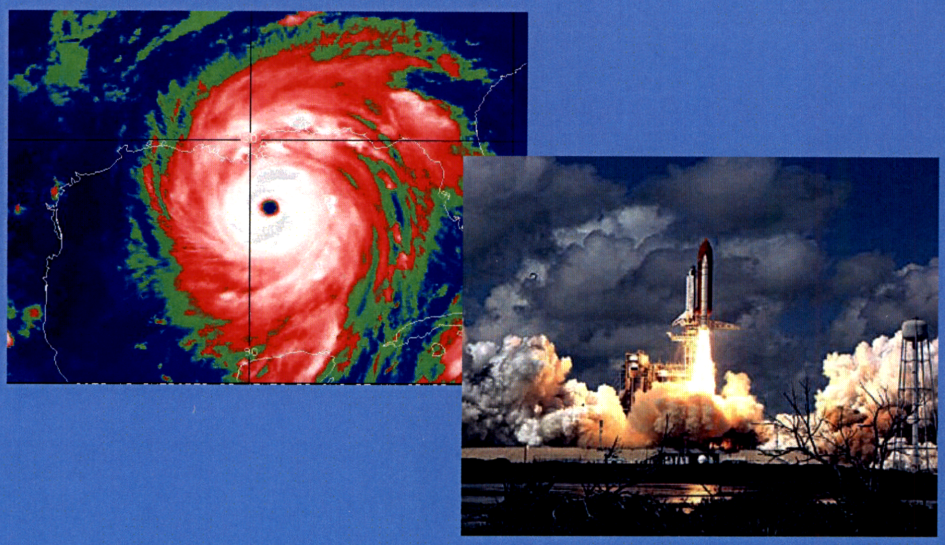
Economic and Workforce Impacts of Hurricane Katrina, Demographic and Related Changes on NASA's Space Shuttle Program:

Findings and Recommendations



Summary Report -March 30, 2007

Prepared by

Christopher T. King
Tara Smith
MaryAnn Anderson
Bryan Hadley
J. Bruce Kellison
Eliza Evans
Ara Merjanian
Andrew Stackhouse

RMC
RAY MARSHALL CENTER
for the Study of Human Resources

IC2 INSTITUTE
THE UNIVERSITY OF TEXAS AT AUSTIN

Lyndon B. Johnson School of Public Affairs
The University of Texas at Austin
3001 Lake Austin Blvd., Suite 3.200
Austin, TX 78703 (512) 471-7891

IC^2 Institute
The University of Texas at Austin
2815 San Gabriel
Austin, TX 78705 (512) 475-8900

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Launch image provided by NASA.

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At the Ray Marshall Center, Susie Riley again worked her magic, taking our disparate pieces and pulling them together into a professional report, with help from consulting editor Sally Furgeson. Karen White watched kept things running smoothly. Galen Bollinger at the IC^2 Institute assembled the survey data and provided the researchers with the requisite tables.

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Introduction

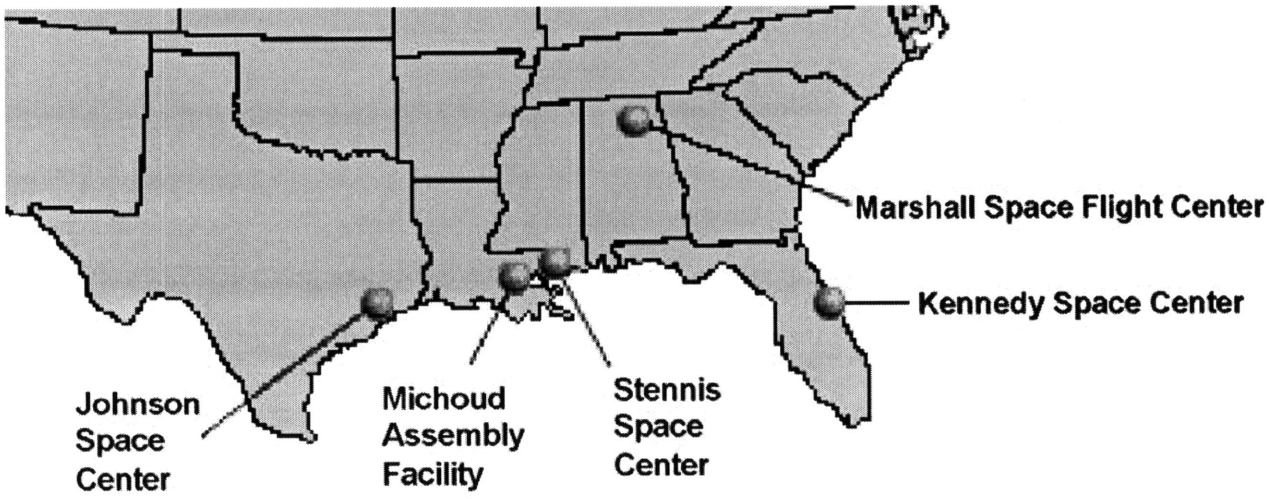
Officials with the National Aeronautics and Space Administration's (NASA) Space Shuttle Program (SSP) are concerned about potential adverse impacts of several major factors on their capacity to fly up to sixteen missions between late 2006 and the SSP "fly-out" date in September 2010. This report assesses the impacts of these factors, which include Hurricane Katrina and the aging of the shuttle program workforce, and offers findings and recommended strategies for consideration by NASA and its major contractors.

Background

Prior to President George W. Bush's January 2004 announcement of the new vision for space exploration, NASA had been working under a mission schedule that kept the shuttle active through 2012 while assessing the fleet's requirements to maintain operations through 2020. With the announcement of the Constellation Program, the shuttle's fly-out date was set for 2010. This abbreviated time horizon forced NASA to reconsider construction plans for the International Space Station (ISS), accelerating infrastructure missions and delaying or deleting logistic and scientific missions. The ISS must be completed before the shuttle's fly-out as the international research partners have specifically designed components to take advantage of the vehicle's cargo hold.

Each space shuttle mission requires months of intensive planning and implementation by highly skilled teams of scientists, engineers, production, technical, and support staff in key NASA facilities located on or near the Gulf Coast (see Figure 1). Two facilities in particular, John C. Stennis Space Center in Hancock County, MS and Michoud Assembly Facility in New Orleans East, LA, are critical to NASA's ability to continue space shuttle operations.

Figure 1. Major NASA Space Program Operations in the Gulf Coast Region



Source: NASA "Where We are Located" http://nasajobs.nasa.gov/work/where.htm

Together, SSC and MAF employ nearly 4,000 workers (see Table 1). Both facilities face serious *internal* challenges as a result of ongoing demographic changes, primarily the aging of their workforce. Because these workers are highly educated and uniquely skilled, they would be very costly to replace, both in terms of the time it would take to recruit, screen, hire, and train new workers and in the lost productivity for the shuttle program.

Table 1. NASA Space Shuttle Program-Related Employment in the Gulf Coast Region, June/July 2006

Facility & Contractor	Number of Employees	% Retirement-Eligible in next 3-5 years
Michoud Assembly Facility	2,143	
NASA Direct	6	
Lockheed Martin	2,137	40-50%
John C. Stennis Space Center	1,712	
NASA Direct	365	
Pratt Whitney/Rocketdyne	240	30%
AGT, Inc.	63	17%
Jacobs-Sverdrup NTOG	169	12%
Mississippi Space Services	617	2%
Other	258	

Source: Unpublished figures provided by NASA and SSP contractors.

MICHOUD ASSEMBLY FACILITY

Michoud Assembly Facility (MAF) is responsible for the production of the space shuttle's external tank (ET). For more than 30 years, Lockheed Martin (Lockheed) has been the prime contractor for the ET, and its employees have developed a strong commitment to the work and to the mission of the space program. Lockheed will continue to produce the ET through 2008 under current contracts. Beyond that, Michoud will play a key role in the development of the new Orion space exploration vehicle.

One of the largest employers in the New Orleans area, Lockheed has 2,137 people at MAF. Approximately 40% of Lockheed's Michoud employees are or will be eligible to retire within the next five years (Table 1). Lockheed's workforce at Michoud is split between two major age groups: 1) those hired when the Space Shuttle Program was ramping up in the late 1970s and early 1980s; and 2) those hired since 2000 when Lockheed started addressing aging workforce issues. This age division influences the commitment of the Lockheed workforce to the SSP fly-out.

Older workers, tied to Michoud by Lockheed's retirement policies, are likely to stay on at MAF unless other factors drive them out. As for the "touch" employees—approximately 600 workers engaged in the hands-on production and assembly of the ET—their union, the United Automobile, Aerospace and Agricultural Implement Workers of America (UAW), recently renegotiated their contract. Workers with fewer than 30 years at Lockheed will lose fully-covered retiree medical benefits; this may cause some to retire early, and at a lower pension, in order to ensure that they and their spouses will continue to have full medical coverage.

Lockheed assesses its workforce capacity at 90% of what is needed to fly-out the space shuttle. The company has more than 400 job postings for Michoud work, but is currently focusing on local recruiting due to the challenges of bringing in outside individuals to an area facing a severe housing shortage following Hurricane Katrina.

STENNIS SPACE CENTER

The highly skilled workforce at SSC has been involved in the testing of the space shuttle main engine (SSME) since 1975. Truly a unique national asset, the 8,300-acre center

is surrounded by a 125,000-acre acoustic buffer-zone. This zone allows NASA, Department of Defense, and other public and private organizations to test large propulsion systems at one of three test complexes with the flexibility to focus on individual engine parts all the way through to complete rocket stages. There are four SSME contractors at Stennis: Applied Geo Technologies, Inc; Jacobs-Sverdrup; Mississippi Space Services; and Pratt & Whitney Rocketdyne. In the next five years, between 2-30% of their workers will be eligible for or considering retirement.

Applied Geo Technologies (AGT)

AGT currently supports a number of operations at SSC, including SSME testing, through instrument calibration, cleaning, and repair services. AGT has held the lab services contract at SSC since 2004, operating the Measurement Standards & Calibration Lab, the Environmental Testing Labs, and the Gas & Materials Analysis Lab.

AGT employs 63 people at SSC; about half work on the metrology and calibration team. Most received their training through the military, which is slowly starting to outsource the metrology function. Currently, only five colleges in the nation have precision metrology (PMEL) programs in development; however, they are far from producing their first graduates. AGT estimates that individuals who enter PMEL occupations without military experience generally require 2-3 years of on-the-job training before they are fully productive. The typical AGT employee has been on-site at Stennis for 18 years. AGT's management is concerned that 5-10% of their workforce may leave their jobs in the next year, with Hurricane Katrina and the recovery process being a primary factor in their decision to leave.

Jacobs-Sverdrup (J-S)

An active contractor for test facility support and modifications at SSC since the 1960s, Jacobs-Sverdrup currently holds the Test Operations contract. The company's 169 on-site employees staff the NASA Test Operations Group (NTOG), which is responsible for engineering support and performance testing, as well as providing engineers and technicians for testing systems. Employees are evenly split between technicians and engineers/ engineering associates. In July 2006, about 67% of J-S workers voted to unionize, with the driving issue being wages. As part of their NASA contract, J-S salaries are based on U.S.

Department of Labor wage determinations, which did not increase in 2006 despite rising inflation and increased costs of living on the Gulf Coast.

J-S managers believe that some 12% of employees who are near retirement may soon decide to leave, though others who had planned to retire are now staying on to earn money for rebuilding their homes. J-S is concerned both about the workload at SSC during the transition from the Space Shuttle Program to the new exploration program and about employees who continue to face challenges in Katrina recovery.

Mississippi Space Services (MSS)

Mississippi Space Services, which currently holds the Facility Operating Services (FOS) contract at Stennis, was created as a joint venture of Computer Sciences Corporation (CSC) and Shaw Group's Environmental & Infrastructure, Inc. specifically for this contract, which was up for re-competition in fall 2006. The FOS contractor is responsible for a wide range of SSC activities, including infrastructure maintenance, construction, mail services, and public affairs. MSS employees are involved in SSME testing and certification processes, as well as barge operations, logistics support, and test stand and building maintenance.

Of the approximately 600 MSS employees at SSC, about two-thirds are in the International Association of Machinists union. Because it supports the whole Stennis complex, MSS has found that many of its staff are lured away by other organizations on-site, including NASA. Since the storm, MSS has had trouble filling engineering and safety positions, primarily due to the rising salary demands of job-seekers.

Pratt & Whitney Rocketdyne (PWR)

On site since SSC opened, Rocketdyne has made all the engines used in U.S. space travel. Bought by Pratt & Whitney's parent company, UTC, in August 2005, Rocketdyne has a NASA sole-source contract that was up for renegotiation in December 2006. PWR's workforce at SSC is evenly split between technicians and engineers. PWR's test engineer position requires several years of on-the-job training as there is no specific college preparation program for the profession. The current test engineer team is comprised of individuals initially trained in petroleum, mechanical, and electrical engineering.

The average age of PWR employees is 46, with approximately 30% at or near retirement age. Due to the conditions of the acquisition, the health benefits for employees

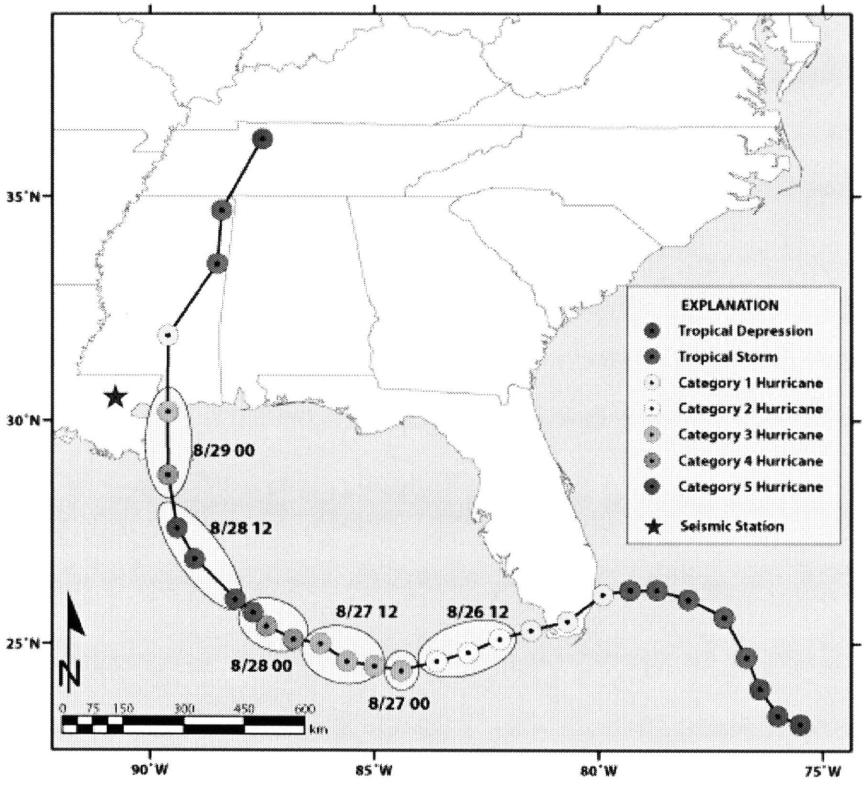
have changed considerably. Because of this, PWR's chief executive at SSC expects many workers to retire before the end of the four-year grace period in 2009.

HURRICANE KATRINA AND RECOVERY

Hurricane Katrina made landfall along the Louisiana-Mississippi border on the morning of August 29, 2005 with sustained winds of more than 125 miles per hour, a strong Category 3 storm (Figure 2). The sheer size of the storm – hurricane force winds were measured more than 125 miles from the eye, with the eye itself being more than 32 miles across – meant that communities across Louisiana, Mississippi, Alabama, and the Florida panhandle experienced significant rainfall, damaging winds and a storm surge. In all, more than 90,000 square miles were declared a disaster area.

The storm passed between the Stennis and Michoud facilities, which are just about 45 miles apart. While neither facility suffered major damage, damage estimates to both MAF and SSC total approximately $760 million.

Figure 2. Path of Hurricane Katrina



Source: University of Memphis Center for Earthquake Research and Information.

Storm surge and tornadoes resulting from Hurricane Katrina caused significant damage across the Gulf Coast region. Katrina spun out 43 confirmed tornadoes, eleven in Mississippi. In Western Mississippi, storm surge topped 24-28 feet, causing enormous damage (see Figure 3).

Figure 3. Waveland, MS Katrina Damage

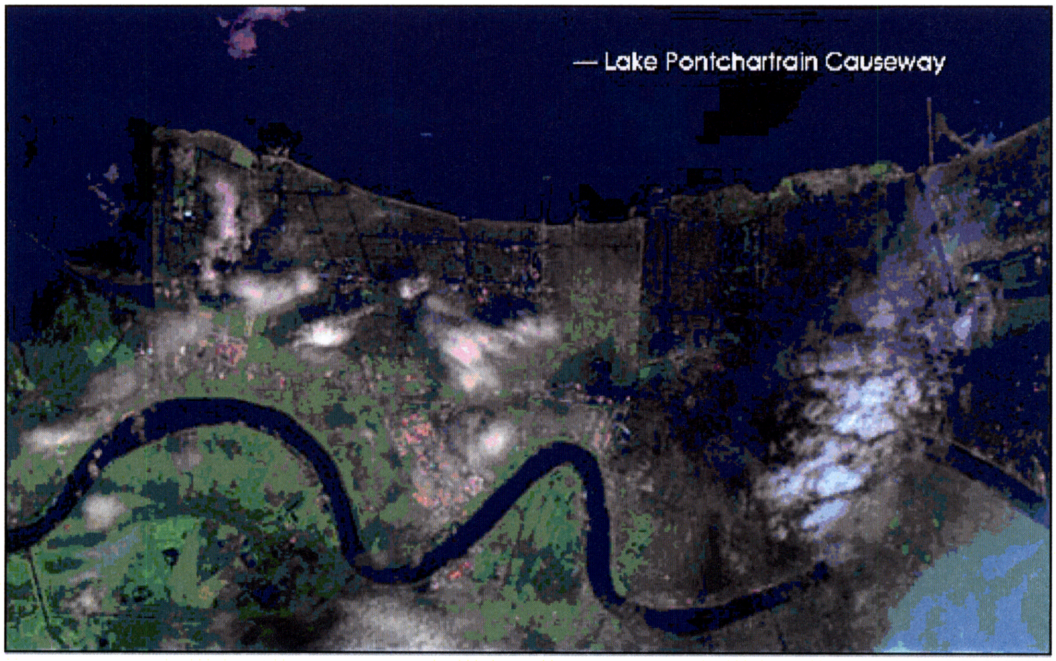
As this photo study demonstrates, Waveland, MS was a beach-front community. The top photo was taken in September 1998. In the bottom photo, the same community as seen on August 31, 2005, two days after Hurricane Katrina made landfall.

Source: US Geological Survey, "Before and After Photo Comparisons: Mainland Mississippi," in *Hurricane Katrina Impact Studies:* Washington, DC: US Department of the Interior, 2005.

St. Tammany Parish experienced a 12-16 foot storm surge; in New Orleans East, St. Bernard and Plaquemines Parishes the storm surge was estimated at 15-19 feet; and in western New Orleans the storm surge topped 10-14 feet. Following the storm's landfall,

more than 80% of the City of New Orleans was under water, in some places more than 20 feet deep, as a result of levee failures along Lake Pontchartrain (see Figure 4). While the storm surge primarily swept in and out of coastal areas quickly, the flooding in New Orleans lasted for weeks due to the failure of the levees and the breakdown of the pumping systems normally used to keep the below-sea level city dry.

Figure 4. New Orleans Flooding



August 30, 2005

April 26, 2000

In the April 2000 image, developed areas are in lavender.
In the August 2005 image, flood waters appear grey or dark blue/black.
Source: NASA, "Hurricane Season 2005: Katrina," NASA, 2005.

The destruction of much of the region's infrastructure, as well as the uncertain, protracted pace of recovery, has created difficult, and ongoing, problems for many SSP workers. More than a year and a half after Katrina, the residents of New Orleans and the surrounding region continue to face housing shortages and negotiate damage to the transportation, health care, and educational infrastructure. It is unclear how long it will take public and private actors to overcome these obstacles and rebuild the region. While residents of Mississippi have faced fewer recovery barriers in terms of protracted flooding and governmental indecision, they are still struggling with rising costs of living, the hassles of insurance settlements and bureaucratic red tape in obtaining the money they need for recovery. Residents across the region struggle daily with the ongoing toll of reconstruction efforts on numerous fronts: roadways, retail stores, public services, recreation sites and more. The status of the economic and physical infrastructure of the Gulf Coast will factor heavily in the ability of NASA to meet its goals for SSP by September 2010.

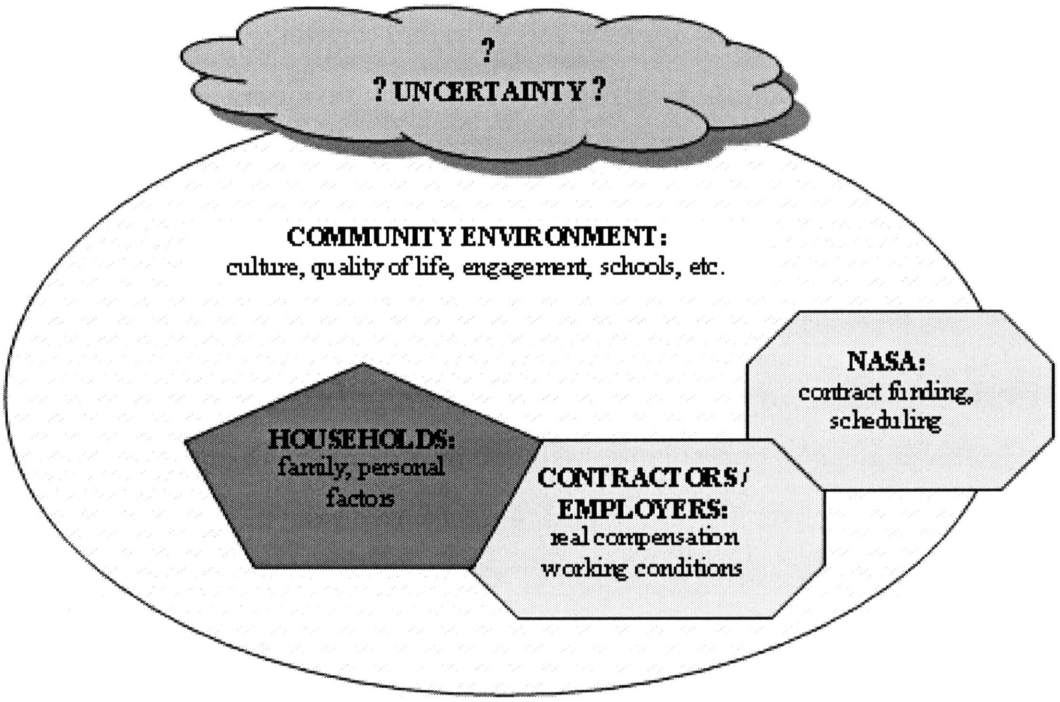
Study Approach

Katrina and its effects, the aging of the SSP workforce, as well flight scheduling pressures, contracting and management practices, and continuing uncertainty over the details of future space exploration and contractors' roles in it, all may adversely affect the ability of NASA's Space Shuttle Program to accomplish its mission between now and fly-out in September 2010. NASA turned to researchers at the University of Texas at Austin[1] to conduct an independent analysis of these factors and their effects on the shuttle program and develop recommend strategies for addressing identified issues.

The analysis derives from a conceptual model of the factors affecting NASA/SSP workers and their families (Figure 5), in which households, as the principal decision-making units, are influenced by a series of major factors including working conditions and compensation, family/personal factors, and community/environmental factors.

[1] Researchers at Texas A&M University's Mays Business School studied these issues independently. At NASA's request, the teams collaborated on surveys of NASA contractor employees and their spouses to avoid excessive staff burden.

Figure 5. Conceptual Model of Household Decision-Making



While some of these factors are within the household's control (e.g., assets/liabilities, whether the spouse works outside the home), many others, such as compensation and working conditions, as well as whether key groups of workers will be employed at these facilities in the future, are under the control of NASA and its contractors. Other factors, like the pace and extent of recovery from Katrina, depend to a large extent on the efforts of the community and its elected and civic leaders.

At any given time, one set of factors may emerge as more important in the household's decision-making. For example, in the aftermath of Hurricane Katrina, with growing uncertainty over the recovery of their communities, workers and their families may come to value family and community factors, including an attachment to the area and its cultural traditions, more highly than compensation and working conditions. For workers in their 40s, 50s, and 60s with job- or firm-specific skills as well as substantial debt (e.g., mortgages), attachment to the workplace may become that much greater and may overwhelm community/ environmental factors. Uncertainty over the future of their employment—especially their future role in NASA's space exploration program—may also affect their decisions.

UT researchers established three parameters for this analysis:

- A *time period* of 2006 through September 2010.

- A *focus primarily on Michoud and Stennis* and their roles in the manned space flight program. Developments in closely related *programs, related sites*, and the *contractors* themselves have been considered as well. UT researchers conducted parallel interviews and focus groups at Marshall in order to "benchmark" NASA and contractor employee experiences and concerns.
- A focus on the *contractor workforce*, since NASA employees represent only a small fraction of the total workforce at these two facilities, and NASA has more direct control over working conditions and retention incentives for its own workers.

The analysis draws on the following data sources:

- Extant data on the nature of work, community, and related factors in the NASA facilities and the surrounding area, and how these factors have been changing before and since September 2005, have been assembled and synthesized.
- In-depth interviews with NASA and contractor administrators and staff, as well as with union, government, community, business, and education leaders to obtain their views regarding the internal and external factors affecting workers' decisions.
- Focus groups with contractor staff to learn more about the issues affecting NASA's contract workforce and to tailor the in-depth surveys of workers. The UT team conducted a total of thirteen focus groups with 109 individuals at the Marshall, Michoud, and Stennis facilities.
- Surveys of NASA's contractor employees to gain detailed knowledge of the external (e.g., Katrina-related) and internal (e.g., aging workforce, retirement) factors affecting their decisions about remaining with the SSP program, as well as possible actions by NASA, its contractors, and others that would induce them to remain at work through mission fly-out. Some 1,497 workers at MAF and SSC participated in at least one part of the survey, including 51% of Lockheed's Michoud workforce and 48% of the AGT, J-S, and MSS workforce at Stennis.

Analysis of these data involved several key steps, including establishing employment requirements by facility and contractor; making "softer" judgments about the likelihood of key events and factors affecting workers and their households (e.g., poor housing, inadequate Katrina recovery, loss of contracts); and determining the likely effects of key factors on shuttle program employment requirements using system dynamics models. Once these factors were understood, researchers estimated deviations from the employment requirements under various simulations and articulated recommended strategies to be implemented by NASA, its contractors, and other key actors. This brief is drawn from the 2007 final report of this study *Economic and Workforce Impacts of Hurricane Katrina, Demographic and Related Changes on NASA's Space Shuttle Program: Findings and Recommendations.*

Key Findings and Impact Assessment

The findings presented here offer a compelling story of great adversity and challenges tempered by perseverance and adaptability in the wake of Hurricane Katrina. They also highlight workforce and workplace trends that existed prior to, and continued after, Katrina. One of the major findings is the strong attachment to community and longevity with and dedication to the Space Shuttle Program, the facilities, and specific employers/contractors. This has prevented greater losses through attrition and disruptions in the program than might have been expected or experienced in another setting. Still, the continuing effects more than a year and a half after Katrina are cause for major concern and will require thoughtful action to mitigate their adverse impacts.

Context Overview

Prior to Katrina, MAF and SSC faced the daunting challenge of Return to Flight, a compressed production and testing schedule, an aging workforce, a changing contractual and competitive environment, and the end of the space shuttle program. In addition, the program has evolved in an absence of and dissociation from an innovation system that typically supports complex, high-performance enterprises like SSP through the provision of technological and process improvements and an appropriately skilled workforce.

For decades, the contractors and workers at MAF and SSC have enjoyed a high degree of revenue and job security without having to adopt an aggressive market orientation. The issue is particularly pronounced at MAF, where one company, Lockheed Martin, essentially has produced one product for one customer for nearly 30 years, and that customer's needs are now undergoing a significant change. By their own admission, contractor employees at both facilities have only recently begun to appreciate that their job security depends at least in part on the generation of new business. This increasingly market-oriented stance, although good for contractors and their employees in the long term, strains the short-term requirements of the SSP. Employees worry that they lack skills that can be rewarded internally or transferred to other employers, increasing their anxiety about remaining with a program that is unlikely to carry many of them through to retirement.

Compounding these challenges is the aerospace industry's lack of critical mass to attract more technologies, businesses, and talent to the Gulf Coast region to create a sustainable, mutually reinforcing environment with sufficient churn of ideas, revenue, and people to support SSP and related NASA programs. Perhaps related to this, NASA and its contractors have not forged strong relationships with regional education and workforce systems. Without these relationships, there is no local pipeline for new, skilled workers and few resources for the professional development of current workers.

The interaction of these trends, the local innovation context, and a compressed timeframe had the following consequences for the pre-Katrina SSP: significantly greater productivity requirements, particularly for Return to Flight, with little or no inflow of new talent. To reach the productivity levels required from an already thin workforce means the SSP depended on more work from the same pool of people, using the same tools to produce products that must perform flawlessly.

The principal means employed to accomplish program goals to date have been compulsory overtime, uncompensated overtime, discouragement of accumulated leave-time use, and willing contributions of workers' time due to good will and strong personal commitment to the SSP mission. Hurricane Katrina has had obvious negative consequences for this delicate but serviceable arrangement.

These issues will not be resolved by the time the SSP program is completed in 2010. However, they have significant implications for the success of the mission. Despite significant efforts put forth by NASA, contractors, and employees to fulfill the SSP mission, Katrina continues to stress many, if not all, of the systems on which the mission depends, leaving only limited fault-tolerance.

Findings

NASA/Contractors

Production Schedule and Work Organization Issues. To meet the revised launch schedule precipitated by the 2010 fly-out deadline, an aggressive ET production schedule has been put in place at Michoud along with an accelerated SSME testing schedule at Stennis. Several issues arise from this situation:

Schedules require overtime on a regular basis: 65% of Michoud and 45% of Stennis survey respondents report a usual Work-week of more than 40 hours. Some groups are affected disproportionately (e.g., foam sprayers).

For a period following Hurricane Katrina, the new production schedule called for external tanks to be shipped to Kennedy Space Center for completion, requiring a cadre of Michoud workers to be detailed to KSC for 60-day assignments. This practice has since ended.

> *"Rigid schedules do not allow a balance between work and personal time…Life post-Katrina has been a never-ending maze and there just never seems to be enough time to accomplish what is required, both professionally and personally."*
>
> **Michoud Survey Respondent**

Schedule pressure is contributing to worker stress and may present safety challenges.

Mandatory overtime and off-site details have made it hard for employees to manage the demands of home rebuilding and repair as well as of day-to-day life in hurricane-affected areas. These factors will be an issue for individuals for the foreseeable future, as many have yet to start rebuilding due to the slow release of funds through Louisiana's Road Home Program and the difficulty in finding contractors.

Program/Contract/Job Uncertainty. The imminent termination of the SSP and the transition to the new Constellation Program creates uncertainty about future job prospects. Further, incomplete communications about the Program and the impacts on and options for employees also hampers employees' ability to process and plan for the changes.

Only half of Stennis and 57% of Michoud survey respondents report feeling secure in their jobs (Figure 6).

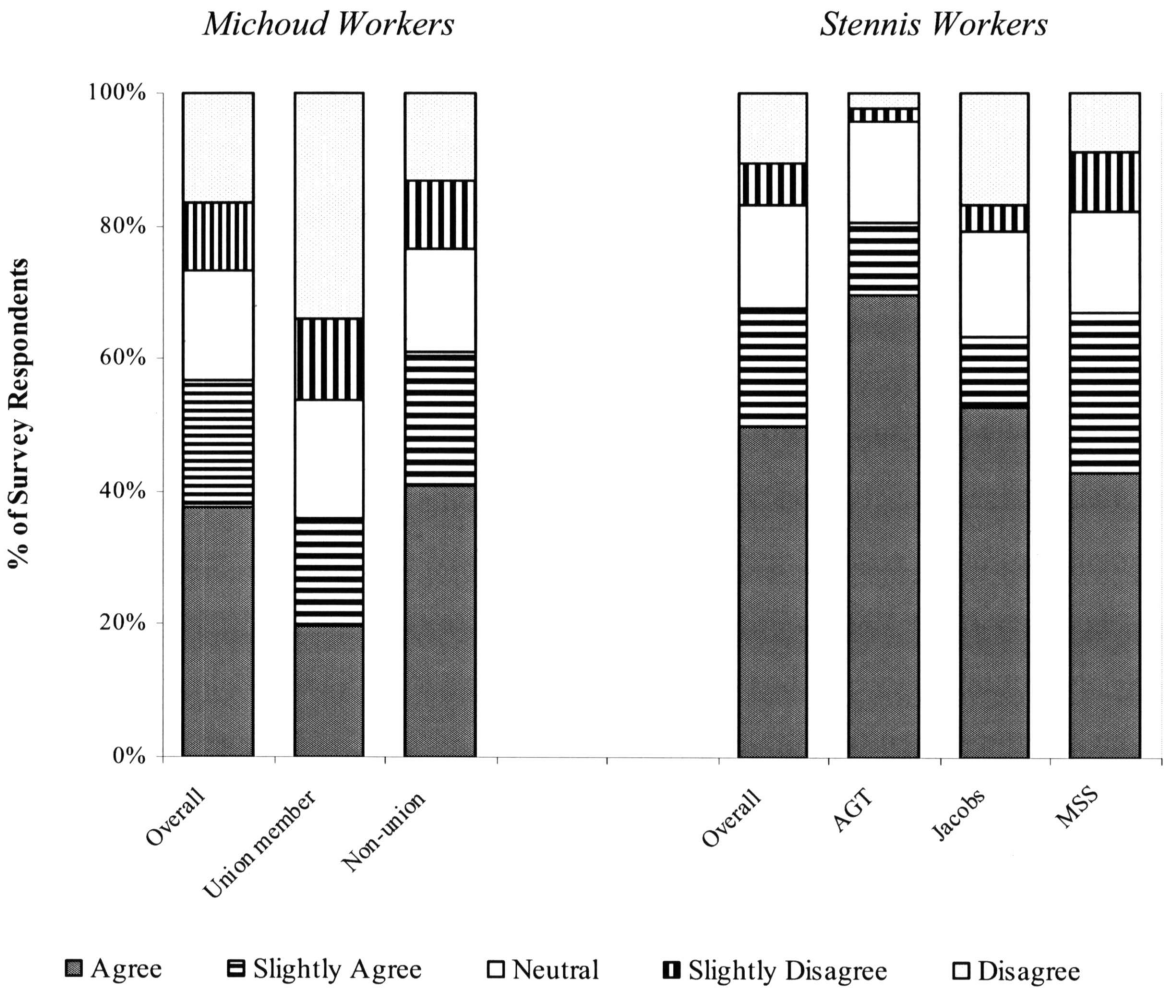
Only 37% of Stennis and 42% of Michoud employees agreed that the contractors provided timely communication about projects and contract status (Figure 7).

In the short term, workers expressed concern about organizational changes, which may disrupt the workflow and their employee benefits as contracts are/are not renewed. In both the focus groups and surveys, respondents suggested implementing a site-based

insurance and retirement benefits scheme to provide continuity during program and contractor transitions. Employees need assistance in translating general information about the SSP and Constellation Program into more specific contractor/job-related information.

Figure 6. Survey Response: Job Security

"I am secure in my job."



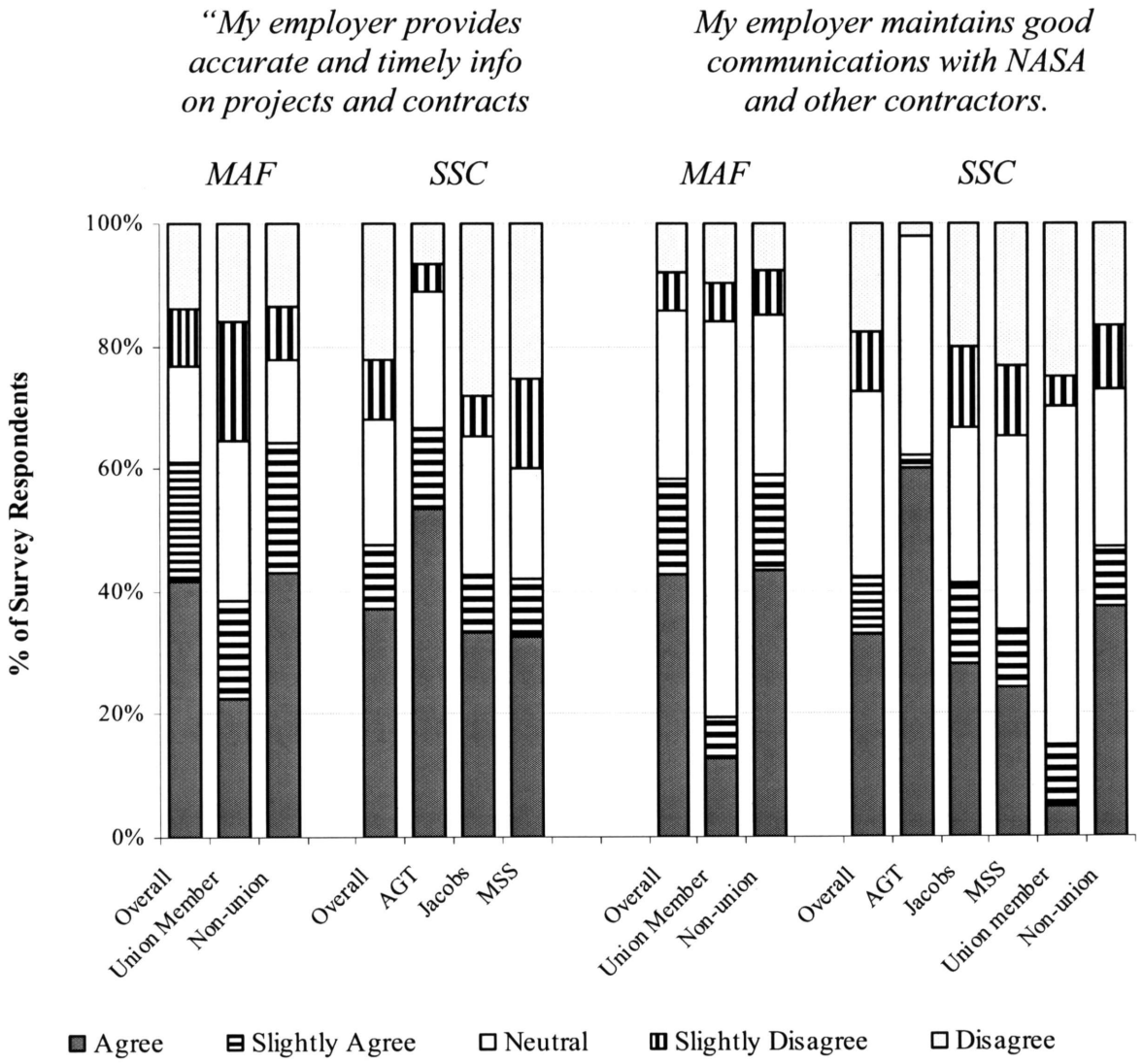
Paperwork, Bureaucracy, and Communication. Employees understand the need for and the value of a well-documented process and clear, formal rules for public accountability. However, in many cases, governmental requirements were described as redundant, contradictory, constantly changing, or otherwise hampering efficient completion of the work.

Several noted that paperwork consumed a major portion of their Work-week.

Only 33% of SSC respondents and 43% at MAF agreed that there is good communication with NASA and other contractors (Figure 7). Such gaps have caused false starts and delays.

Many employees noted that personnel changes at NASA have resulted in a lack of understanding of key systems and relationships and have interrupted or delayed critical decisions and work processes. Coupled with the multiple layers of bureaucracy required to make and interpret decisions and authorize work, these conditions can impair efficient project management and mission effectiveness.

Figure 7. Survey Response: Communications



Compensation. In the focus groups, workers at the two facilities reported being generally well compensated. However, only 29% of Stennis and 30% of Michoud survey respondents reported being well compensated relative to their performance. Even hourly workers noted problems with the adequacy of wage scales in many occupations, though they believe individuals often are not hired at a high enough level within the scale to attract and retain new workers. Focus groups highlighted several additional issues:

> *"The fry cook at Sonic makes $12.50 an hour. My paycheck doesn't look as strong as it did when that guy was making minimum wage."*
>
> **Stennis Focus Group Participant**

Current market conditions and the high cost of living are eroding effective salary and wage rates and will likely affect retention and recruitment.

Overall, nominal wage rates in the region have increased, and select employers have made adjustments to salaries.

Although NASA has, in many cases, recognized the cost overruns in construction and repairs, adjustments to staff salaries have not been forthcoming, notwithstanding recent cost-of-living and other increases.

Respondents noted that these recent increases were either not available to all employees, based on dated performance ratings, and/or otherwise inadequate in the current market.

Workforce Development. In part because of NASA's contracting structure at SSC and MAF, neither NASA nor its contractors have fully exploited ongoing workforce development opportunities on-site or in the region. The exigencies of the SSP production and launch schedule have also forestalled meaningful transfer and integration of innovative processes in many components. Few postsecondary institutions or workforce centers in Southern Mississippi or the New Orleans metropolitan area reported ongoing projects or communications with MAF/SSC contractors about the specialized skills demands or training options for new/incumbent workers.

The future of NASA programs in the Gulf Coast region depends on contractors having a coherent workforce development strategy, in partnership with NASA and local/regional workforce entities.

Contractors lack comprehensive recruitment efforts and the "pipeline" for providing such workers in the long term is inadequate.

In combination with the short-term manpower and training issues identified below, employers will need to work with regional partners to establish a coordinated and comprehensive workforce development approach for long-term success.

Time and funding for pre- and in-service training for the MAF and SSC workforces, and limited career advancement opportunities in the face of increased job demands and responsibilities, make internal cultivation of an appropriately skilled workforce challenging.

Manpower, Workload, and Productivity. The SSP enjoys a very skilled and motivated workforce performing unique functions. However, this is a potentially depleting asset due to a number of factors:

Respondents noted "thin" staffing levels or outright shortages in critical or "single-point failure" positions and tasks in the short term. The case of foam sprayers at Michoud is illustrative. Workers noted that this critical function is performed by a small number of individuals working in highly specialized teams, many of the members of which are currently suffering from Katrina-related dislocations. This situation makes the tasks they perform subject to failure or significant delays with little ability for short-term recovery.

Katrina has disrupted the supply of workers through attrition, but the issue is broader than Katrina. Current contracts limit the contractors' ability to hire sufficient workers and they are reluctant to hire workers or seek contract modifications because of concerns over competition and costs. Of survey respondents, just 18% from Michoud and 21% from Stennis believe their employers are staffed sufficiently to complete the SSP mission (Figure 8).

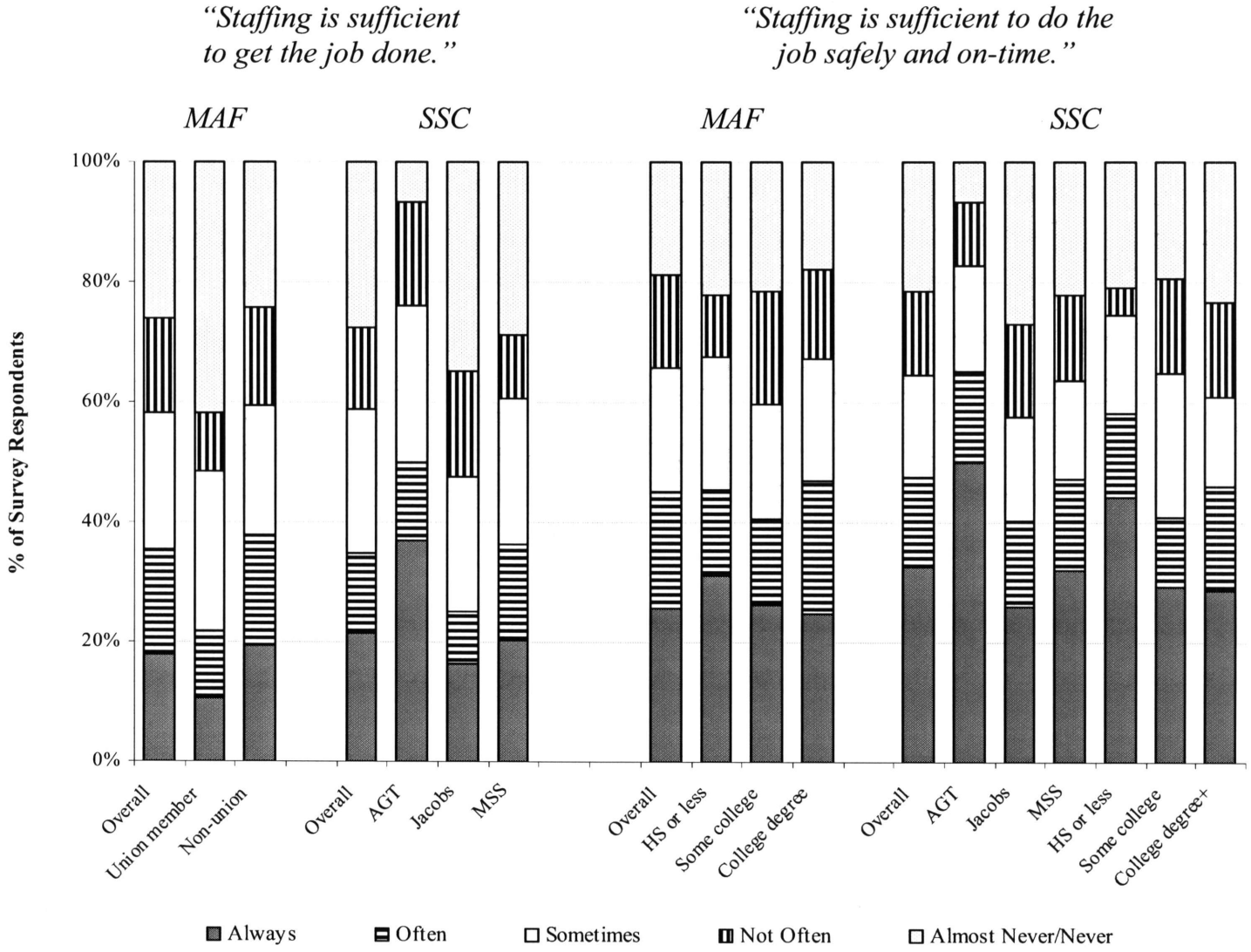
These issues have manifested themselves in production backlogs, mandatory overtime, constant on-call status, and time away from home to be on-site at KSC. This is causing workplace stress and potential safety lapses for workers who are also tired and preoccupied with home reconstruction concerns.

Respondents noted that they do not always have up-to-date equipment and technology or adequate facilities in certain areas, and basic equipment (e.g., computers, telephones) for new employees is often insufficient.

Preventative and corrective maintenance is often lacking and needed repairs delayed. It was noted that even needed, recognized, and funded repairs cannot not always be completed because of the dictates of the production schedule.

Although exacerbated by the hurricane, many of these factors were a concern prior to Katrina, in part due to an environment where cost control and speedy Space Shuttle component delivery are the focus. While understandable, these imperatives are affecting the morale and productivity of incumbent workers and can hurt retention and recruitment efforts.

Figure 8. Survey Response: Staffing Levels

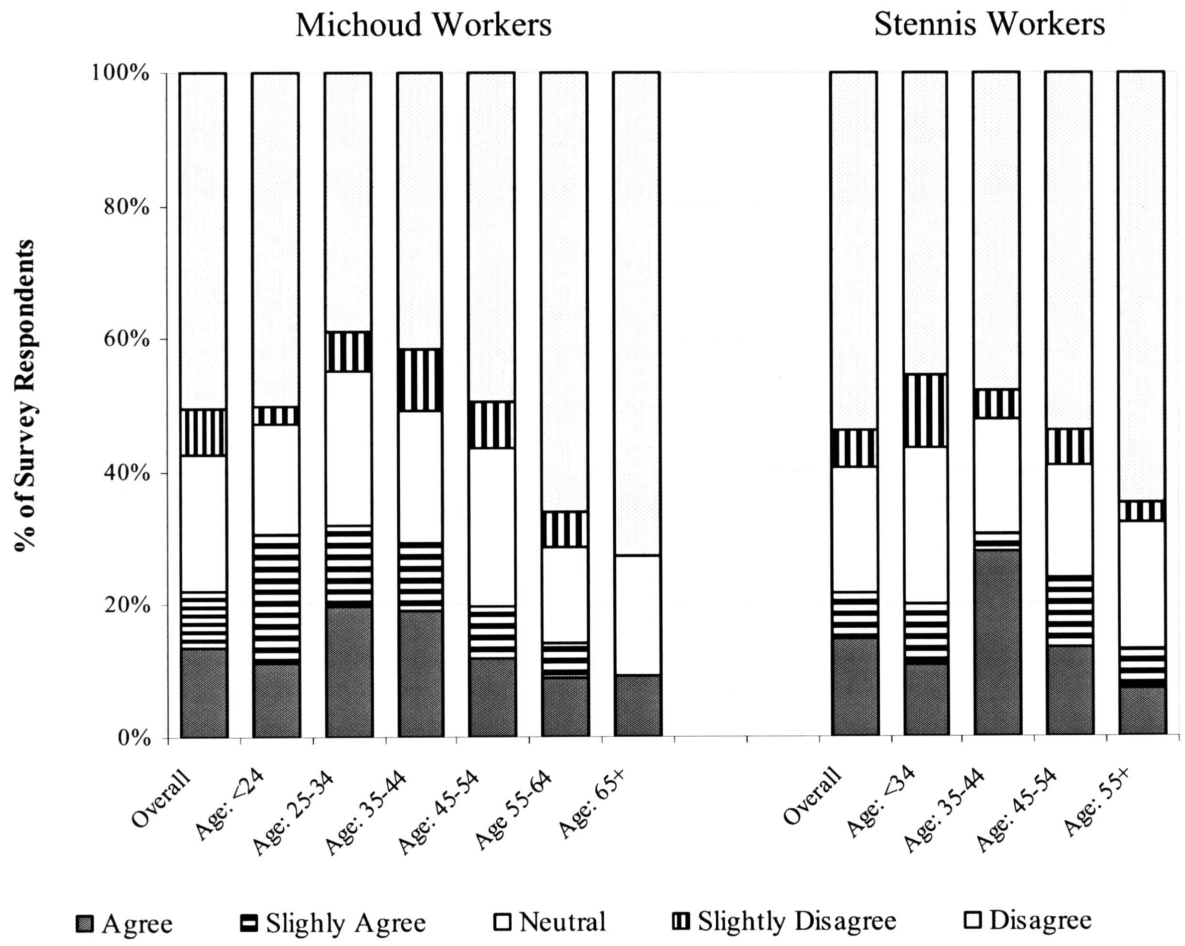


Fatigue and Morale. In addition to the concerns associated with changing benefits, many respondents noted that sick and leave-time policies are often unfair or unrealistic, inconsistently applied, and/or require further flexibility. Employees were very grateful for the forbearance and flexibility that allowed them to maintain their income stream and attend to personal business immediately after Katrina. However, many face continuing personal disruptions and require ongoing flexibility for the foreseeable future to reduce workplace stress and turnover.

Nearly a quarter of MAF and 18% of SSC respondents report being "burned out from work" often or very often. Overall work satisfaction at Michoud has declined to 34% from a pre-Katrina level of 45%. Work satisfaction at Stennis declined much less, from 57 to 52%. Nearly a fifth of Michoud workers and 14% of Stennis workers report searching for other work on a weekly or even a daily basis. Almost 30% of respondents age 35-44 at Stennis and almost 20% at Michoud say that they will likely seek a new job in the next year (Figure 9).

Figure 9. Survey Response: Job Search

"I will probably look for a new job in the next year."



Safety. The issues identified in previous sections all have potential adverse impacts on workplace and Space Shuttle safety. Respondents noted the pervasive disruptive effects of the Columbia disaster and the time and effort devoted to the subsequent/ongoing investigation and redesign. Many expressed concern that necessary actions and investments in equipment, training, and compliance have not been made. An independent review of workplace accident/injury rates, workers' compensation claims, or the overall safety profile of the Program is not part of this report, but it is an issue that merits further review.

HOUSEHOLDS

Continuing Effects of Katrina. In the focus group sessions, at least half of the participants noted significant housing issues, ranging from the entire or partial loss of their homes, to continued dislocation, to scarcity of affordable temporary and permanent housing options for incumbent workers during the reconstruction phase as well as for new employees. These findings are corroborated by the results of the survey in which 57% of Michoud respondents and 54% of Stennis respondents reported homes with significant or major damage.

Many of these workers have family members who still reside outside of the region. Uncertainty surrounding the recovery and reconstruction of housing, schools/day care centers, businesses, roadways, and other critical public, private, and governmental infrastructure continues as the major overall factor affecting employees. Even those employees who did not experience a loss of home or property and related dislocation are affected by the community and workplace factors. These factors are affecting the facilities' ability to recruit new workers to replace those who have left or will leave due to retirement and other exigencies.

Respondents recounted harrowing stories of the hurricane and its immediate aftermath. They expressed gratitude for the job they have and the support they have received from NASA and their employers. Most exhibited noteworthy resilience and determination to rebuild, remain with the Program, and be productive workers. However, a year and a half after the storm, many, perhaps most, workers still face significant obstacles to normalcy:

- shortages of livable housing for ownership or rental at affordable prices

- lack of reliable and reasonably priced contractors, materials, and supplies to complete reconstruction
- lack of other business, household, and personal services
- lack of schools and day care options
- lack of, inadequate, or high cost of property, auto, or health insurance
- lack of significant blocks of time required to commute, resettle/re-employ family members and attend to children and the elderly, meet with construction/ remodeling contractors, address insurance and financing challenges
- overall high cost of living
- crime
- lack of critical public and governmental infrastructure and services
- hassles with FEMA, SBA, state and local requirements, and other governmental entities
- lack of recreational and social amenities
- lack of medical and mental health services

> *"I haven't skipped a beat in doing my work for NASA after the hurricane, but I believe that in trying to rebuild my entire life outside of work…it's probably larger than most people can handle. I'd appreciate a little help."*
>
> **Stennis Survey Respondent**

With significant recovery challenges in their personal and community lives, workers at both facilities reported large drops in overall life satisfaction. At Stennis, the percentage of workers reporting being satisfied or very satisfied with life before the storm was 88%. Post-Katrina evaluations dropped to 63%. At Michoud, the drop was even more dramatic: 83% reported overall pre-Katrina life satisfaction, but only 47% reported being satisfied or very satisfied after the hurricane. Individuals' own pre- and post-Katrina assessments of their physical and mental health also dropped precipitously.

> *"After Columbia, we'd go home to escape work. After Katrina, we go to work to escape home."*
>
> **Michoud Supervisor Interviews**

These experiences are having a profound and possibly lasting effect in terms of personal/family stress, fatigue, and fear, burnout, and health impacts and are undoubtedly

having, and will continue to have, residual effects on work performance. It is important to note:

EAP staff at both facilities continue to counsel employees and caution that these stresses traditionally become even greater about a year after the event

For many workers and their families, rebuilding is just beginning, thus the stress of balancing work and family time will be worse in the coming months.

The interplay between these factors and the effects of the production schedule noted above is a variable that must be fully understood and weighed carefully in Shuttle Program decisions. The issues identified in this section are inextricably linked to and overlap with those discussed in the Community Environment section.

COMMUNITY ENVIRONMENT

Transportation Challenges and Commute Times. Transportation challenges continue to affect commute times and, ultimately, workers' stress and time available to complete personal and work-related functions. Many workers still live in areas geographically more dispersed than before Katrina, as far away as Baton Rouge, Gulfport, or Hattiesburg. More than half (54%) of MAF employees report longer post-Katrina commute times, compared to only 16% at Stennis. This finding could be a function of the relative isolation of the Stennis facility and the likelihood that commuting times will be considerable no matter where the worker lives or relocates. With "time" at such a premium for employees, effective management of transportation challenges and commuting times can have a significant positive impact on worker productivity.

Michoud-area Redevelopment. Many workers at Michoud remarked in focus groups, interviews, and surveys on the poor conditions of the surrounding community. The area around Michoud was hit hard by Hurricane Katrina, with flooding estimated at nearly 20 feet. Since the storm, few residents and few restaurants, child care, or other services have returned to the community. The roadways to Michoud are potholed and in places still littered with debris. Workers reported feeling less secure because of higher crime rates and greater isolation. As NASA and the Michoud/Stennis facilities are vital to the regional economy, efforts to leverage more rapid redevelopment may be warranted to improve retention.

Modeling the Impact of Hurricane Katrina and Other Factors on the Space Shuttle Program at Michoud and Stennis

A simulation model was developed to assess the possible ramifications that Katrina and other factors might have on the successful completion of the Space Shuttle Program. The model was built using Vensim simulation software, which is based on system dynamics methodology. System dynamics is an approach to understanding the behavior of complex systems over time. It models the feedback loops and delays that exist in any complex system. Through simulation, a dynamic system can be modeled and the behavior of that system studied under different external scenarios, allowing the impacts of different policies on system behavior to be examined.

The model focused on the "burnout dynamics" that occur when a workforce is subjected to extended overtime and excessive fatigue. SSP workers have endured excessive non-work-related fatigue as a result of Katrina, in addition to the stress resulting from the aggressive work schedule needed to meet Return-to-Flight requirements and the new fly-out deadline. The purpose of the model is to see how these factors influence the completion of the remaining shuttles. Different policies were tested to quantify their impact on the shuttle program. The assumptions and logic of the model are supported by interview, survey, and focus group findings regarding fatigue related to Katrina recovery and fatigue related to production schedule, Return-to-Flight, and fly-out.

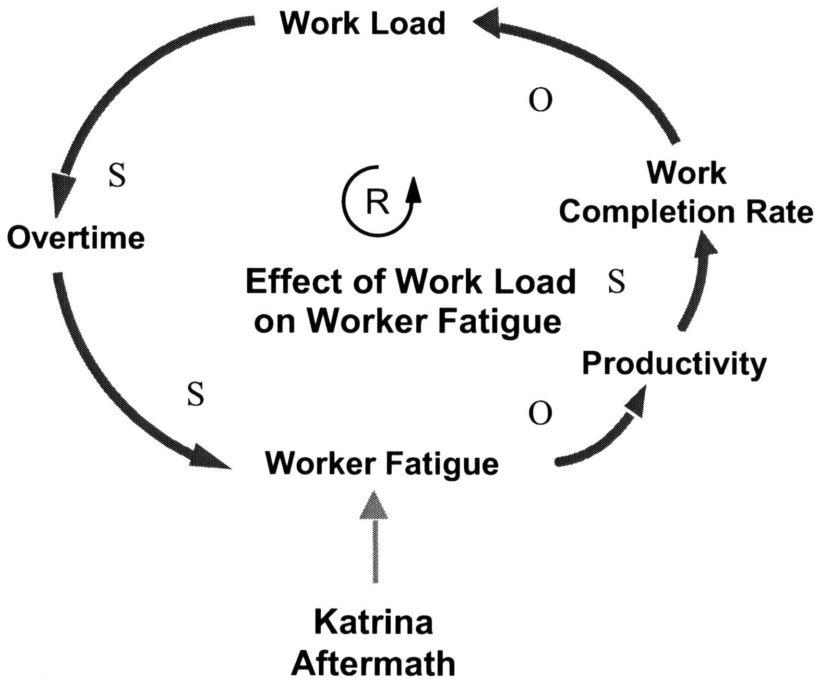
Model Dynamics

The two models presented in this section performed well in terms of capturing system behavior in the simulations. Figure 10 illustrates the primary dynamics of the simulation with a causal-loop diagram. Each arrow represents a causal link between two variables. In this case, it is assumed that Katrina caused a significant increase in *worker fatigue* as the workers try to put their lives back together in a far more stressful living environment. This increased *worker fatigue*—although not directly work related—leads to a decrease in *productivity*. Thus, the arrow is labeled with an "O" next to it, representing a move in the opposite direction. In contrast, an "S" label next to an arrow indicates that the two linked

variables always move in the same direction, e.g., a decrease in *overtime* decreases *worker fatigue.*

Any drop in *productivity* will decrease the *work completion rate*, and, in turn, increase the *workload.* In order to meet the planned flight schedule with current staffing levels, *overtime* will be necessary at both MAF and SSC, leading to an even greater loss in *productivity.* This is commonly called a reinforcing loop (notated in the diagram by an R in the center of the loop enclosed by a circular arrow): any increase in *worker fatigue* ultimately reinforces itself, leading to even more *fatigue.*

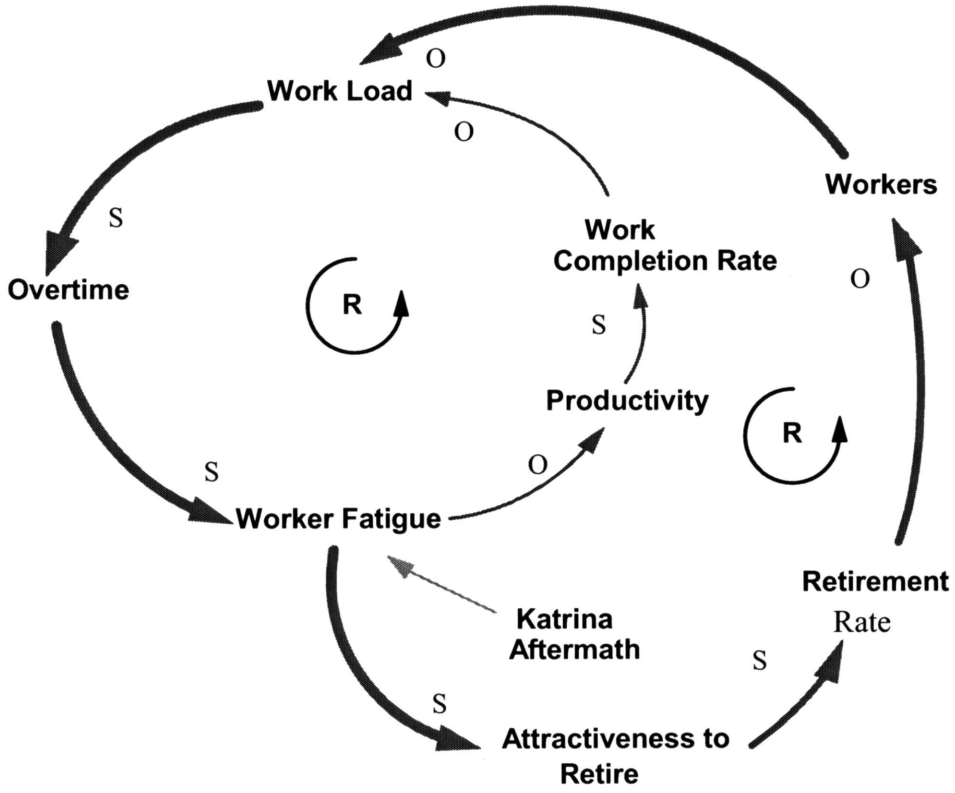
Figure 10. The Effect of Worker Fatigue on Productivity



Another factor threatening the flight schedule is the number of experienced workers who may retire before completion of the program. As indicated in Table 1, the shares of the Space Shuttle Program workforce in these facilities that is retirement-eligible in the next 3-5 years is substantial, ranging from a low of 2% to around 50%. Katrina has likely made this an even more critical issue as illustrated in Figure 11, in which increasing *worker fatigue* may in turn increase the *retirement rate* as workers choose to retire earlier than otherwise planned. Such an increase eventually decreases the number of workers, which increases the

workload on the remaining workers. Because this leads to even more *worker fatigue*, another reinforcing loop is created. It is important to point out that the retirement rate could have an impact on the production schedule even without the Katrina effects. When experienced workers leave as they become eligible for retirement, they place an increasing burden on the remaining workforce, which, in itself, will increase the fatigue of those remaining and negatively affect their productivity. This simulation is investigated in the simulations presented below.

Figure 11. The Effect of Retirement on Productivity



Although the model primarily considers the age structure of the contractor workforce, retirement decisions are influenced by more than age or other eligibility factors. *Pull factors* may include negative impacts that Hurricane Katrina may have had on family finances. Some employees reported having their retirement savings wiped out by the cost of rebuilding their homes, which would lead them to work well past their planned retirement dates. *Push factors* include the uncertain contracting environment that puts into question the viability of

retirement benefits should the worker have to change employers in order to remain with the Space Shuttle Program or continue working on another NASA project. Continued quality-of-life challenges in the region also enter into employees' job-changing and retirement decision-making as push factors.

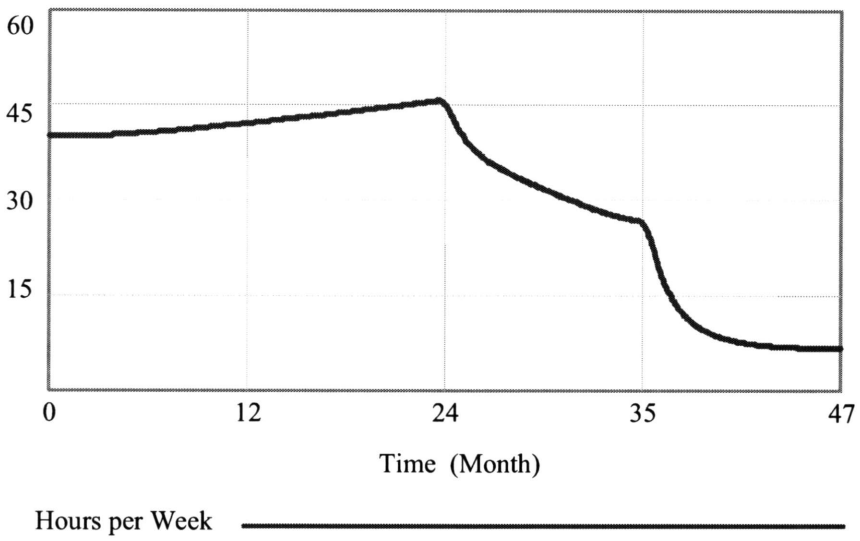
Simulation Results

The model was simulated using a production schedule of five space shuttles each in 2007 and 2008, four in 2009, and two in 2010. The model does *not* provide a point prediction of the Space Shuttle Program's performance but instead shows the anticipated behavior of the system given the accuracy of the available data and underlying assumptions.

Baseline Program Performance

The model was simulated to test the program's performance without the effects of Hurricane Katrina. It was assumed *that the current workforce could meet the production schedule of five shuttles in 2007*, although this assumption could not be empirically verified. The model also assumes that experienced workers are replaced with new workers as they retire, but that the new workers' productivity is reduced by 15% until they become fully trained after three years, an effect derived from both the productivity literature and estimates provided by contractor human resource directors. As is illustrated in Figure 12, the hours per week needed to keep the program on track according to the current flight schedule in the simulation reaches a maximum of 46 at month 23; that is, 23 months after the beginning of 2007 or near the end of 2008. When the number of shuttles per year decreases at month 24 to four per year, the required number of hours significantly decreases, and overtime is no longer required for the duration of the program. In fact, some reduction in workforce after month 23 could be facilitated without consequences for program timing. Again, these results are highly dependent on the assumption that current contractor capacity could support five shuttles per year, an aggressive schedule compared with production in the recent past.

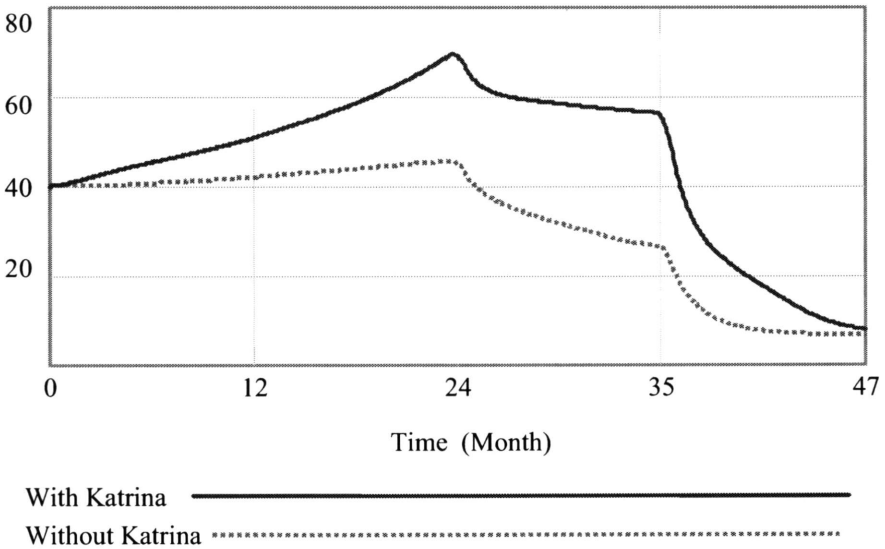
Figure 12. Simulated Average Work-week without Fatigue Effects



THE HURRICANE EFFECT

The model was then simulated to test the effects of worker fatigue caused by Hurricane Katrina and the continuing recovery efforts. Although the actual loss in productivity caused by fatigue could not be determined, a conservative estimate of 10% was used. As Figure 13 shows, the resulting loss in productivity greatly increases the need for overtime in the contractor workforce. The peak demand for labor is 72 hours per week, which occurs just before the shuttle demand decreases to four missions per year. As can be seen from the graph, significant overtime will be required into 2010, the final year of the Shuttle Program.

Figure 13. Average Work-week with Katrina Effects



Impacts of Policy Changes

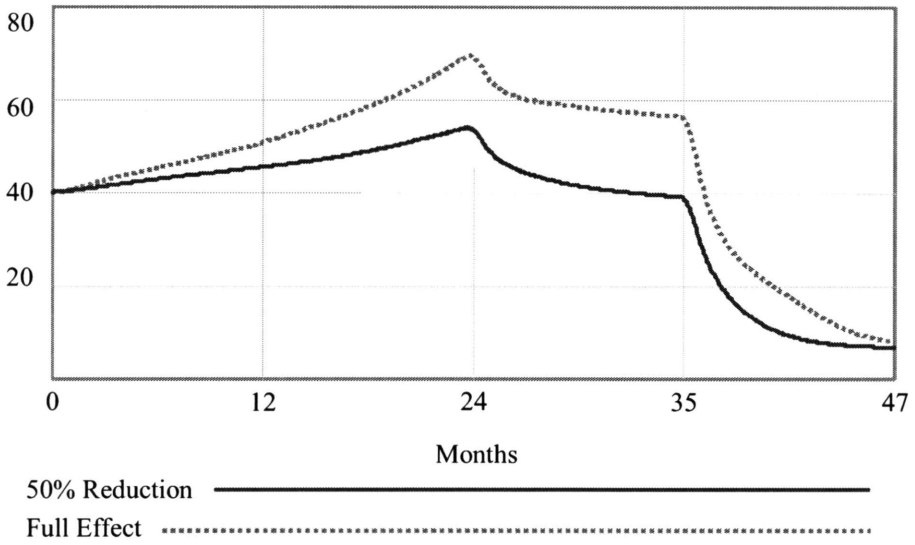
NASA, its contractors and other influential actors can intervene by changing their policies and practices, of course. Several policy changes were tested to quantify their potential impacts on system performance. While reducing the employees' external fatigue can improve program performance, NASA's and contractors' influence over the factors creating external fatigue may be insufficient to materially change productivity. Two leverage points that can be addressed, however, are:

- reducing the rate at which experienced employees retire, which both NASA and contractors can accomplish; and
- modifying the shuttle schedule, which only NASA can do (presumably in consultation with Congress).

Effect of Reducing External Fatigue

The data available do not provide insight into how policies altering workers' external environment will reduce this fatigue. Because of the lack of dynamic data, i.e. the change in external fatigue over time, the model has been simulated assuming that actions were taken to reduce their external fatigue and that this decrease in fatigue was present throughout the entire simulation. As illustrated in Figure 14, this action reduces the maximum workload requirement to 56 hours/week with substantial overtime, and production returns to a standard 40-hour week at approximately month 29, that is, near the middle of 2009. Other reductions in fatigue were simulated with similar results.

Figure 14. Work-week Effects of Externally Reduced Fatigue

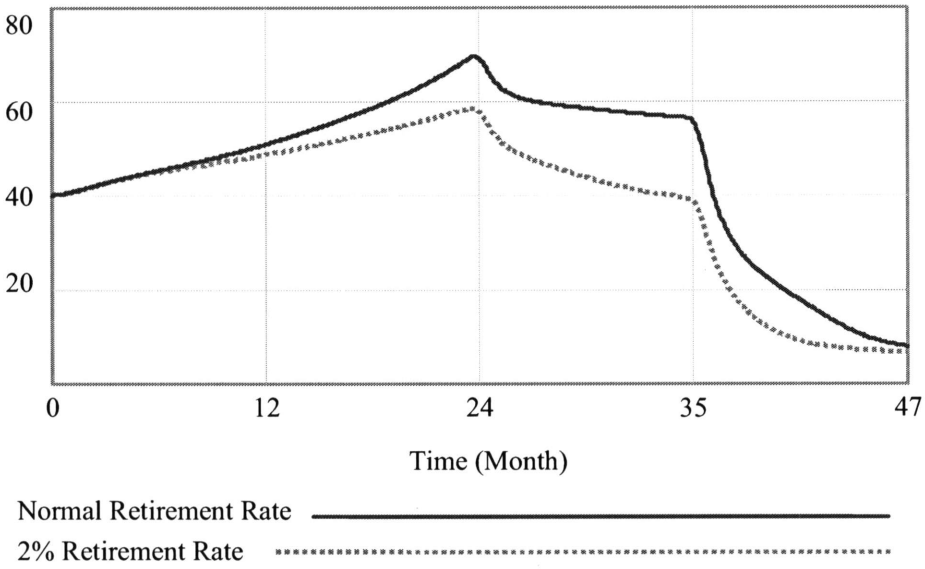


EFFECT OF REDUCING THE RETIREMENT RATE

Although implementing policies to reduce external fatigue greatly improves performance, the resources required and the ability to implement such policies may not exist or be readily attainable. However, some reduction of the rate of retirement during the remaining years of the shuttle program may well be feasible.

In the simulation, it is assumed that 30% of the workers are eligible to retire in the next three years, an approximate average of contractors' self-reports of the percentage of workers who are or will be eligible for retirement in the next few years. To illustrate the consequences of implementing policies that would reduce the retirement rate, a simulation assuming only a 2% retirement rate per year for the remainder of the program was run. As illustrated in Figure 15, policies to encourage workers to stay on the job until the end of the program can significantly reduce the need for overtime in the system. (As discussed in the next section, there is also precedent for such actions.) The peak work-week is reduced to 59 hours per week and falls to a standard 40-hour week at month 31, again around the middle of 2009.

Figure 15. Work-week Effect of Reducing the Retirement Rate



Achievement of lower-than-expected retirement rates will require intervention on the part of both the contractors and NASA. Retention of potential retirees will require addressing:

- the widely held view that contractor compensation has not kept pace with increases in the cost of living since Katrina;
- decreasing job satisfaction; and
- general uncertainty related to the contracting environment (e.g., contracts for space exploration).

Effect of Modifying the Shuttle Schedule

The other key variable that can be modified is the shuttle schedule itself. Figure 16 shows the results of changing the production schedule. The model was simulated using two different simulations:

Simulation 1: Assumes level production of four shuttles per year for the remainder of the Program.

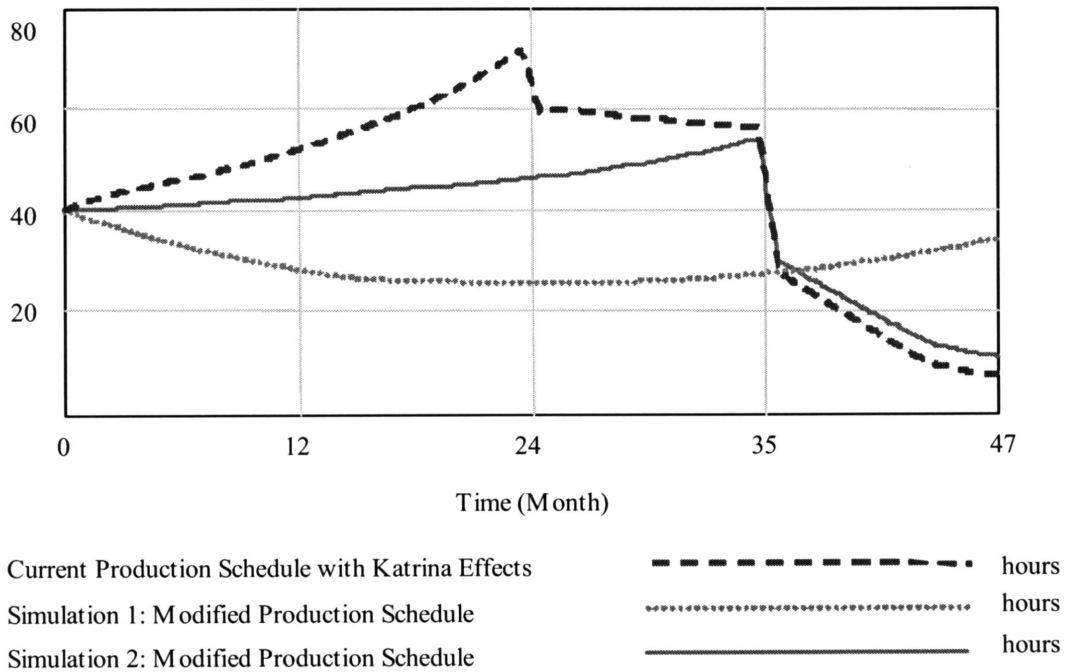
Simulation 2: Assumes that 4.5 shuttles would be completed for the next three years, and 2.5 shuttles would be completed during the final year.

Both simulations assume that sixteen shuttles will be produced within the current Program timeframe, the same as the current schedule.

The results for Simulation I, the level-production simulation, show no need for overtime because of the earlier assumption that current resources had the capacity to support five shuttles per year.

Simulation II, which decreases production to 4.5 shuttles per year, produces some interesting results. The peak workload occurs at month 35 with a required work-week of 53 hours. The fact that the peak occurs much later in the schedule, i.e., late 2009, is encouraging, because it is possible that outside factors may change, easing workers' fatigue from external sources. Hence, the required hours per week may even be less in reality than indicated here because all of the simulations assume a constant level of external fatigue.

Figure 16. Work-week Effects of Modifying the Program Schedule



IMPLICATIONS OF THE MODEL SIMULATIONS

In initial interviews, NASA and contractor managers at both MAF and SSC repeatedly voiced their concern about employee fatigue and its possible impacts on workforce retention, overall worker physical and mental wellbeing, and the successful completion of SSP. The one-year anniversary of Katrina had just passed, and managers expected that issues of fatigue, morale, recruitment, and retention would escalate as Katrina recovery across the Gulf Coast continued its sluggish pace.

The system dynamics model simulations illustrate that managers' concerns are well founded. Employee survey results clearly show that burnout, poor physical and mental health, and other proximate determinants of fatigue are present in the contractor workforce at both MAF and SSC. These findings are further supported by the multiple and indirect signals that a not-insignificant share of workers want or are seeking to leave, as evidenced by their job search behavior, deteriorating satisfaction with work and life at home and in their communities, and continued frustration with Katrina recovery.

The simulations show that interventions geared toward reducing worker fatigue will produce measurable, positive results that support successful SSP missions. The model is not prescriptive. NASA and contractors may consider pursuing a number of options to achieve the results reflected in the simulations. However, the model does show the direction and magnitude of both modest and dramatic changes in retirement policies, external fatigue factors, and production and testing schedules. The model does not illustrate the *combined* effect of multiple interventions, but it does show when and how interventions are likely to yield results.

The current schedule calls for the majority of SSP production and testing to be done in the near term, with ten of the remaining sixteen shuttle flights scheduled for 2007 and 2008. Table 2 summarizes the simulation results. The baseline model shows that, even in the absence of Katrina, the current production schedule would require a maximum workweek of 43 hours per week in month 23 (i.e., near the end of 2008), a workload that is in line with past experience. However, as the Hurricane Effect simulation shows, when the impact of Katrina-related fatigue is factored in, the maximum work-week balloons to 72 hours per week in month 23. Clearly, such a workload requirement for this already stressed population is untenable, even if only for a short time.

Four intervention options are simulated, all of which yield significant reductions in the maximum Work-week required from the Hurricane Effect simulation, as summarized in Table 2. Reduction of fatigue caused by the hurricane recovery and the challenges of meeting the exigencies of everyday life, no matter what the mechanism for achieving this reduction—e.g., telecommuting, onsite health and daycare, commuter busses—potentially reduces the 72-hour maximum Work-week to 56 hours. Reduction of the retirement rate to 2% also drops the maximum Work-week from 72 to 59 hours. Two modified shuttle mission schedules are presented to illustrate the productivity impact of reorienting workflow such that more work is pushed out in time—to month 35 in Modified Schedule 2—when workers may be better able to meet a demanding work schedule should hurricane recovery accelerate or progress and take hold. Modified Schedule 1 illustrates the effect of pushing the most demanding workload even further out. It shows an underemployed workforce during the time when the other simulations have very high workloads.

Table 2. Work-week Effects of the System Dynamics Models

System Dynamics Models	Maximum Work-week Required (hrs/wk)	Timing of Maximum Work-week (months from Jan. 2007)
Baseline 2007--5 shuttle missions 2008--5 shuttle missions 2009--4 shuttle missions 2010--2 shuttle missions	43	23
Hurricane Effect	72	23
Interventions		
Reduce External Fatigue	56	23
Retention of Retirement-Eligible Workers	59	23
Modified Shuttle Schedule 1 2007--4 shuttle missions 2008--4 shuttle missions 2009--4 shuttle missions 2010--4 shuttle missions	No overtime required	n/a
Modified Shuttle Schedule 2 2007—4.5 shuttle missions 2008—4.5 shuttle missions 2009—4.5 shuttle missions 2010—2.5 shuttle missions	53	35

Source: Authors' estimates.

The point is not to advocate for any particular simulation as a specific policy choice but to show the dynamics to which NASA and its contractors are subject in the relationship between fatigue and productivity and the probable consequences for the SSP different parameter adjustments. All but one of these simulations fail to yield a level of relief required to meet SSP "fly-out" while maintaining a healthy and productive workforce. The necessary reduction in worker fatigue likely will require multiple and diverse interventions to yield the productivity of which this stressed workforce is capable.

The simulations clearly show that significant overtime is required to stay on schedule under any simulation given the impact of Katrina, its prolonged recovery and other factors. However, the simulations also show that the most influential leverage point is changing the timing of the shuttles scheduled. By leveling shuttle production over the remaining life of the program, overtime would not be required if all other conditions remain the same. Even a slight reduction of one half of a shuttle per year will ease overtime requirements during the next two years, which are critical for the hurricane recovery process. Note that both of these actions will, however, still produce the desired sixteen shuttles within the current program timing. Even modest modifications of the SSP mission schedule will yield disproportionate results in terms of reduced fatigue and concomitant productivity gains. Policies to retain aging workers and to reduce external fatigue may also prove effective in relieving overtime requirements. Specific recommendations are discussed in the next section.

Recommendations

This section builds on key findings from the analysis of information gained from an environmental scan, interviews, focus groups, and contractor employee surveys. The University of Texas research team offers a series of recommended actions for NASA and the contractor community to consider implementing at MAF and SSC. No effort has been made to estimate the cost of these recommended measures. The recommendations are organized by the primary entity that would be expected to implement or act on them.

NASA 1. Work Scheduling and Organization

Consistent with the mission of the Space Shuttle Program and its required deliverables, NASA should consider modifications to the current Shuttle Program flight schedule that will allow for completion of key tasks in an orderly and less stressful manner. Specifically, NASA should:

- **Reduce the number of shuttle flights in 2007 and 2008**, either by extending shuttle fly-out to 2011 or by reducing the number of flights in those years by one per year. Any reduction in workload during the rebuilding and recovery process from Hurricane Katrina would alleviate pressure on contractor workforces by lessening mandatory overtime, worker fatigue, and attrition. An extension in the fly-out period also would reduce the gap in contractor tasks between the end of the SSP and the start of the new Orion Crew Exploration Vehicle (CEV) program.
- **Permit contractors greater flexibility to modify work procedures**, such as telecommuting and varied work schedules (for instance, staggered start and stop times and four-day Work-weeks), to minimize lost productivity and work/family stresses due to extended commuting times. This appears to be a bigger issue at Michoud than at Stennis.

NASA 2. Contracting and Job Uncertainty

NASA should **engage in a comprehensive communication strategy** to provide greater transparency and keep contractor employees better informed about plans for the current and future Space Program and the impacts on and prospects/opportunities for employees in the NASA contractor community. The combined effects of Katrina and its aftermath and changes to the SSP have generated enormous, sometimes unbearable

uncertainty for these workers. Uncertainty leads to stress, which can produce fatigue as well as adverse impacts on safety and productivity.

NASA 3. Reduction of Paperwork and Bureaucracy, and Communication Improvements

Working with contractors and auditors, NASA should **review policies and procedures** for establishing and communicating operational and administrative requirements, approvals, and personnel and other changes to minimize redundant or unnecessary paperwork and other requirements and to make sure all contractor employees are fully informed of, prepared for, and able to carry out critical tasks in a timely and efficient manner.

NASA 4. Internal Awareness and Communications

A continued awareness of the ongoing impact of the hurricane and related job stresses on households and communities is a necessary overall strategy. NASA and contractors should continue to **develop effective communications strategies** (e.g., newsletters, releases, forums, and surveys) that both deliver information about the Program, its schedule, contracting conditions, and employment, and to collect feedback about personal, Program, and workplace issues. Employees reported in focus groups that NASA and the contractors were very aggressive about scheduling morale- and community-building events to support employees in the months immediately following Katrina. One year later, however, during a time period in which Employee Assistance Program (EAP) experts say that the stress and strain of coping with a disaster like Katrina actually peaks, the frequency of community-building events at both facilities has tapered off.

NASA 5. External Community Involvement and Advocacy

Both Stennis and Michoud are considered valuable community assets that drive high-skill, high-wage employment and economic development in the surrounding areas. NASA and its contractors should use their position, power, and influence in the community and with federal, state, and local government officials to **advocate and demand accountability** for

prioritized, rapid, orderly, and sustained improvements in community infrastructure and to address the critical issues identified by their workers.

EMPLOYERS/CONTRACTORS 1. COMPENSATION

Contractors should consider, and also urge NASA to consider, **meaningful changes to employee net compensation** to address the rising cost of living in the Gulf Coast region and to help them recruit and retain critical talent in local and national labor markets. In particular, SSP contractors should:

- negotiate an aggressive increase in salary across the board to keep pace with the rising cost of living;
- consider implementing site- rather than just employer-based eligibility for critically important retirement and insurance benefits;
- explore instituting a housing subsidy;
- examine options for creating a retraining benefit or services for workers facing job losses;
- revisit the retention incentives and bonuses provided for government and contractor employees in the Air Force's Titan Program, including providing additional years of service to the retirement formula for employees who stay on the job through mission "fly-out."[2]

EMPLOYERS/CONTRACTORS 2. MANPOWER, EDUCATION AND TRAINING IMPROVEMENTS

Working closely with NASA, contractors should:

- review current and future expected work requirements to **determine optimal staffing levels**;
- **complete a comprehensive staffing, compensation/benefits, promotion, and training plan** that reduces mandatory overtime, accounts for natural attrition and anticipated retirements, addresses retirement and health benefit concerns, and provides adequate skill-based capacity;
- **develop ongoing relationships with the region's education, employment and training institutions to create and maintain a robust "pipeline"** for growing and keeping the workforce skills they need locally;

[2] Some of these recommended actions have analogues for civil servants in the NASA Workforce Flexibility Act of 2004.

- **hire temporary workers** as needed and feasible to address current backlogs.

Such a review and plan would reduce scheduling and delivery bottlenecks and prevent delays. Specialized training should be consistent with the required new and ongoing skill sets identified in the plan. Key operational positions should be the critical focus of this review, but administrative and support positions should also be considered.

EMPLOYERS/CONTRACTORS 3. WORKPLACE ENVIRONMENT AND MORALE/ PRODUCTIVITY

In the months immediately after Hurricane Katrina, NASA and its contractors responded with great compassion and granted noteworthy flexibility to its workforce as they adapted to a very difficult and unprecedented situation. In conjunction with the manpower and training improvements outlined above, contractors should **review their human resource policies and practices for consistency and fairness** and should extend flexibility in their application where needed to allow employees to conduct necessary personal business without fear of formal or informal reprisals.

- Any such modifications to these provisions should include a **"sunset" feature** to allow for formal reconsideration/modification as conditions necessitate.
- Contractors should also **conduct a function inventory** of general and specialized workplace equipment, business/office tools, and facilities to make sure they are in good condition and sufficient for the demands of the schedule, follow industry standards for safety and preventative/corrective maintenance, and are available for new employees immediately upon hiring so new workers can be trained and equipped in a timely manner.
- NASA contractors should **include employee retention strategies as a contract requirement.**[3]

[3] This has been suggested in U.S. Government Accounting Office, *SPACE SHUTTLE: Actions Needed to Better Position NASA to Sustain Its Workforce through Retirement*, Washington, D.C.: USGAO, GAO-05-230, March 2005.

EMPLOYERS/CONTRACTORS 4. SAFETY

Contractors should carefully and thoroughly **review the safety environment** to ensure that actual practices comply with stated policies and procedures without overly burdening work processes. Worker comments in focus groups and surveys suggest that work-site safety is increasingly an issue in Katrina's aftermath. Contractors should assess whether and the degree to which the issues identified in the Key Findings and Impacts section are or may be contributing to safety lapses and an increase in safety risks of the Program to workers at the facilities, to astronauts, and to the public. This is clearly an area that cannot be taken too seriously.

EMPLOYERS/CONTRACTORS 5. TRANSPORTATION AND COMMUTING OPTIONS

Employers should **consider strategies to relieve or offset the costs and lost time associated with excessively long commutes**. Several focus group participants noted the value of a company-arranged shuttle bus that once ran from Baton Rouge to these facilities, stating that the time spent on the buses not only relieved the stress of dealing with traffic, but also provided them with time to arrange for repairs on their homes, communicate with displaced family members, and other important personal matters. Contractors should consider reinstating free or fare-based shuttle bus options serving employees living in certain concentrated regions. This may require an employee survey to identify likely locations and to gauge interest in such an option. Additionally, work options such as telecommuting and varied work schedules may be deployed to minimize time lost to commuting.

EMPLOYERS/CONTRACTORS 6. EMPLOYEE ASSISTANCE PROGRAMS (EAP)

Contractors have relied upon valuable traditional EAP offerings and Katrina-related services for their workers. The recent offering of U.S. Navy services at the Stennis Center to its employees is an encouraging development. However, the lingering effects of Katrina and very slow pace of recovery suggest that more can be done. Although an independent review of the quality and accessibility of these programs is beyond the scope of this report, contractors should **undertake such a review of EAP offerings** to determine their effectiveness in meeting the extraordinary, ongoing needs of their workforce. In addition to

continuing and extending traditional EAP programs such as counseling, workshops, and referrals, contractors should **consider customized offerings and strategies** that comport with the time and family demands of workers and that address particularly stubborn issues such as housing, casualty insurance, education/daycare services, transportation, and working with government agencies and regulations. Strategies might include business referral services, negotiated group discounts, and ombudsman services.

Concluding Observations

In addition to the trends, issues, and recommendations that have been outlined in the earlier sections, several observations are noteworthy.

First, no one single factor is leading to adverse impacts on the Space Shuttle Program's capacity to successfully and safely "fly-out" the program by September 2010. Rather, a *complex, dynamic array of interacting forces* is doing so. Hurricane Katrina's effects have been serious and enduring, and they are coming hard on the heels of stresses stemming from the Columbia disaster and its ongoing investigation and the recently announced ten-year truncation of the Shuttle Program itself. Addressing the situation effectively and systemically will necessarily entail a number of related responses on the part of all of the key actors, including NASA, the contractors, employee unions and associations, and leaders from the wider community.

Second, *Hurricane Katrina's effects are truly unimaginable* for anyone who has not experienced them. Residents suffered through the storm, which was horrible enough, but they have had to continue dealing with its aftermath. And, the effects clearly are not abating for the foreseeable future, which makes them that much harder to bear. Roads, schools, hospitals, utilities and housing — the very basics in life that everyone simply takes for granted — are still not back to capacity in the region. Neither are the amenities such as restaurants, movie theaters, malls, and beaches that make life pleasant on a day-to-day basis. NASA's and the contractors' workforces are continuing to meet the SSP schedule *despite* having to live in such difficult conditions.

Third, *uncertainty* remains a serious issue. Recent announcements about the space exploration contracts for the Constellation Program with its contractors/employers notwithstanding, it is not at all clear for many of the workers at Michoud and Stennis that they and their particular skill sets will be required once the Space Shuttle Program ends. For workers in their late 40s or 50s who are not yet eligible to retire from their current employer, this uncertainty is especially troubling. Unlike many workers who have become accustomed to dealing with the ups and downs of market forces and who may have worked for an ever-changing list of employers in recent decades, workers at Michoud in particular have largely

been insulated from these realities — until now. Confronting such realities in the best of times is painful. In hard times, such as those in the Gulf Coast, they can be terrifying.

Fourth, the SSP workforce is unabashedly *passionate about the program and their role in it*. They are committed to carrying out their work on the shuttle well and on time, almost no matter what the personal cost. The intense strain these workers are under came through loud and clear in the interviews and focus groups, in which several workers broke down while recounting their experiences. The employee survey results bear out both employees' abiding commitment to the Shuttle Program and the difficulties they endure to remain part of it. It would behoove NASA and its contractors to take action to address the issues facing the workforce through a variety of strategies so that workers can meet the program's goals while balancing vitally important work and family demands.

Finally, although some of the forces affecting the Gulf Coast, e.g., Katrina, are highly unusual, the *strategies recommended for addressing them are not*. In fact, between NASA and the U.S. military, many of these strategies—e.g., added compensation, modified schedules, retention bonuses, retirement incentives—are now quite commonplace and well within the scope of traditional government/contractor responses for such large and important national programs.