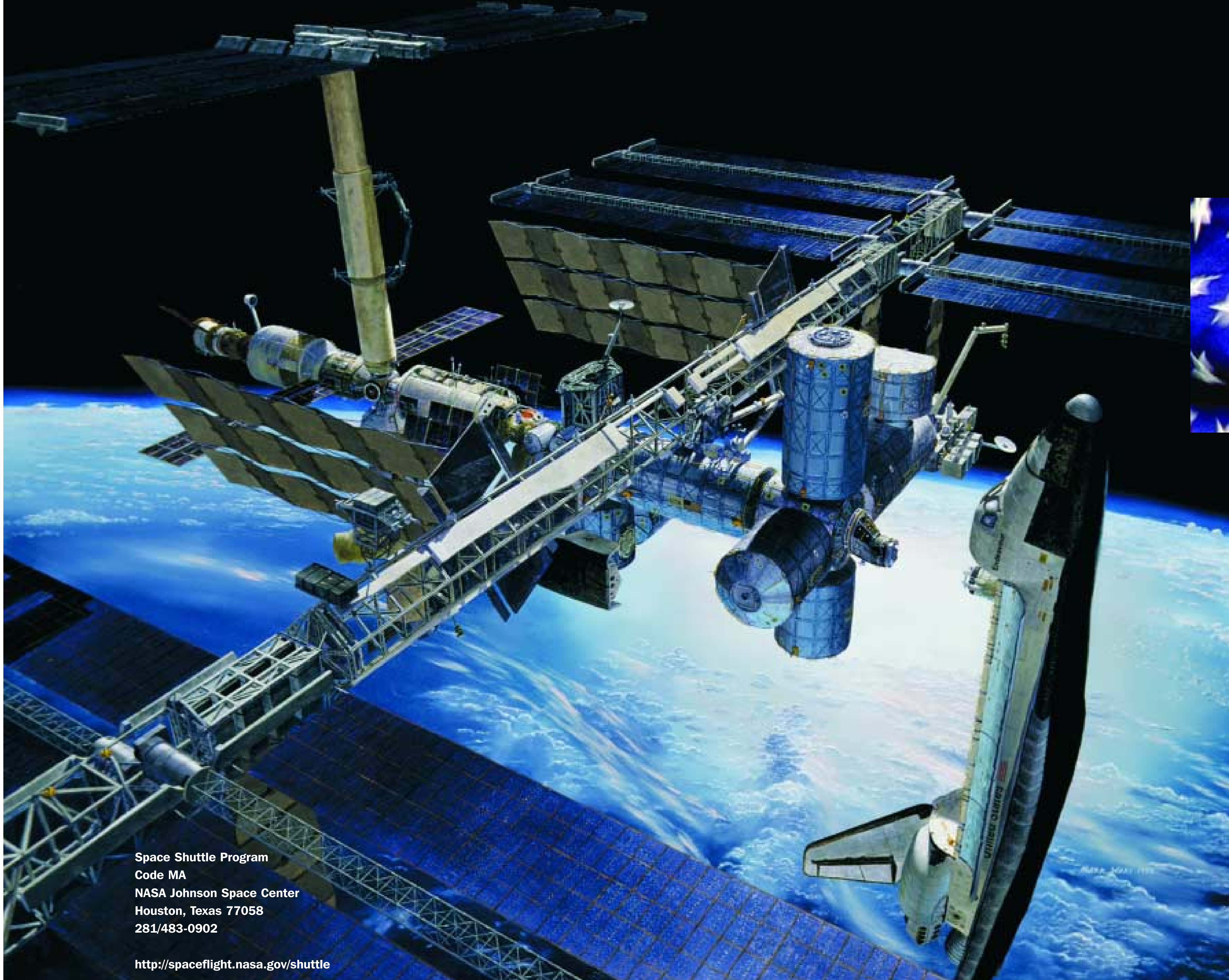
ANNUAL REPORT

2002



Space Shuttle Program

Space Shuttle Program
Code MA
NASA Johnson Space Center
Houston, Texas 77058
281/483-0902

http://spaceflight.nasa.gov/shuttle

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NP-2002-11-024-JSC

The future depends on what we do in the present.

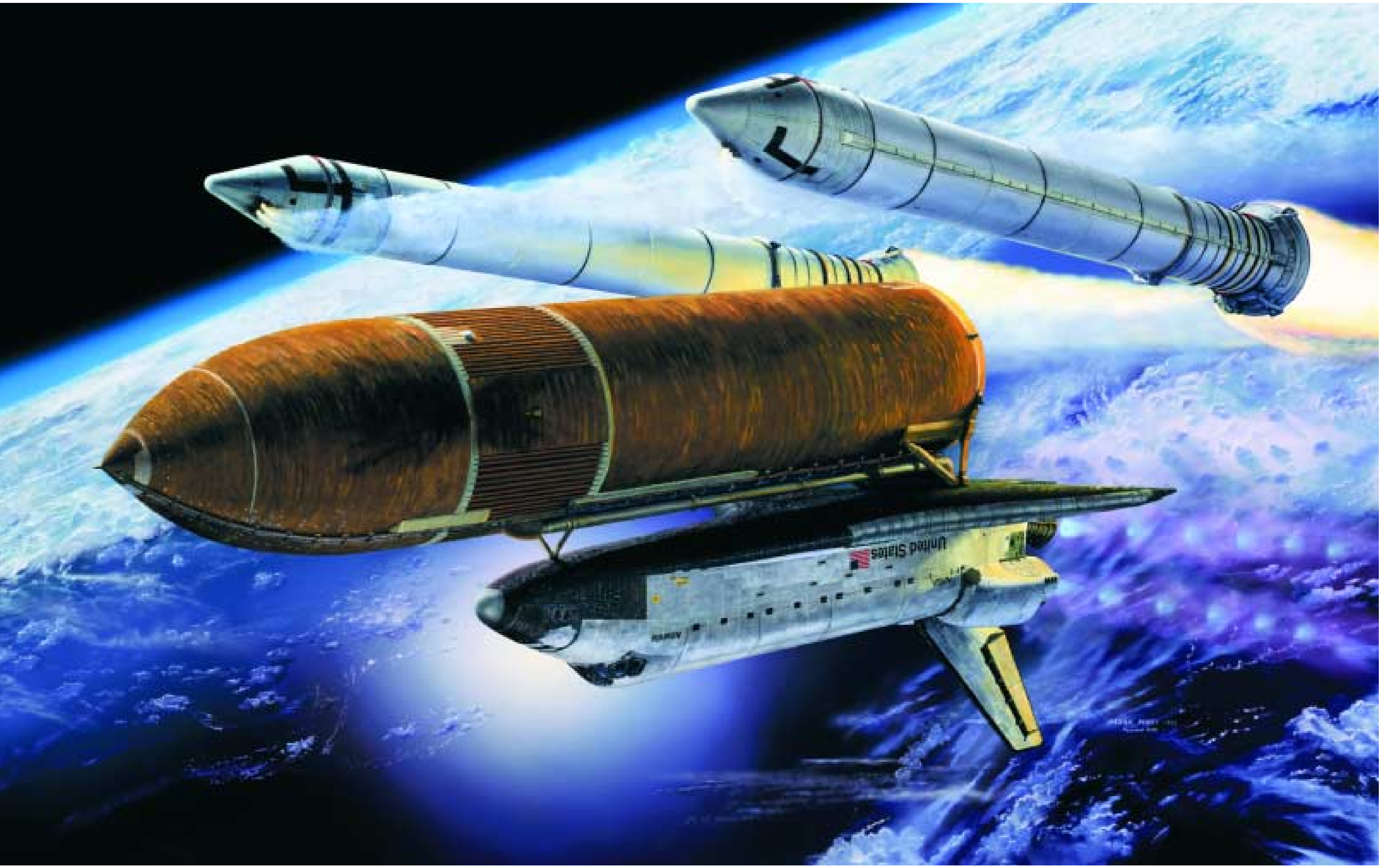
Mahatma Gandhi

Since joining NASA this past May as the new Deputy Associate Administrator for International Space Station and Space Shuttle, I continue to be impressed with the dedication and performance of the NASA Human Spaceflight team. The Space Shuttle Program has experienced another great year as the signature element of the nation's Integrated Space Transportation Plan, and I am pleased to recognize this important contribution. The men and women of this superb team continue an outstanding tradition of safe and effective human spaceflight, and your senior leadership applauds this achievement. Thanks to your efforts, the science-driven International Space Station remains on track toward the Administrator's vision of International Core Complete. Congratulations on another great year!

Michael C. Kostelnik
Deputy Associate Administrator for International Space Station and Space Shuttle Program

Contents

America's best gets better



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Artist's rendering of booster separation at approximately T+2 minutes.

Over the past decade, the Space Shuttle Program has achieved remarkable success. Improvements have led to an 80 percent decrease in launch risk and nearly a 100 percent increase in cargo capability to low Earth orbit. Increased stabilization of processes and procedures has contributed to a 70 percent decrease in in-flight anomalies. Aggressive efforts to control and reduce operational costs have led to an amazing 40 percent decrease in the overall program cost and workforce while at the same time achieving a 26 percent reduction in the number of workforce accidents. America's best has certainly gotten better!

But the best is yet to come! With the increasing likelihood that the space shuttle will be the primary human space transportation system through at least the middle of the next decade and possibly 2020, deliberate efforts to reduce program risk through vehicle upgrades and improvements will continue. Increased emphasis on maintaining the safety and integrity of infrastructure, systems, skills, and processes is a key ingredient of our strategy to control risks and maintain a safe and viable system through 2020. Additional cost reduction will be achieved through appropriate consolidation of facilities and efficient utilization of existing manufacturing, production, and test capacity. System and vehicle improvements also enable the opportunity to reshape the operations paradigm and reduce the overall cost associated with space shuttle flight operations.

As we develop strategies to meet the challenges before us, our commitment to work together to overcome the "speed bumps" of the future must be paramount. The business of space travel is not about the individual. On the contrary, our success has been and continues to be built upon the chemistry and power of the team, comprising multiples of talented individuals. Our constancy amid change must be the dependence upon the team approach, where diversity of background and experience combines to produce innovative ideas and revolutionary concepts necessary for us to adapt to the ever-changing environment.

The last 20 years of space shuttle operations have been incredible. The next 20 years will be even more remarkable, as we begin to fully utilize an orbiting laboratory and open wide the doors of space travel and discovery. Our workforce is talented and committed to safety and mission success. Our leadership is vibrant and creative. We can make it happen. We will make it happen!

Ronald D. Dittemore
Manager, Space Shuttle Program

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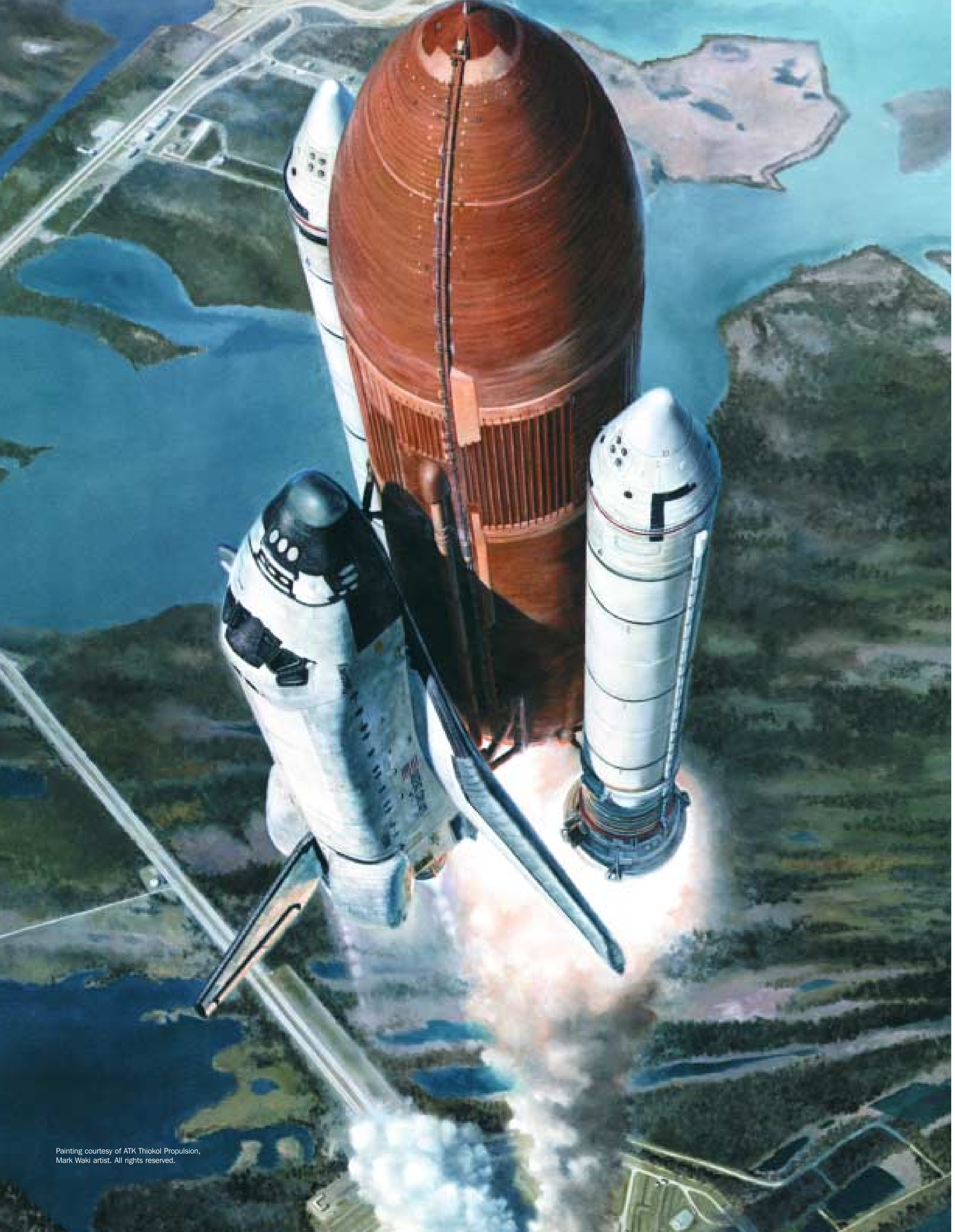
SPACE SHUTTLE PROGRAM

Mission Statement

Our mission is to provide safe, reliable, and efficient human access to low Earth orbit and the International Space Station, optimizing scientific research, demonstrating advances in technology, and stimulating national interest in education and exploration.



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GOALS

Fly Safely

Safety is the foundation of the program, the core value that influences all processes and decisions. The risks associated with human spaceflight must capture our unyielding attention and continually drive our actions to mitigate those risks.

Meet the Manifest

ISS and research customers require reliable access to space. We must continue to be flexible in space shuttle planning to accommodate customer requests and in resolving technical issues to best meet our customers' needs.

Improve Supportability

Reliance upon the space shuttle system for human access to space will continue for many years. It is imperative that we proactively and aggressively ensure the viability, safety, and integrity of our systems, infrastructure and workforce.

Improve the System

Improving safety and reducing operations costs are basic cornerstones of the Space Shuttle Program. Improved hardware reliability, process robustness, operational efficiencies, and high-performance organizational structure are areas of continued emphasis and priority.

OBJECTIVES

Maintain the safety and integrity of the existing shuttle systems and processes, and maintain critical safety checks and balances

- Maintain adequate knowledge and skill capabilities
- Provide reliable facility infrastructure to support Space Shuttle Program objectives
- Establish program-wide process control emphasis and provide increased insight into supplier processes through aggressive utilization of surveillance, symposia, and product-process integrity audits
- Identify and resolve obsolescence concerns and logistics weakness

Improve the safety and reliability of the space shuttle system

- Decrease risk of catastrophic loss of vehicle and crew, improving to 1/1000 loss of vehicle and 1/10,000 loss of crew during launch to orbit phase
- Reduce accepted risk causes of hazards
- Provide industrial engineering improvements, reducing risk to workforce and collateral damage to flight and ground systems

Reduce the cost of operations

- Reinvent processes to streamline interfaces and optimize/reduce system change
- Maximize utilization of existing excess manufacturing and facility capacity through consolidation; eliminate unnecessary facilities

Achieve and maintain environmental compliance

SENIOR MANAGEMENT

Space Shuttle Program Council

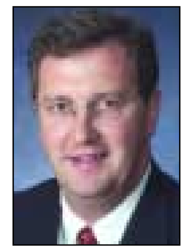
Ronald D. Dittemore
Manager
Space Shuttle Program (JSC)

Linda J. Ham
Manager
Program Integration (JSC)

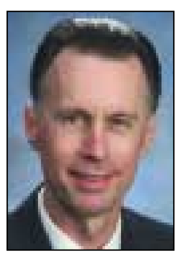
James D. Halsell
Manager
Launch Integration (KSC)

Alex A. McCool
Manager
MSFC Projects (MSFC)

Lee Norbraten
Manager, Space Shuttle
Development (JSC)



Ralph R. Roe
Manager
Vehicle Engineering (JSC)

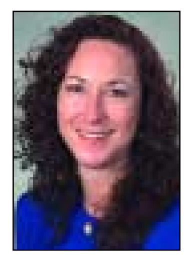


Lambert D. Austin
Manager
Systems Integration (JSC)

Michele A. Brekke
Manager, Customer and
Flight Integration (JSC)

James B. Costello
Manager
Business Office (JSC)

William J. Harris
Manager, Safety and
Mission Assurance (JSC)

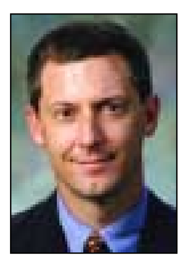


Joyce Rozewski
Manager
Logistics (KSC)

Steve Hawley
Director
Flight Crew Operations (JSC)

Jon C. Harpold
Director
Mission Operations (JSC)

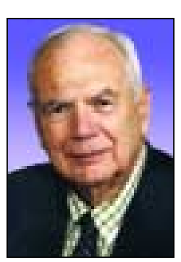
David A. King
Director
Shuttle Processing (KSC)



Allen Flynt
Manager
Extravehicular Activity (JSC)

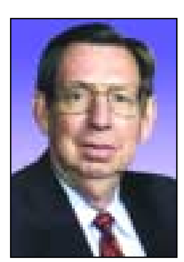
Joan Baker
Technical Assistant to the
SSP Manager (JSC)

David A. Hamilton
Chairman
Chief Engineers Council (JSC)



George D. Hopson
Manager, Space Shuttle
Main Engine (MSFC)

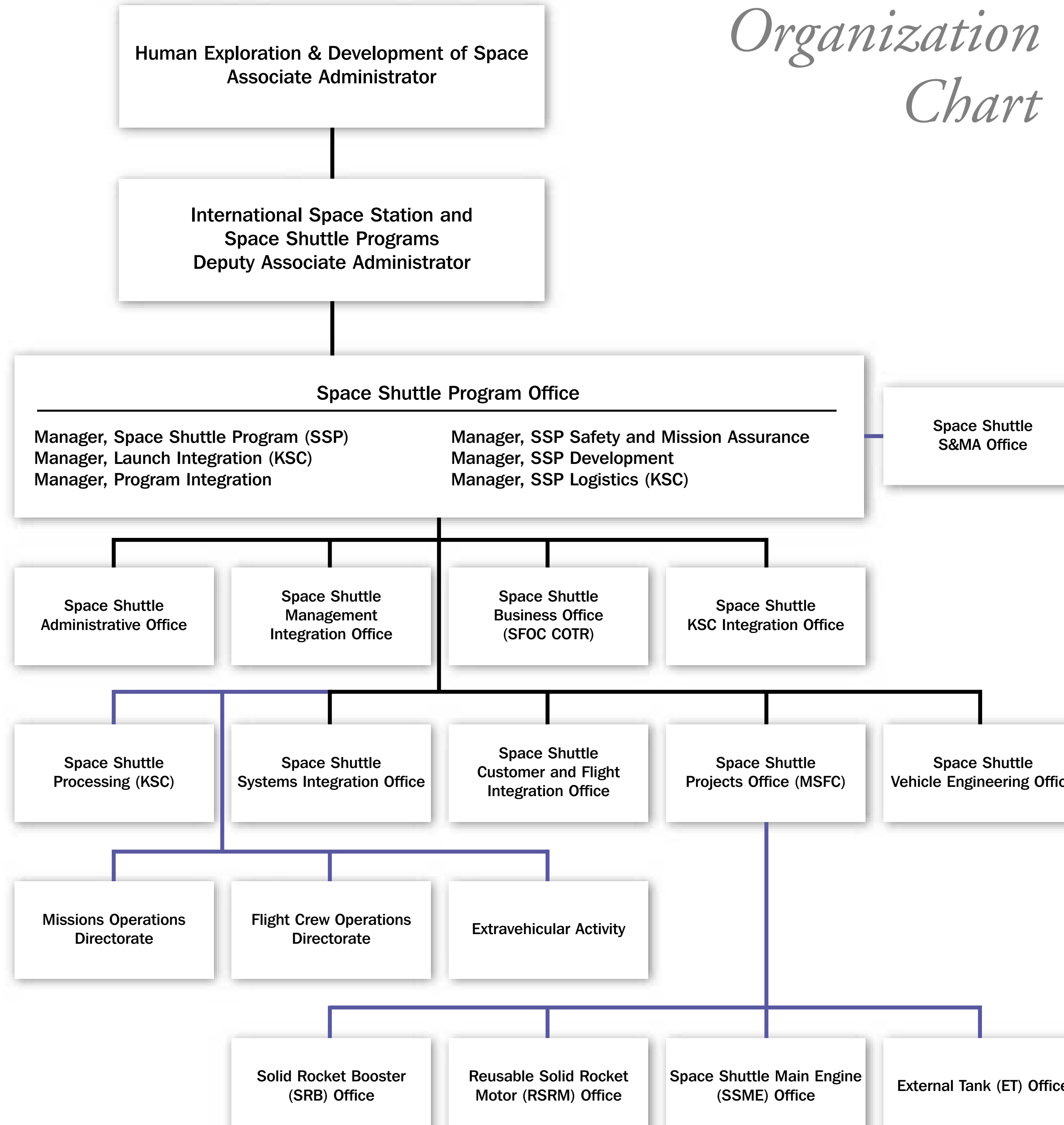
Michael U. Rudolphi
Manager, Reusable Solid
Rocket Motor (MSFC)



Jerry W. Smelser
Manager
External Tank (MSFC)

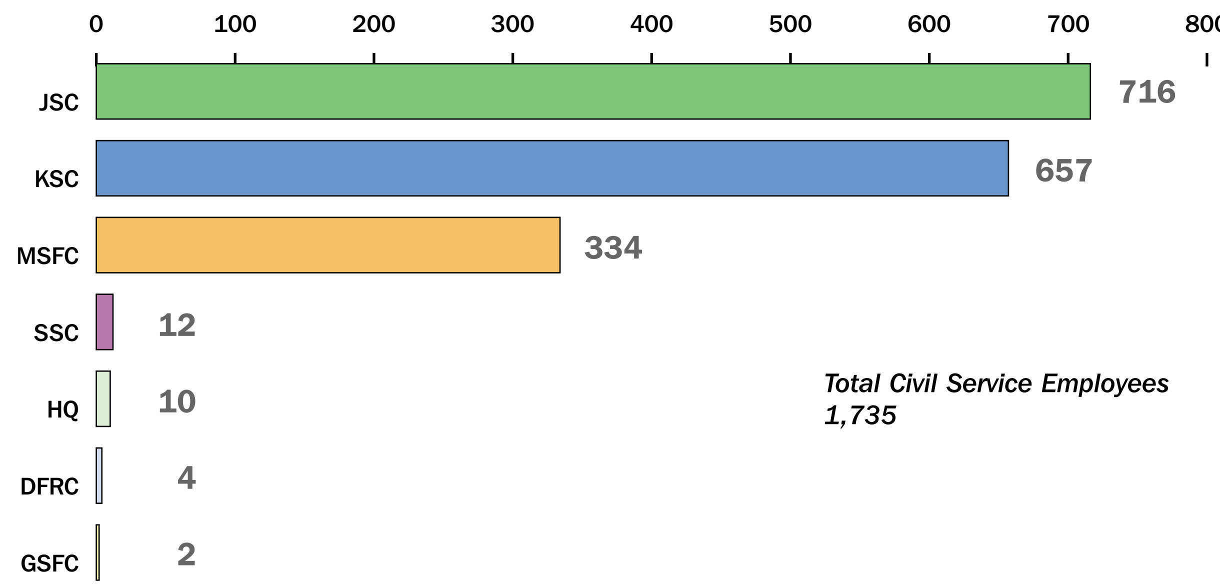
Alex A. McCool
Acting Manager
Solid Rocket Booster (MSFC)

Space Shuttle Program Organization Chart

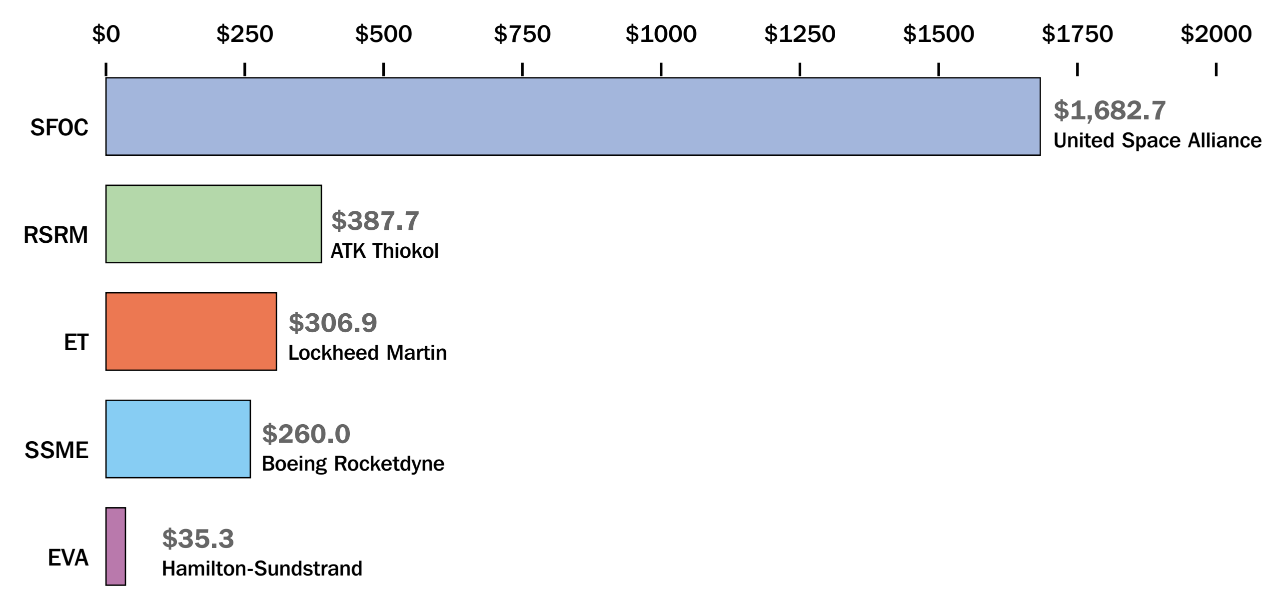


Civil Service Workforce & Major Contracts

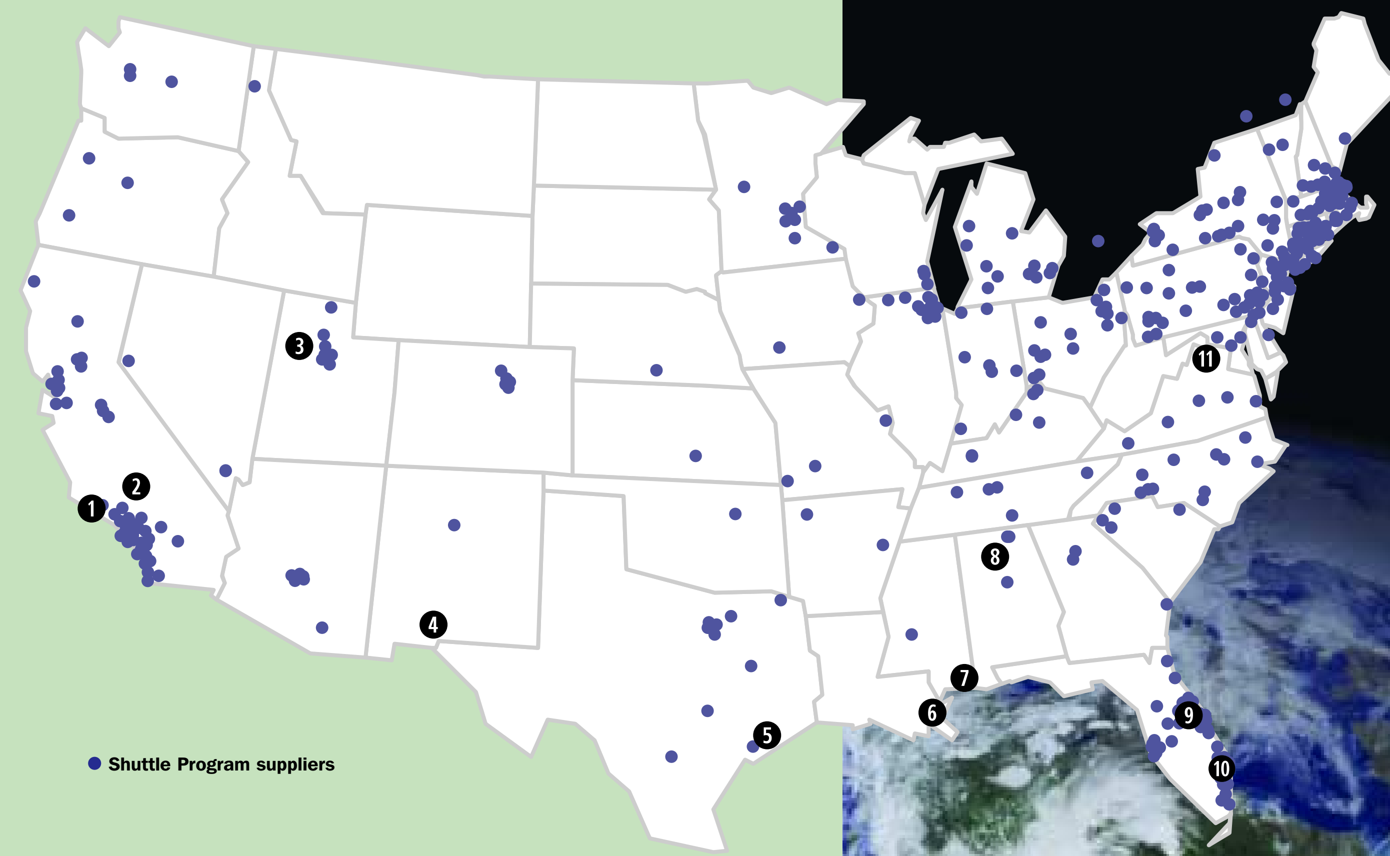
Civil Service Workforce by Center



Fiscal Year 2002 Contract Values (Millions)



Major Sites



1. **Canoga Park, CA**
   Space Shuttle Main Engines
   Boeing – Rocketdyne Propulsion
2. **Edwards AFB, CA**
   Alternate Landing Site
3. **Brigham City, UT**
   Reusable Solid Rocket Motor
   ATK Thiokol Propulsion
4. **White Sands Test Facility**
   White Sands, NM
5. **Johnson Space Center**
   Space Shuttle Program Office
   United Space Alliance
   Boeing NASA Systems
   Houston, TX
6. **Michoud Assembly Facility**
   External Tank
   Lockheed Martin
   New Orleans, LA
7. **Stennis Space Center**
   SSME Test
   Bay St. Louis, MS
8. **Marshall Space Flight Center**
   Space Shuttle Project Office
   SSME SRB ET RSRM
   Huntsville, AL
9. **Kennedy Space Center, FL**
   Ground Processing Operations
   Solid Rocket Booster
   Launch Integration
   United Space Alliance
   Boeing NASA Systems
10. **West Palm Beach, FL**
    Alternate Turbopumps
    Pratt & Whitney
11. **NASA Headquarters**
    Washington, DC

Shuttle Flights To Date

110 TOTAL FLIGHTS
85 SINCE RETURN TO FLIGHT

BEFORE 51-L (FLIGHT 25)

FLT. NO.	LAUNCH DATE	LANDING DATE	STS NO.
25	01/28/86		51-L
22	10/30/85	11/06/85	61-A
19	07/29/85	08/06/85	51-F
17	04/29/85	05/06/85	51-B
13	10/05/84	10/13/84	41-G
11	04/06/84	04/13/84	41-C
10	02/03/84	02/11/84	41-B
8	08/30/83	09/05/83	8
7	06/18/83	06/24/83	7
6	04/04/83	04/09/83	6

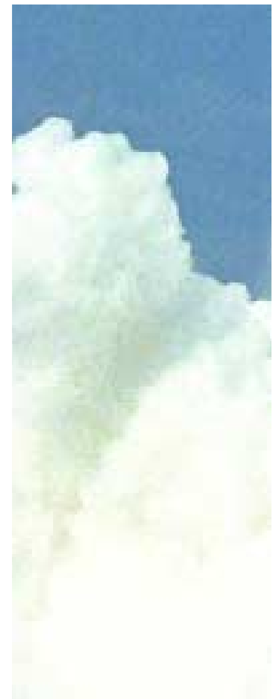
Challenger
OV-099
10 Flights

FLT. NO.	LAUNCH DATE	LANDING DATE	STS NO.
108	03/01/02	03/12/02	109
95	07/23/99	07/27/99	93
90	04/17/98	05/03/98	90
88	11/19/97	12/05/97	87
85	07/01/97	07/17/97	94
83	04/04/97	04/08/97	83
80	11/19/96	12/07/96	80
78	06/20/96	07/07/96	78
75	02/22/96	03/09/96	75
72	10/20/95	11/05/95	73
63	07/08/94	07/23/94	65
61	03/04/94	03/18/94	62
58	10/18/93	11/01/93	58
55	04/26/93	05/06/93	55
51	10/22/92	11/01/92	52
48	06/25/92	07/09/92	50
41	06/05/91	06/14/91	40
38	12/02/90	12/10/90	35
33	01/09/90	01/20/90	32
30	08/08/89	08/13/89	28
24	01/12/86	01/18/86	61-C
9	11/28/83	12/08/83	41-A
5	11/11/82	11/16/82	5
4	06/27/82	07/04/82	4
3	03/22/82	03/30/82	3
2	11/12/81	11/14/81	2
1	04/12/81	04/14/81	1

Columbia
OV-102
27 Flights

FLT. NO.	LAUNCH DATE	LANDING DATE	STS NO.
106	08/01/01	08/22/01	105
103	03/08/01	03/21/01	102
100	10/11/00	10/24/00	92
96	12/19/99	12/27/99	103
94	05/27/99	06/06/99	96
92	10/29/98	11/07/98	95
91	06/02/98	06/12/98	91
86	08/07/97	08/19/97	85
82	02/11/97	02/21/97	82
70	07/13/95	07/22/95	70
67	02/03/95	02/11/95	63
64	09/09/94	09/20/94	64
60	02/03/94	02/11/94	60
57	09/12/93	09/22/93	51
54	04/08/93	04/17/93	56
52	12/02/92	12/09/92	53
45	01/22/92	01/30/92	42
43	09/12/91	09/18/91	48
40	04/28/91	05/06/91	39
36	10/06/90	10/10/90	41
35	04/24/90	04/29/90	31
32	11/22/89	11/27/89	33
28	03/13/89	03/18/89	29
26	09/29/88	10/03/88	26
20	08/27/85	09/03/85	51-I
18	06/17/85	06/24/85	51-G
16	04/12/85	04/19/85	51-D
15	01/24/85	01/27/85	51-C
14	11/07/84	11/15/84	51-A
12	08/30/84	09/04/84	41-D

Discovery
OV-103
30 Flights



FLT. NO.	LAUNCH DATE	LANDING DATE	STS NO.
109	04/08/02	04/19/02	110
105	07/12/01	07/24/01	104
102	02/07/01	02/20/01	98
99	09/08/00	09/20/00	106
98	05/19/00	05/29/00	101
87	09/25/97	10/06/97	86
84	05/15/97	05/24/97	84
81	01/12/97	01/22/97	81
79	09/16/96	09/26/96	79
76	03/22/96	03/31/96	76
73	11/12/95	11/20/95	74
69	06/27/95	07/07/95	71
66	11/03/94	11/14/94	66
49	07/31/92	08/08/92	46
46	03/24/92	04/02/92	45
44	11/24/91	12/02/91	44
42	08/02/91	08/11/91	43
39	04/05/91	04/11/91	37
37	11/15/90	11/20/90	38
34	02/28/90	03/04/90	36
31	10/18/89	10/23/89	34
29	05/04/89	05/08/89	30
27	12/02/88	12/06/88	27
23	11/26/85	12/03/85	61-B
21	10/03/85	10/07/85	51-J

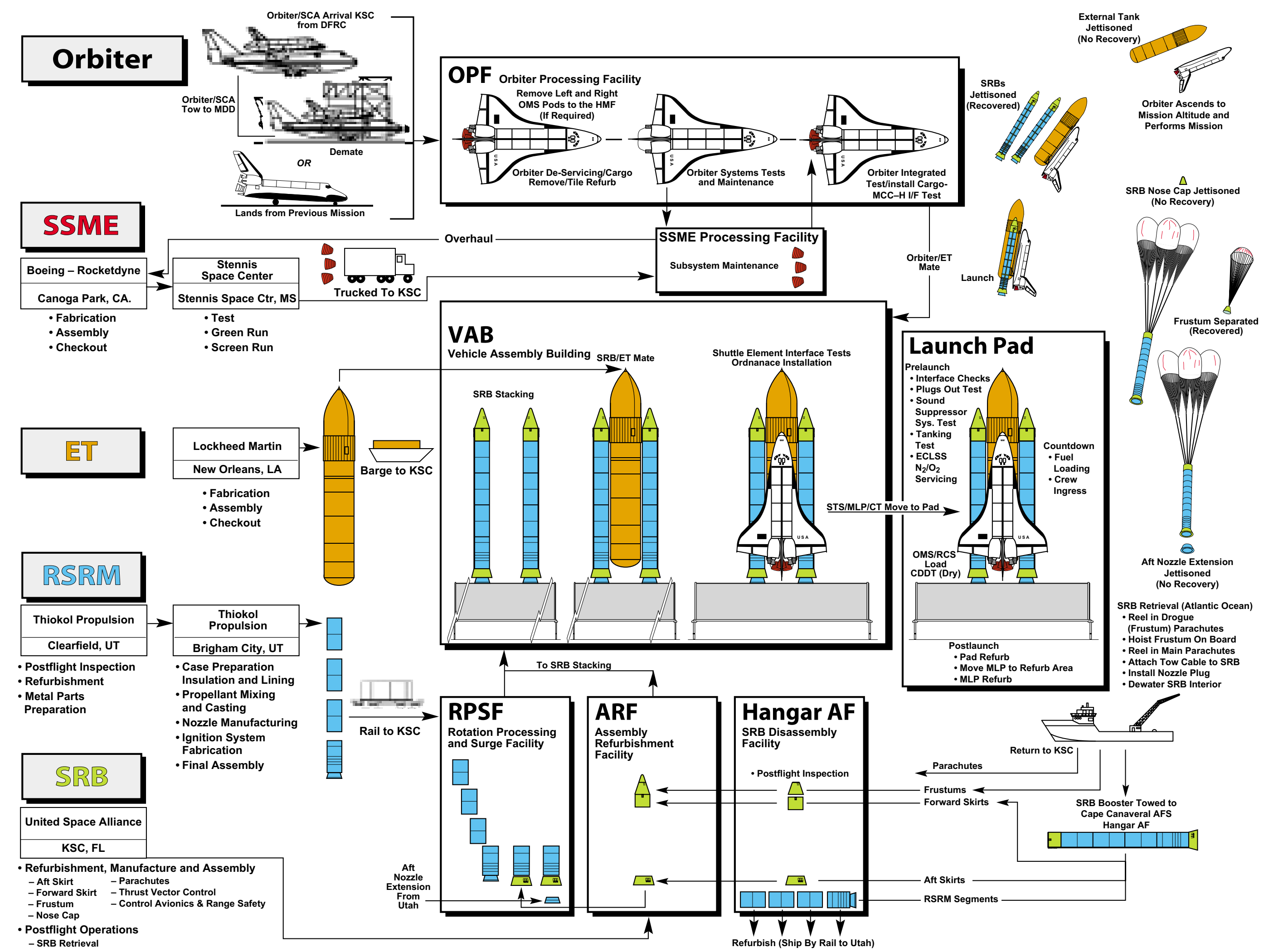
Atlantis
OV-104
25 Flights

FLT. NO.	LAUNCH DATE	LANDING DATE	STS NO.
110	06/05/02	06/19/02	111
107	12/05/01	12/17/01	108
104	04/19/01	05/01/01	100
101	11/30/00	12/11/00	97
97	02/11/00	02/22/00	99
93	12/04/98	12/15/98	88
89	01/22/98	01/31/98	89
77	05/19/96	05/29/96	77
74	01/11/96	01/20/96	72
71	09/07/95	09/18/95	69
68	03/02/95	03/18/95	67
65	09/30/94	10/11/94	68
62	04/09/94	04/20/94	59
59	12/02/93	12/13/93	61
56	06/21/93	07/01/93	57
53	01/13/93	01/19/93	54
50	09/12/92	09/20/92	47
47	05/07/92	05/16/92	49

Endeavour
OV-105
18 Flights

Hardware Flow

Building, flying, and refurbishing the space shuttle involves many complex operations. Having the major elements come together at the right time and place requires great teamwork and communication. The schematic below depicts how shuttle hardware "flows" from the many locations throughout the U.S., to the launch pad, and then is refurbished for another mission.



Resource Management

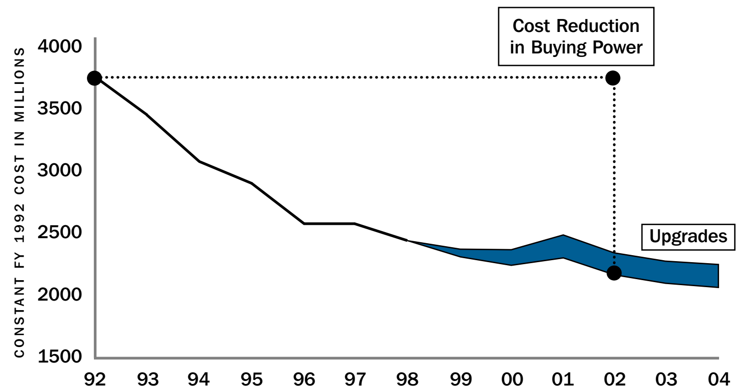
James B. Costello
Manager, Business Office

The SSP continues to meet budget commitments. However, the aerospace industry is facing a difficult economic environment, which in turn makes it very difficult to sustain the program infrastructure (systems, facilities, knowledge, etc.) based on productivity improvements alone (see budget forecast graph). Overall slow economic conditions in the launch industry over the last several years are taxing the business base and rate structure of most of our industry team. The 30- to 50-year-old infrastructure that makes shuttle launches possible is also in need of repair funding, further straining the budget resources available. The SSP has taken aggressive steps to meet these challenges while meeting our budget commitments.

The SSP industry team has taken several actions to enable more efficient operations and to help defray increased costs. Examples include consolidating shuttle processing and structural inspection and vehicle modifications into one location, relocating and consolidating the new Boeing NASA Systems organization, and reducing the overall footprint of facilities supporting our program at several locations.

The team has been successful in meeting past challenges and will continue to adapt to new ones. Continued flexibility and innovation will allow the program to accommodate economic conditions while maintaining the integrity of the existing systems and infrastructure. Together, the NASA and industry team will continue the legacy of providing safe human transportation to space within budget targets.

BUDGET FORECAST



Inflation factors based on U.S. Department of Labor, Bureau of Labor Statistics.

National Aeronautics and Space Administration
Space Shuttle Program

FINANCING AND OPERATIONS
(For the years ending September 30, 2001 and 2002)
(In millions)

	FY 2002	FY 2001
Financing Sources		
Appropriated Capital	$ 3,270.0	$ 3,118.8
Reimbursables	4.4	0.4
Total Financing Sources	**$ 3,274.4**	**$ 3,119.2**
Shuttle Program Expenses		
Ground Processing	$ 600.4	$ 581.5
Flight Operations	176.5	206.6
Aircraft/Flight Crew	65.9	66.8
Reusable Solid Rocket Motor	391.0	387.7
Solid Rocket Booster	149.0	131.8
External Tank	306.5	329.8
Space Shuttle Main Engine	282.7	279.4
SSME Test Support	31.6	31.4
Vehicle	606.9	557.7
Integrated Logistics	204.3	202.2
Extravehicular Activity	49.0	50.8
Shuttle Integration	203.1	162.7
Institutional Support	168.0	115.3
Construction of Facilities	39.5	15.5
Total Expenses	**$ 3,274.4**	**$ 3,119.2**

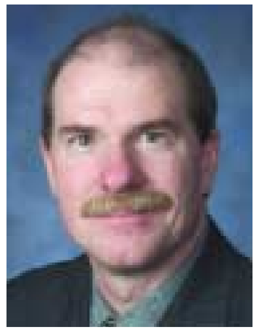
Safety & Supportability Upgrades included in expenses.

Success is determined by those whom prove the impossible, possible.

James W. Pence

The Space Shuttle Endeavour, *controlled by the flight crew of STS-108, is backdropped over a dark mass of clouds as it approaches the International Space Station. The Rafaello logistics module that is being brought up to the orbiting outpost is clearly visible in* Endeavour's *cargo bay.*

Program Safety



Williams J. Harris
Manager, Safety and
Mission Assurance

Human spaceflight has never been safer. Space shuttle operations continue to improve in safety performance both on the ground and in flight. Safety continues to be the top priority of the space shuttle team with a strong NASA and contractor management commitment and employee involvement. We continue to experience downward trends in injury and mishap rates. Our ability to demonstrate continuous improvement in safety is a tribute to the outstanding NASA and contractor workforce, their focus on safety, and their attention to detail. The SSP team is truly world-class.

SAFETY

The SSP has performed flawlessly in the area of protecting the public and the crew, injuring neither during space shuttle operations. The SSP contractor community has also worked diligently to reduce OSHA recordable injuries and lost-time day-away injuries. Since 1997, we have reduced recordable injuries by 45 percent and lost-time day-away injuries by almost 50 percent. We have spent considerable attention to improving the work environment of the SSP workforce. Advances in toxic vapor monitoring, solid rocket booster (SRB) retrieval ship operations, and SCAPE suit operations are just a few examples of improvements this year.

The SSP safety community continued to work together to improve safety. Representatives from Boeing Rocketdyne, Hamilton Sundstrand, Lockheed Martin Michoud Operations, Pratt and Whitney Alternate Pump, ATK Thiokol Propulsion, and United Space Alliance (USA) have established the SSP Contractor Safety Council. The Council provides a forum in which senior safety managers meet to discuss program safety issues, communicate and share lessons learned and best practices, and partner with SSP management to improve safety performance. As a result of this collective team effort, the SSP is performing better than ever in all areas of safety and environmental protection.

The shuttle team and OSHA have partnered to improve workplace safety through participation in OSHA's Voluntary Protection Program (VPP). The VPP is a cooperative effort between industry and OSHA to achieve a safe work environment that goes beyond the requirements of general OSHA compliance. With VPP certification, an organization is recognized as having a world-class safety program. The shuttle team continues to support this initiative with many of its major operating sites now certified as STAR sites. Significant efforts to protect the environment have resulted in the elimination of, and reduction in the generation of, hazardous waste. Since 1998, shuttle processing operations have reduced the amount of hazardous waste generated by more than 33 percent.

PAYLOAD SAFETY REVIEW PROCESS

The SSP Payload Safety Review Panel is a key function in maintaining flight safety by interfacing with payload organizations and technically analyzing payloads for adequate safety implementation. This year, NASA and the European Space Agency (ESA) worked together to establish an ESA payload safety review panel that will perform flight safety reviews of ESA-provided ISS payloads. Initial ESA safety review activities for basic payloads are expected to commence in late 2002.

AEROSPACE TECHNICIAN CERTIFICATION PROGRAM

We are actively developing and recognizing aerospace skills among our team. The Aerospace Technician Certification Program is a joint effort among NASA, industry, and a consortium of schools to establish certification of aerospace technicians to a higher standard than currently exists. Brevard Community College has led the implementation of, and is in the second year of instructing, the first class of "work-ready" candidates for the space shuttle and other aerospace programs. Classes have been conducted using the Kennedy Space Center (KSC) Center for Aerospace Education, which permits use of specialized curriculum and state-of-the-art instructional techniques. Contractor involvement includes USA, who provides full scholarship funding for several participants in addition to technical support and guidance. Congressional and Florida state government support for this initiative continues to be outstanding.

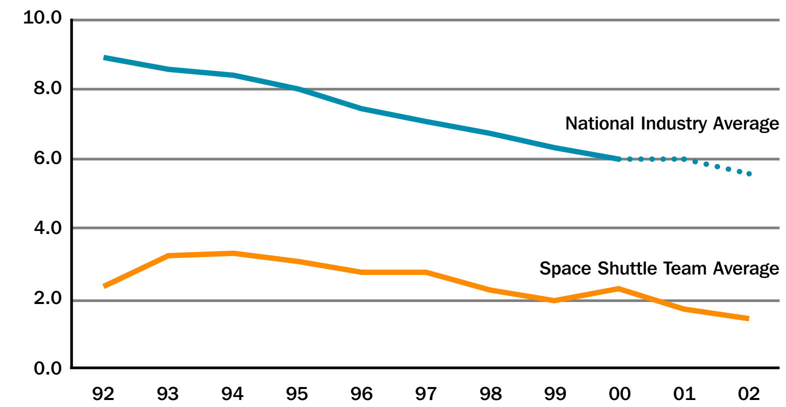
RISK MANAGEMENT

The SSP System Safety Review Panel has been leading the combined efforts of multiple NASA centers and element contractors in developing the space shuttle probabilistic risk assessment (PRA). With the completion of subsystem models and the associated probabilistic data, managers and engineers will be able to conduct system vulnerability analyses and use the results in program decision-making. The dynamic abort risk evaluation is nearing completion and will be integrated with the SSP PRA. The SSP PRA is on schedule to be completed March 2003.

SHUTTLE WORKFORCE IS

Safer Than Ever

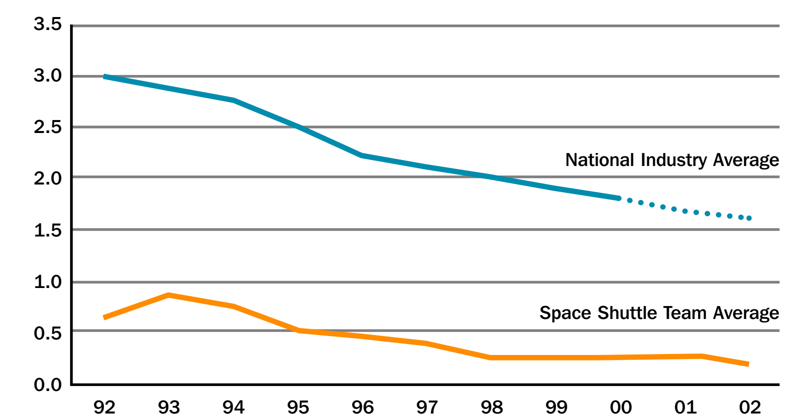
OSHA RECORDABLE INJURIES
Cases per 200,000 hours worked



35% Reduction in Injuries/Illnesses Over 10-Year Period

35%

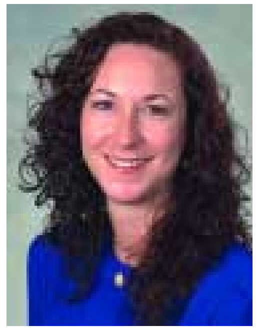
DAY AWAY FROM WORK CASE RATE
Cases per 200,000 hours worked



70% Reduction in Injuries/Illnesses Over 10-Year Period

70%

Industrial Engineering for Safety



Joyce Rozewski
Manager, Industrial Engineering

IES is in its third year of providing SSP upgrades and has delivered a marked improvement on the workforce safety and hardware risk. For workforce and flight hardware safety, the average risk index reduction was 60 percent or greater this year. Several additional IES projects and studies have been approved through FY 2004 and similar risk reduction success will be the focus. Project and study prioritization continue for fiscal years beyond FY 2004 in support of SSP's service life extension initiative.

One facet of the IES program strategy is to encourage the use of state-of-the-art industrial engineering analysis and planning tools, such as computer-aided modeling and simulation, to efficiently and proactively review human-system interfaces for areas of improvement. This can be applied both to the analysis of existing processes and also in the early phases of new designs affecting SSP flight and ground operations.

A highlighted IES project that illustrates this is the Shuttle Landing Facility Flight Simulator project, which modeled the proposed air traffic control tower to be built at the Shuttle Landing Facility at KSC. This was a joint venture funded by the IES program in conjunction with KSC and Ames Research Center. Using the Ames Future Flight Central full-scale virtual airport control tower, the team developed a shuttle landing facility model that allowed facility designers to evaluate several interior tower cab configurations as well as optimize tower height before beginning expensive construction. The Future Flight Central displayed very realistic, detailed, and high-resolution day and night scenes, including the KSC skyline, runway, and topography, thus providing a great resource for the simulation of the new tower. The simulation also evaluated the interior of the tower using human factors principles to finalize the most efficient layout.

The new tower design will allow greater visibility and safety during space shuttle landings and Shuttle Training Aircraft flight operations. During the simulation, engineers checked and evaluated cab ergonomics and several prospective control tower heights under realistic visibility and weather conditions, to ensure the design was optimized to provide greatest visibility and safety during space shuttle landings and Shuttle Training Aircraft flight operations. The model is also planned for future use as a training tool for landing convoy operations.

PROCESS CONTROL

Safety and reliability of SSP hardware continues to increase due to the efforts of the Process Control Focus Group. The steady decline of in-flight anomalies, process escapes, and non-conformances can be attributed in part to the aggressive effort to increase awareness of process control, thereby affecting the culture and environment in which we operate.

The continued success of the Process Control Focus Group has been recognized across the agency, and is being used as a model by the NASA Agency-wide Supplier Outreach Process Control team, which is expanding the process control initiative to other, uncrewed NASA space programs. The synergism and enthusiasm of these two teams working together will ensure the process control message will penetrate far beyond the SSP. The Missile Defense Agency has also expressed interest in these efforts, and teaming with other NASA and external space programs provides tremendous leveraging capability, especially among a key, core group of suppliers that support the supply chains of many sectors of the aerospace industry.

The process control message is delivered through personal, on-site visits to suppliers by NASA and prime contractor executive management, supplier symposiums, and other communications. The suppliers feel renewed enthusiasm as members of the space shuttle team, once they have a better understanding of their products' criticality to the SSP. The process.nasa.gov and CountdownOnline.tv Web sites have been developed to further promote the message and provide guidance relative to the process control initiative.

The Space Shuttle *Atlantis* safely touches down on the runway at the KSC landing facility, completing a successful journey of nearly 11 days.

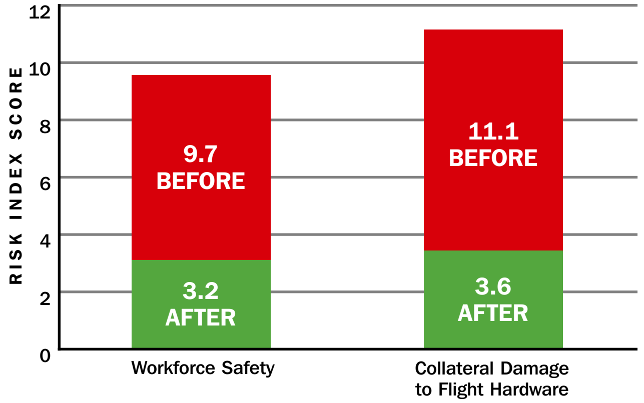
The first joint Space Shuttle Program Supplier Symposium was held January 23-24 of this year at KSC and was extremely successful in reaching a large percentage of the supplier base with a unified process control message. Because of the success of this conference, another Supplier Symposium is scheduled for February 4-6, 2003, at KSC. Attendance is expected to increase to nearly 500 participants. Process control is a major component of the symposium theme, "Pioneering the Future."

A video ("Countdown II: Knowledge, Share the Experience") has been produced addressing the important topic of knowledge capture. It reinforces the importance of documenting processes. Improperly documented processes and lack of knowledge transfer is a risk to programs with aging technology like the SSP. Countdown II addresses this program risk and illustrates the potential consequences of inadequate documentation and training programs.

IES released a process control interactive mini-disk, which is designed to reach the individual worker. The CD includes clips from previous videos and a space trivia game, which includes process control questions. It is entertaining, engaging, and inspiring, while at the same time reinforces the process control message. The feedback has been tremendous, including a sharp increase in activity on the Web sites.

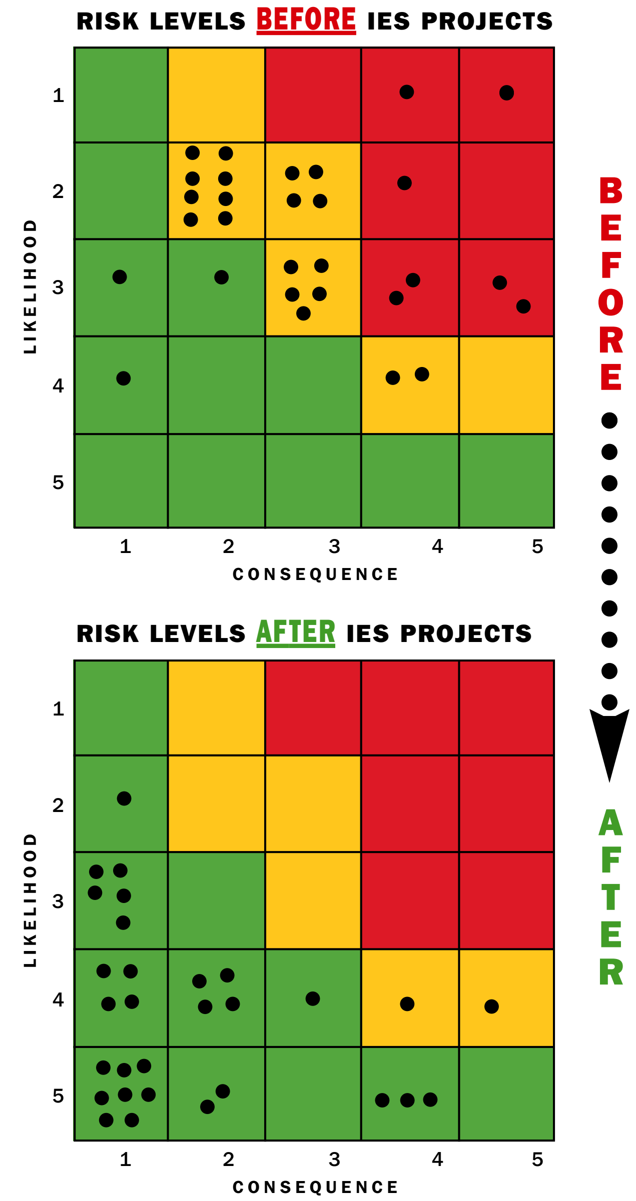
With these supplier outreach and awareness efforts, and with the open sharing and communication of best practices and lessons learned among the SSP prime contractors, the Process Control Focus Group continues to push the envelope with the culture-changing message of process control, helping to improve the performance of the SSP and ensure a safe and reliable program for the future.

IES INITIATIVES AVERAGE RISK REDUCTION



INDUSTRIAL ENGINEERING FOR SAFETY IS

Driving Down Risk



RESULT

- **Increased Safety to Personnel**
- **Increased Safety to Flight Hardware**

STS-108

Highlights

Mission	International Space Station Flight UF-1
Shuttle	*Endeavour*
Launch Pad	39B
Launch	Dec. 5, 2001 4:19 p.m. CST
Window	Less than 5 minutes
Docking	Dec. 7, 2001 2:03 p.m. CST
EVAs	1 space walk Dec. 10, 2001
Undocking	Dec. 15, 2001 11:28 a.m. CST
Landing	Dec. 17, 2001 11:55 a.m. CST
Duration	11 days, 19 hours 36 minutes
Orbit Altitude	122 nautical miles
Orbit Inclination	51.6°

STS-108 EXCHANGES INTERNATIONAL SPACE STATION CREWS

STS-108 was the 12th space shuttle flight to visit the International Space Station (ISS). *Endeavour* delivered the Expedition 4 crew – Commander Yury Onufrienko and Flight Engineers Carl Walz and Dan Bursch – to the orbital outpost. The Expedition 3 crew – Commander Frank Culbertson, Pilot Vladimir Dezhurov, and Flight Engineer Mikhail Tyurin – returned to Earth.

While at the space station, the crew conducted one space walk and attached the Rafaello Multi-Purpose Logistics Module to the space station so that 3 tons of equipment and supplies could be unloaded. The crew later returned Rafaello to *Endeavour's* payload bay for the trip home.

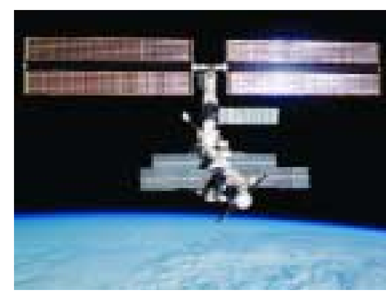
FLAGS FOR HEROES AND FAMILIES

During STS-108, NASA honored the victims of the September 11 terrorist attacks by sending nearly 6,000 small U.S. flags into orbit on *Endeavour* as part of the "Flags for Heroes and Families" campaign. The flags were given to survivors and the families of the victims of the attacks in New York City, at the Pentagon, and on United Airlines Flight 93, which crashed in Pennsylvania.

ENDEAVOUR DEPLOYS STARSHINE SATELLITE

The crew deployed the Student-Tracked Atmospheric Research Satellite for Heuristic International Networking Experiment, also called STARSHINE 2, from *Endeavour's* payload bay, one day before landing.

Teams of elementary, middle, and high school students visually track the satellite and note the times that it passes between selected pairs of targeted stars. Calculations, based on the tracking data, will be used to determine atmosphere density at various altitudes.



■ *Astronauts Dominic L. Gorie (bottom), Mark E. Kelly (left), Linda M. Godwin (top), and Daniel M. Tani, pose for a crew photo on the ISS.*
■ *Astronaut Daniel M. Tani during a space walk to install thermal blankets on mechanisms that rotate the station's main solar arrays.*
■ *The ISS as seen through an aft flight deck window following separation from the Space Shuttle* Endeavour.
■ *STARSHINE 2 is deployed from a canister in the payload bay of* Endeavour.

This photograph of circular clouds was taken by a crew member aboard the Space Shuttle Endeavour during the STS-108 mission.

STS-109

Highlights

Mission	Hubble Space Telescope Servicing
Shuttle	*Columbia*
Launch Pad	39A
Launch	March 1, 2002 5:22 a.m. CST
Window	62 minutes
Docking	March 3, 2002 3:31 a.m. CST
EVAs	5 space walks
Undocking	March 9, 2002 4:04 a.m. CST
Landing	March 12, 2002 3:32 a.m. CST
Duration	10 days, 22 hours 10 minutes
Orbit Altitude	308 nautical miles
Orbit Inclination	28.5°

COLUMBIA SUCCESSFULLY COMPLETES HUBBLE SERVICING MISSION

The STS-109 crew – Commander Scott Altman, Pilot Duane Carey, and Mission Specialists Nancy Currie, John Grunsfeld, Rick Linnehan, Mike Massimino, and Jim Newman – successfully completed the mission's objectives of servicing the Hubble Space Telescope (HST). The upgrades and servicing by the crew provide the telescope with a new power control unit, a new camera, and new solar arrays. This was the fourth space shuttle mission dedicated to servicing the telescope. The next mission is scheduled for 2004.

STS-109 was *Columbia's* 27th flight and its first since 1999 after undergoing modifications.

CREW CONDUCTS FIVE SPACE WALKS

The STS-109 astronauts performed one of the most challenging series of space walks in space shuttle history. Five space walks in five consecutive days totaling 35 hours 55 minutes were conducted to service and upgrade the Hubble. Through STS-109, astronauts have conducted 18 space walks to service the telescope for a total extravehicular activity (EVA) time of 129 hours 10 minutes.

During this extraordinary mission, the crew outfitted the HST with a third generation of solar arrays that are more durable and that generate 20 percent more power at two-thirds the size. The crew installed a new reaction wheel assembly and a new power control unit that distributes power to all Hubble electrical components. Astronauts replaced the Faint Object Camera with the Advanced Camera for Surveys, which doubles the field of view and improves resolution by 5 times. The Near Infrared Camera and Multi-Object Spectrometer, which had been dormant since January 1999, was reactivated when the crew installed a cryogenic cooler and a radiator for its cooling system.

Using the space shuttle's unique capabilities to perform on-orbit satellite servicing, improvements made to the HST systems and science instruments allow astronomers increased opportunities for continued revolutionary discoveries.

■ *Astronauts Michael J. Massimino (left) and James H. Newman after completing a lengthy space walk to finish replacement of the solar arrays on the HST.*
■ *Pictured in Columbia's cargo bay is the Rigid Array Carrier holding the new Hubble solar arrays.*
■ *Astronaut James H. Newman works with payload and general support computers on the middeck of* Columbia*.*
■ *Astronauts John M. Grunsfeld (right) and Richard M. Linnehan near the giant HST at the close of the fifth and final EVA.*

Astronaut Michael J. Massimino, anchored on the end of the Space Shuttle **Columbia's** ***remote manipulator system robotic arm, works in tandem with astronaut James H. Newman during this second session of EVA. The HST, illuminated by the sunrise, provides stark contrast to the blackness of space and the thin line of Earth's atmosphere.***

STS-110

Highlights

Mission	International Space Station Flight 8A
Shuttle	*Atlantis*
Launch Pad	39B
Launch	April 8, 2002 3:44 p.m. CDT
Window	Less than 5 minutes
Docking	April 10, 2002 11:05 a.m. CDT
EVAs	4 space walks
Undocking	April 17, 2002 1:31 p.m. CDT
Landing	April 19, 2002 11:27 a.m. CDT
Duration	10 days, 19 hours 42 minutes
Orbit Altitude	122 nautical miles
Orbit Inclination	51.6°

STS-110 DELIVERS FRAMEWORK FOR SPACE STATION EXPANSION

Space Shuttle *Atlantis* completed its mission to install the 43-foot-long, 26,716-pound S-Zero (S0) Truss, the backbone for future expansion of the ISS. While in orbit, the STS-110 crew members – Commander Michael Bloomfield, Pilot Stephen Frick, and Mission Specialists Ellen Ochoa, Jerry Ross, Rex Walheim, Steve Smith, and Lee Morin – performed four space walks and used the space shuttle and ISS robotic arms to install and outfit the S0. They also prepared the first railroad in space, the Mobile Transporter, for use.

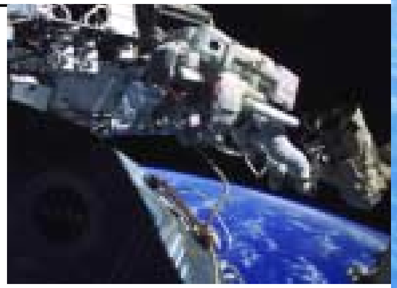
STS-110: A MISSION OF MILESTONES

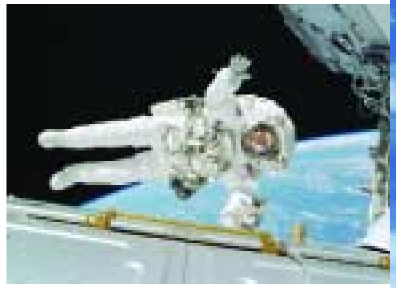
Space Shuttle *Atlantis*' flight to the ISS included several milestones. The STS-110 crew delivered the S0 Truss, the first of 11 pieces that will make up the space station's external framework, eventually stretching to 356 feet in length.

STS-110 Mission Specialist Jerry Ross became the first human to be launched into space seven times. With the two space walks that he performed on this mission, he also earned the distinction of the most U.S. space walks (nine) and space-walking time – 58 hours 18 minutes. Second on the list for both space-walking milestones is Ross' crewmate, Mission Specialist Steve Smith, who also conducted two space walks during STS-110, amassing a total of 49 hours 48 minutes during seven space walks. The total time for the four space walks was 28 hours 22 minutes, which set a record for a single ISS assembly mission.

LOOK AT WHAT'S UNDER THE HOOD!

When STS-110 launched, it became the first space shuttle to use three Block II main engines. The enhanced engines incorporate an improved high-pressure fuel turbopump with a stronger integral shaft/disk and tougher-than-steel bearings. The new design also eliminates welds in the turbopump. These changes will increase the number of flights between major overhauls, reducing operating costs. The new turbopump is not much larger than an automobile engine, yet it generates 360 times the horsepower.





■ *Astronaut Rex J. Walheim, anchored to the Canadarm2, works on connections of the S0 truss during the first scheduled EVA.*
■ *STS-110 and Expedition Four crews pose for a group photo in the* Destiny *laboratory on the ISS.*
■ *Astronaut Rex J. Walheim during the mission's second EVA for the duo of Walheim and Steven L. Smith (out of frame) which included work on the station's robotic arm as well as the giant truss.*
■ *Jerry L. Ross, STS-110 mission specialist, displays mission logos representing the record seven shuttle missions he has flown.*

Every great advance in science has issued from a new audacity of the imagination.

John Dewey

Anchored to the International Space Station's Canadarm2 some 240 miles above the blue and white Earth, astronaut Lee M.E. Morin totes one of the S0 keel pins, which were removed from their functional position on the truss and attached to its exterior for long-term stowage. Morin, teamed up with astronaut Jerry L. Ross (out of frame) for the extravehicular work, was participating in his first career EVA and the second of four scheduled overall STS-110 space walks.

STS-111

Highlights

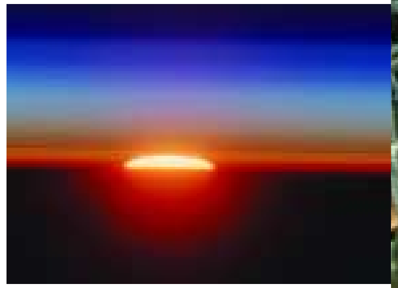
Mission	International Space Station Flight UF-2
Shuttle	*Endeavour*
Launch Pad	39A
Launch	June 5, 2002 4:23 p.m. CDT
Window	5 minutes
Docking	June 7, 2002 11:25 a.m. CDT
EVAs	3 space walks
Undocking	June 15, 2002 9:32 a.m. CDT
Landing	June 19, 2002 12:58 p.m. CDT
Duration	13 days, 20 hours 35 minutes
Orbit Altitude	122 nautical miles
Orbit Inclination	51.6°

ENDEAVOUR RETURNS RECORD-SETTING CREW

Space Shuttle *Endeavour* and its crew completed a flawless ISS crew exchange mission, the fourth of its kind to date by the space shuttle. *Endeavour's* crew consisted of Commander Ken Cockrell, Pilot Paul Lockhart, and Mission Specialists Franklin Chang-Díaz and Philippe Perrin, and the ISS Expedition 5 crew: Valery Korzun, Peggy Whitson, and Sergei Treschev. When *Endeavour* landed, it marked the end of a record-setting flight by the Expedition 4 crew, Yury Onufrienko, Dan Bursch, and Carl Walz. For Walz and Bursch, the 196 days spent in space earned them the U.S. spaceflight endurance record. The previous record was 188 days, set by Shannon Lucid aboard the Russian *Mir* Space Station in 1996.

The ISS received a new crew and a new platform for its robotic arm when STS-111 visited, which was the 14th space shuttle mission to visit the orbital outpost. STS-111 was the first flight of a launch-on-need ISS orbital replacement unit in the orbiter's payload bay. Launch-on-need is a streamlined procedure now used to significantly shorten the time needed to replace critical ISS spare parts.

The STS-111 astronauts performed three space walks to install the Mobile Remote Servicer Base System, a power and data grapple fixture, and Service Module debris panels onto the ISS and replace the wrist roll joint on the space station's robotic arm. The STS-111 crew also unloaded 8,983 pounds of supplies and science experiments from the Leonardo Multi-Purpose Logistics Module and space shuttle middeck.



■ *Astronaut Philippe Perrin floats near the Microgravity Science Glovebox in the* Destiny *laboratory.*
■ *The STS-111 (back row) and Expedition 5 crew members gather for a group photo.*
■ *Astronaut Franklin R. Chang-Díaz, anchored to the foot restraint at the end of the Canadarm2, participates in the first scheduled EVA for the STS-111 mission.*
■ *This sunset over the Sahara Desert was photographed by the STS-111 crew members aboard* Endeavour.

The Space Shuttle Endeavour *lifts off, creating billows of smoke and steam on its way into space to the International Space Station. Mission STS-111 was the 18th flight of* Endeavour *and the 110th flight overall in NASA's Space Shuttle program. This mission marked the 14th shuttle flight to the ISS and the third shuttle mission for 2002.*

Space Shuttle Program Development

Lee Norbraten
Manager, Space Shuttle Development

Planning for Long-Term Operations

Fiscal Year 2002 was another successful year with outstanding progress in several upgrade projects. The Cockpit Avionics Upgrade (CAU), which will significantly increase crew safety by improving situational awareness and reducing workload, has successfully completed its initial design review and several testing milestones. This project is on schedule and within budget, and is slated for a critical design review next year. The space shuttle main engine's (SSME) block II fuel turbopump, which was fully implemented in 2002, and the advanced health management system will significantly improve ascent reliability. The external tank (ET) friction stir welding process, which is being used today to manufacture ET hardware, is producing much stronger, defect-free welds.

FY 2002 UPGRADE PROJECTS
Safety Upgrades
Cockpit Avionics Upgrade, Phase I
SSME Advanced Health Management System, Phase I
Improved Main Landing Gear Tire and Wheel
ET Friction Stir Weld
Supportability Upgrades
Long Life Alkaline Fuel Cell
SRB Integrated Electronics Assembly
RSRM Nozzle/Case Joint J-leg Insulation
SRB Range Safety Command Receiver-Decoder
SRB Altitude Switch Assembly
Micro-meteoroid Orbital Debris
Device Driver Unit
Mass Memory Unit

These upgrade accomplishments can be seen in more detail within other sections of this report. They, along with supportability upgrades, demonstrate our commitment to improving our hardware and ensuring safe, reliable space transportation. Other ongoing projects with significant accomplishments this year are depicted in the table on this page.

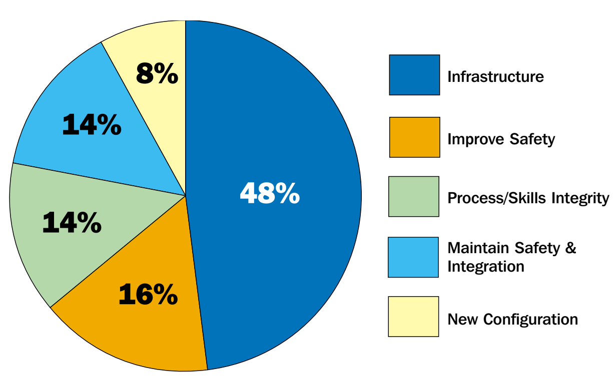
SERVICE LIFE EXTENSION STRATEGY

The Shuttle Development Office developed the service life extension investment strategy, identifying upgrades and supportability options to maintain the space shuttle fleet capabilities through at least the middle of the next decade and potentially through 2020. A core team composed of members from each of the program/project elements and NASA Headquarters was assembled to recommend projects to be funded. An executive committee composed of SSP council members, NASA Headquarters representatives, and industry partners was established to provide oversight of the core team.

The team selected and developed the Analytic Hierarchy Process as an objective ranking tool to prioritize candidate projects. It is a mathematical-factors-based analytical tool that enables the explicit ranking of projects based on selected factors and weightings. The Analytic Hierarchy Process has been successfully used by many private industry companies and government agencies, such as IBM, Ford Motor, Lockheed Martin, U.S. Department of Veteran's Affairs, Federal Aviation Administration, United States Army, and the Department of Housing and Urban Development.

The request to assess the space shuttle capability to fly through 2020 allowed the Space Shuttle Development Program Office to make a longer-term and, therefore, more strategic approach to safety and supportability upgrades. The scope of the review covered all assets needed to fly safely and effectively, noting that any deterioration of these assets could represent additional risk to the program. This assessment included the high-profile safety upgrades as well as ground support and test equipment, facilities and infrastructure, vendors and suppliers, and critical skills. We also solicited ideas from throughout the shuttle government and contractor community to ensure a complete canvassing of the service life extension needs. The team, which initially identified over 300 distinct needs, is currently reviewing each of them so that the items that have the highest urgency and the highest risk are addressed in proper order. These needs will be reassessed annually to maintain proper prioritization. The chart below shows the percent of projects separated by category.

SERVICE LIFE EXTENSION CANDIDATES

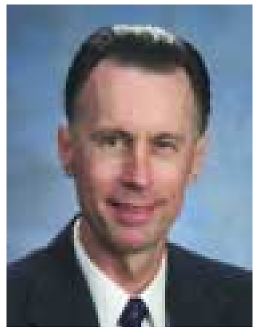


No pessimist ever discovered the secret of the stars, or sailed to an uncharted land, or opened a new heaven to the human spirit.

Helen Keller

This view of shock-wave condensation collars backlit by the Sun occurred during the launch of the Space Shuttle Atlantis on September 8, 2000. The scene was captured on 35mm motion picture film. One frame was digitized to make this still image. Although the primary effect is created by the forward fuselage of the Atlantis, secondary effects can be seen on the SRB forward skirt, shuttle vertical stabilizer and wing trailing edge, behind the SSME.

Systems Integration



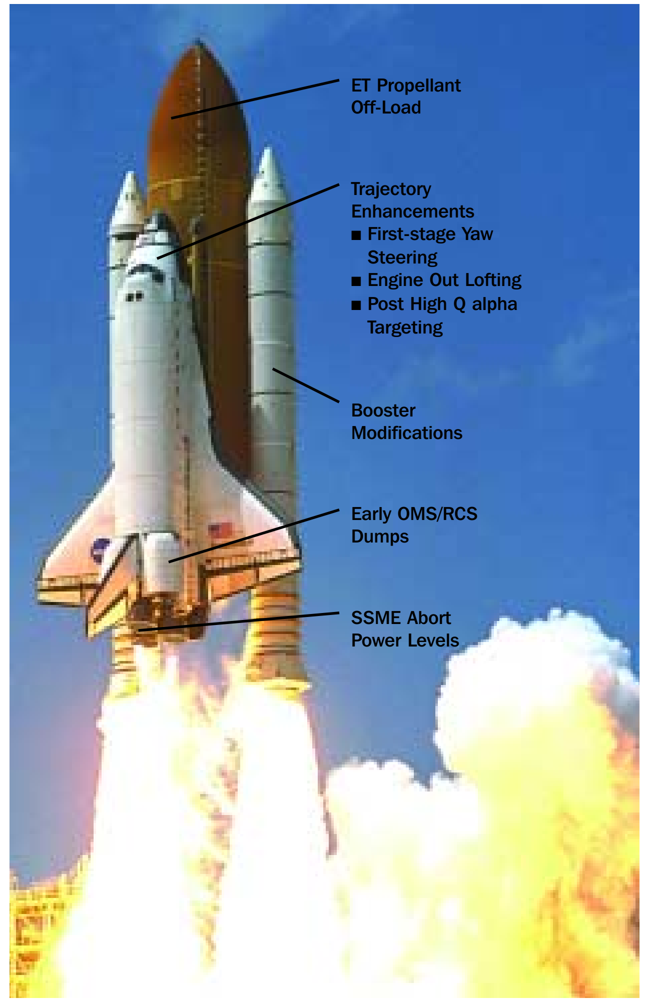
Lambert D. Austin
Manager, Systems Integration

Abort-To-Orbit From the Launch Pad

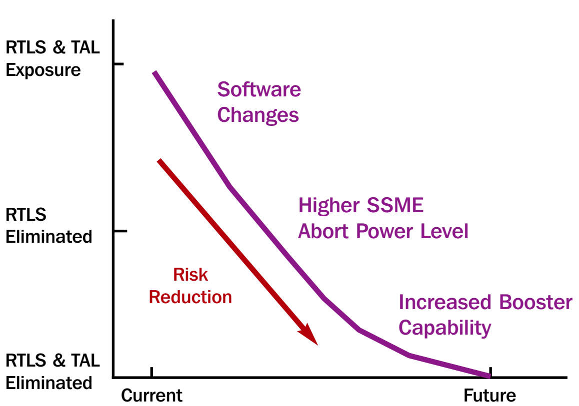
Enhancing the abort capability of the space shuttle during the ascent flight phase has been an ongoing goal of the SSP to increase operational flexibility, to expand the flight regimes for a successful mission completion with an intact abort, and to enhance flight crew and vehicle survivability during contingency events. A variety of vehicle and trajectory design enhancements have produced substantial abort improvements over the years. Initial evaluations conducted in 1996 were successful in demonstrating the feasibility of providing transoceanic abort landing (TAL) capability from the pad, thus eliminating the return-to-launch-site (RTLS) abort mode. Recent assessments have focused on eliminating both the RTLS and TAL by achieving full abort-to-orbit (ATO) capability from liftoff. This means the orbiter would be able to reach orbit even if it lost power from one SSME at liftoff or any other time during ascent flight.

In support of developing a shuttle ATO capability at liftoff, additional vehicle configuration and trajectory enhancements were identified that could be applied for improving abort capabilities. One option is to increase SSME abort power levels. Current studies are evaluating power levels as high as 113 percent. Another configuration option includes off-loading the liquid oxygen and hydrogen propellants from the ET. This propellant off-load also reduces the vehicle total weight, greatly improving thrust-to-weight conditions critical for an engine-out trajectory scenario. Additionally, a variety of trajectory design features called "abort enhancements" have been identified that improve abort capability, especially for ISS missions. These enhancements range from trajectory steering, attitude, and target optimization to the orbital maneuvering system (OMS)/reaction control system (RCS) dumps. By incorporating these trajectory enhancements in combination with booster performance modifications, trajectory and system evaluations are showing that the SSP can achieve ATO capability at liftoff.

Once achieved, ATO capability at liftoff would increase launch probability by eliminating TAL and RTLS weather constraints, increase the likelihood of space shuttle mission objectives being achieved for all intact abort modes, and increase crew survivability in contingency situations by desensitizing the flight profile to SSME failures.

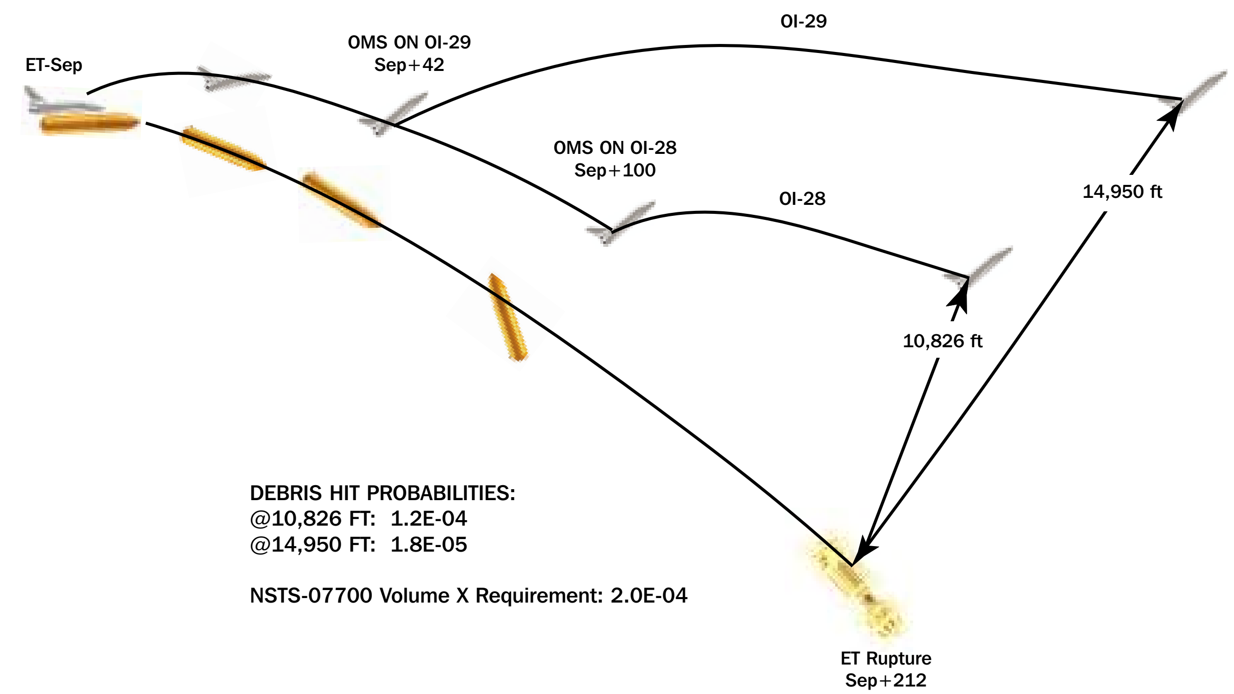


INCREASED ASCENT PERFORMANCE



Improving Performance – Reducing Risk

OI-29 POST MECO TAL IMPROVED SEPARATION



ET/ORBITER SEPARATION DYNAMICS IMPROVEMENT

A change in the shuttle flight software was implemented with Operational Increment-29 (OI-29) to improve the orbiter-to-ET separation margins by better managing orbiter alpha (pitch angle) and beta (yaw angle) at ET separation. These software changes have improved space shuttle safety through enhanced ET separation margins by reducing ET debris hit probability, improving entry interface attitude margins for the TAL aborts, and improving near-field separation clearances for nominal mission profiles. OI-29 first flew in April 2002 on STS-110.

TAL scenarios with small angles of attack (alpha) and large sideslip (beta) angles at ET separation often result in excessive orbiter roll angles at entry interface. The excessive roll angles result in significant delays in initiation of the OMS engines' post ET separation burn because the burn cannot begin until the orbiter alpha, beta, and roll angles are within a predefined set of limits. The alpha-beta management software change implemented with OI-29 eliminates the TAL excessive roll condition by actively targeting the beta and roll angles to zero and alpha to 28 degrees at entry interface. The change also automated the flight crew's previous involvement of manually managing alpha and beta for extreme cases. Avoiding delays in the OMS engine start time is critical for attaining safe separation distances from the ET, since the OMS engine burn is the primary source for generating velocity away from the ET. Maximum separation distances are important because the ET can violently rupture as little as three minutes after separation and expose the orbiter to debris impacts.

ET separation certification studies have also shown that near-field orbiter/ET attach hardware clearance margins (within the orbiter umbilical well) are improved for normal (no-failure) missions by lowering the target angle of attack at ET separation. Therefore, the OI-29 alpha-beta management software change was expanded to include lower alpha targeting at ET separation for the no-failure condition. The software change allows the pitch rate to remain in place until the desired alpha is reached or a predefined timer expires. This approach also minimizes the amount of RCS propellant required to execute the maneuver.

Systems Integration (continued)

PURSUING INCREASED FLEXIBILITY FOR QUICKER DELIVERY OF ISS SPARE PARTS

The ISS maintains, on orbit, a quantity of orbital replacement units (ORUs) for all critical subsystems. Once removed and replaced, the failed part returns to Earth on the next shuttle mission for repair, and the ISS awaits replenishment of its on-orbit spares inventory.

ORUs like the DCSU (shown here being installed in the cargo bay) require quick delivery by the SSP.

The SSP and ISS Program are working together to dramatically reduce the time between ORU replenishment need identification and flight from 1 year to 45 days.

Like other payload bay cargo, ORUs may be manifested either on the sidewall of the orbiter's payload bay or on a cross-bay carrier. Presently, any ORU to be manifested on a space shuttle mission has to be assigned roughly a year in advance of the flight to be properly analyzed for all thermal, structural, electrical, ground-handling, and other concerns. ORUs like the direct current switching unit (DCSU) manifested on STS-100/6A and the early ammonia servicer on STS-105/7A.1 were subjected to this lengthy analysis process. In the event of multiple failures involving a specific ORU, the lengthy manifesting lead-time could result in a loss of or reduced ISS critical functions. This would leave the ISS vulnerable to a partial shutdown of system operations.

Upon successful development of a new joint process to get ORUs to orbit more efficiently, ISS will be allowed to reserve locations either on the orbiter sidewall or on a cross-bay carrier for stowing ORUs of various categories. Bounding analyses will be performed, considering variations in weight, center of gravity, etc., and ORUs will be grouped into categories (defined by size, weight, and other attributes), with the goal of being able to "drop in" an ORU or define a cross-bay carrier's complement of ORUs approximately 45 days before launch. Reducing the current timeline from 1 year to approximately 45 days will dramatically improve flexibility, reduce ISS risk, and minimize impacts caused by late-breaking manifest changes.

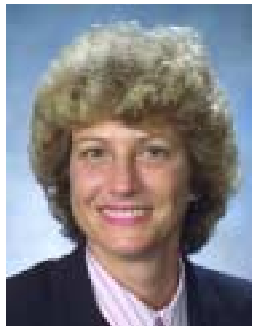
NEW CAMERA PROVIDES UNIQUE PERSPECTIVE

The SSP has developed the ability to provide a real-time, externally mounted video feed from the space shuttle during launch and ascent. This stand-alone camera system is mounted to the cable tray on the ET liquid oxygen tank to provide unique real-time views of key space shuttle events, including views of the orbiter, ET, and SRBs throughout the liftoff, SRB separation, and ET separation stages. Similar to systems previously used for the Delta and Atlas rocket programs, the camera is activated before liftoff and transmits color video via an inter-tank telemetry package incorporating two S-band antennae.

A multi-discipline, multi-center team designed this system utilizing "off-the-shelf" hardware, thereby allowing for faster implementation. Requirements included minimal facility impacts, equipment costs, and implementation time. Benefits include liftoff debris assessments, orbiter tile damage timelines, thermal protection system (TPS) performance, forward RCS paper-cover detachment, SRB plume recirculation dynamics, forward RCS jet firings, and ET separation dynamics/model verification.

New stand-alone camera provides real-time views of key space shuttle events.

Customer and Flight Integration



Michele A. Brekke
Manager, Customer and Flight Integration

The Space Shuttle and the ISS Programs are working together to establish an integrated flight assignment process for payloads. Pressurized and small unpressurized payloads requesting flight assignment on either the space shuttle or the space station will be considered for manifesting, using a more efficient, single, integrated process. This process will better serve our payload customers by implementing Agency priorities and optimizing scientific research.

The integrated process merges space shuttle and space station flight assignment responsibility into a joint forum called the Joint Research Planning Working Group. Co-chaired by representatives from Space Shuttle and Space Station Programs, it also includes representatives from the Research Planning Offices (those offices who sponsor payloads) as well as the international partners.

Upon full implementation, this process will ensure optimal use of space shuttle and space station resources. It will also provide a level playing field for flight assignments. This integrated flight assignment process takes a big step toward the ultimate goal of flying the Agency's highest-priority payloads within a reasonable timeframe.

Common Processes – Increased Science

COMMON REQUIREMENTS FOR MIDDECK AND SUB RACK PAYLOADS

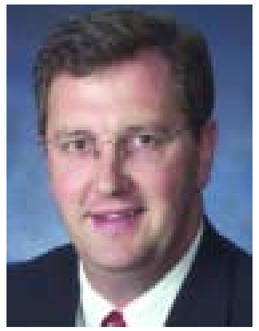
One of the goals in the payloads offices of both the SSP and the ISS Program is to provide a streamlined, user-friendly integration process for payloads. Many developers of pressurized payloads want to operate their payload facilities on both the space shuttle and the space station. Some experiments require short-duration exposure to microgravity and some require long-duration exposure, often reusing the same payload facility. In addition, many payloads that require power on orbit also require power during ascent and descent.

To facilitate the integration process for these payloads, the SSP and ISS Program have developed a set of common requirements that provides envelopes to which a developer may choose to design. A payload designed to this set will be compatible with both middeck and sub rack interfaces and requirements, significantly reducing documentation and integration resources. Note that not all requirements could be made common. In addition, the payload designer may choose not to design to the common requirements based on unique requirements.

This common requirements approach will benefit the customer as well as both Programs by reducing documentation and resources needed for integration.

Astronaut Michael J. Massimino, mission specialist, STS-109, works at the stowage area for the Hubble Space Telescope's port side solar array. Astronauts Massimino and James H. Newman removed the old port solar array and stowed it in Columbia's payload bay for a return to Earth. They then installed a third-generation solar array and its associated electrical components. Two crew mates had accomplished the same feat with the starboard array on the previous day.

Space Shuttle Vehicle Engineering



Ralph R. Roe
Manager, Space Shuttle Vehicle Engineering

Orbiter Modifications

NEW MODULAR MEMORY UNIT

A modular memory unit (MMU) has been developed to address supportability issues with the space shuttle's tape-driven data storage devices. The project's primary objective is to replace the existing functions of the space shuttle mass memory units, operational recorders, and payload recorders, and to integrate these functions into a single unit. Space Shuttle Vehicle Engineering met this objective when the MMU was used on STS-110, its first shuttle flight, in April 2002. The MMU provides storage and retrieval capability for flight-critical software and vehicle and engine data.

Implementing the MMU increases performance and reliability, and reduces weight and power consumption. Using commercial, off-the-shelf (COTS) systems and open systems standards lets us more readily achieve repairs and future upgrades.

CENTRALIZED ORBITER MODIFICATIONS TO REDUCE COSTS

Orbiter maintenance down periods (OMDPs) are periodic "time-outs" for inspections, interval requirements, time and cycle maintenance, and modification incorporation. Intrusive orbiter major modifications (OMMs) are often piggybacked onto the OMDP periods.

Previous OMDP/OMM overhauls, with one exception, have been performed in Palmdale, California, where the vehicles were manufactured. To reduce cost and centralize operations and maintenance activities, NASA Administrator Sean O'Keefe announced in early February 2002 that the planned OV103 *Discovery* OMDPs/OMM would be performed at KSC. Work officially started on *Discovery's* OMDP/OMM on September 1, 2002.

During the upcoming OMDP/OMM, *Discovery's* airframe, wiring, and subsystems will be thoroughly inspected. Several modifications will also be implemented, including the multifunction electronic display system, which will replace Discovery's mechanical cockpit instrumentation with computerized displays.

Orbiter Upgrades to Improve Shuttle Safety

COCKPIT AVIONICS UPGRADE ADDRESSES SOLUTION TO RADIATION ENVIRONMENT

The cockpit avionics upgrade (CAU) of the orbiter data processing system will significantly improve space shuttle safety by providing the crew with graphics-oriented situational awareness and by reducing the crew workload. We are accomplishing this by replacing the processors that drive the cockpit displays and developing new software that will execute in those processors.

To reduce development time, the CAU Project Team takes advantage of COTS products whenever possible. However, the higher radiation environment of space presents a particular challenge because electronic components such as computer processors and memory are particularly susceptible to radiation. Unfortunately, COTS products have not traditionally been designed with radiation susceptibility in mind. A radiation particle can cause an "upset" of the electronic patterns in these components, thereby generating unexpected and incorrect results in the executing software. Special software can be written to detect and respond to these "upsets," or the hardware can be specifically designed to withstand the radiation.

Identifying radiation as a risk to project success, the CAU Project Team embarked early with component identification and radiation testing. The team identified the best COTS products and subjected them to radiation testing. Based on this rigorous testing approach, the CAU Project Team identified and demonstrated the key critical processor and memory components. This successful demonstration is enabling the team to fulfill the goal of delivering this high-priority safety upgrade to the vehicle in the shortest possible time, with a maximum amount of throughput and memory capacity. The first flight of the CAU will be in 2006.

LONG-LIFE ALKALINE FUEL CELL UPGRADE REDUCES COSTS

In February 2000, the SSP authorized the design, fabrication, and qualification of the long-life alkaline fuel cell (LLAFC). The SSP authorized improvements to the fuel cell's power plant to increase its operational life from the current 2600 hours to 5000 hours, which will result in substantial cost savings to the SSP. The LLAFC will be replaced only half as often as the current fuel cells, at the same price. Improvements that will result in increased life include individual cell design enhancement to reduce frame corrosion, more durable external seals, non-cracking insulator plates, and a stainless steel regulator housing.

A 96-cell qualification test article has been assembled to demonstrate these improvements. The qualification test began in March of this year and will be complete in 2003. Upon successful completion of the 5000-hour test, the LLAFC will be certified and made available for installation into the fleet beginning in 2004.

MAIN LANDING GEAR TIRE AND WHEEL ASSEMBLY UPGRADE IMPROVES SAFETY MARGINS

One of the safety improvements initiated is an upgrade to the main landing gear tire and wheel assembly. The upgrade is intended to add 20 percent more load-carrying capability to the tire and wheel above the current tire/wheel certification of 142,500 pounds. Since landing loads and criteria will not be changed, the additional capability will provide a safety margin during landings. Initial activities focused on the iterative process of tire design and testing, which will result in a selection of the specific design for production in early 2003. The upgraded tire and wheel assembly will be integrated into the orbiter fleet in 2004.

This year, the focus was on development testing, which is nearing completion, in support of a Program decision this fall to select the best tire/wheel configuration. Testing at Wright Patterson Air Force Base has demonstrated that the new tire will be capable of meeting the Program goal of increasing by 20 percent the load-carrying capability to 171,000 pounds. Testing is now under way to determine which tread compound provides the best wear resistance for landings at KSC and Edwards Air Force Base.

On the current tire, about 0.42 inches of material was worn away, and three of the 16 carcass plies were exposed. On the new tire, only 0.12 inches of tread material was worn away, and none of the carcass plies were exposed.

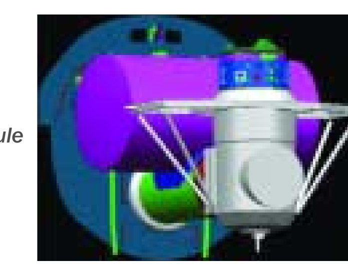
Increased Safety – Increased Reliability

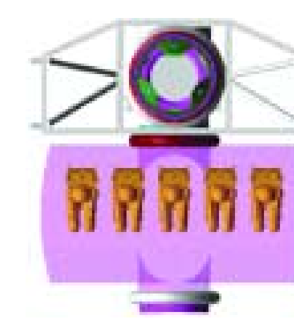
ENHANCED CREW ESCAPE STUDY

As part of the SSP's continuing effort to improve overall vehicle safety and reduce crew risks, enhanced crew escape systems continue to be investigated. Studies included crew egress systems ranging from extraction seats to pressurized capsules for retrofit into the orbiter fleet. The most promising concept to date uses ejection seats incorporated into an additional crew compartment located in the payload bay between the forward payload bay bulkhead and the external air lock, as shown in the figure. Five crew members would ride in ejection seats in the compartment during ascent and descent. Both orbiter pilots would also be seated in ejection seats inside the orbiter crew module. In the event of an incident requiring crew ejection, crew members would eject from both the payload bay compartment and the crew module and parachute to safety.

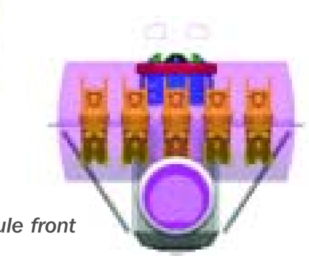
The Enhanced Crew Escape Study will continue next year, refining the payload bay ejection seat compartment concept and continuing to examine the associated escape systems for technical feasibility.

Payload bay module





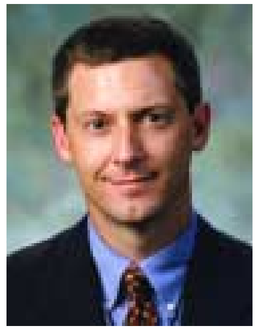
Payload bay module top



Payload bay module front

Extravehicular Activities

New Strategies Reduce Cost, Improve Efficiencies



Allen Flynt
Manager, Extravehicular Activity

EVA performance in the last year has been remarkable. In the four missions (STS-108, -109, -110, & -111) since October 2001, the crews executed 13 EVAs – a total of 87 hours.

EVAs are a fundamental component in the assembly of the ISS. They also enable on-orbit serviceability of satellites and the HST.

STS-109 HST SERVICING MISSION-3B

One of the past year's highlights was the servicing of the HST. During the STS-109 mission in March 2002, the space shuttle crew successfully executed five EVAs in five consecutive days to upgrade and service the HST. This was the fourth time that visiting astronauts performed EVAs to make life-extending changes and to improve Hubble's overall productivity. Upgrades included installing two new rigid-panel solar arrays, the Advanced Camera for Surveys, and a cryogenic cooler and radiator system for the Near Infrared Camera and Multi-Object Spectrometer. Maintenance tasks included the critical replacement of the power control unit and replacement of a reaction wheel assembly. The HST Program confirmed during the flight that all of the EVA-installed components were activated successfully. STS-109 accumulated 35 hours 55 minutes of EVA time. To date, 14 different astronauts have conducted 18 space walks during the four space shuttle servicing missions for a total of 129 hours 10 minutes. The observatory is now collecting scientific data at an unprecedented rate, and current estimates are that the instrument upgrades installed during the STS-109 mission have resulted in a factor of 10 improvement in overall discovery efficiency.

EXTRAVEHICULAR MOBILITY UNIT SYSTEM LEVEL ORUs

With increased EVA tasking in the future, we must improve efficiency in order to implement a successful EVA program within NASA's budget constraints. NASA initiated a review of all extravehicular mobility unit (EMU) processing (ground and on-orbit), and implemented a new approach to both.

To improve operational flexibility, on-orbit reliability, and ground processing, we have redesigned several interfaces within the EMU, to provide an on-orbit capability to exchange major components. After several years of redesign, production of new hardware, and fleet conversion, the EMU now can be separated into four major ORU systems.

These 100 percent interchangeable components can now be separated by an unassisted crew member while on orbit, without the use of special tools. All interfaces use captive fasteners, one-way installations, and self-alignment features with visual feedback of proper installation. What's more, these ORU interface features do not require on-orbit maintenance.

Highlighting improvements, the HUT (hard upper torso) is conformable to three different sizes. This flexibility enables the crew to effect size changes on orbit in case of hardware failure and ensures an optimized suit fit for crew members. The modular element flexibility also drastically reduces volume and weight impacts to shuttle payload capability if replacement items are needed. Previously, an entire ORU was needed to facilitate a fit change or replace failed components.

EVA COST REDUCTIONS AND EFFICIENCY IMPROVEMENTS

Over the past year, the EVA Project Office has implemented multiple strategies to reduce the cost of EMU processing and improve efficiencies. By taking advantage of 20 years of historical experience with the EMU design, and lessons learned over the last 3 years of heavy EVA operation, we have established more realistic assumptions to reduce requirements. For example, because of a much better understanding of actual EMU use with a demonstrated reliability greater than predicted, the EVA Project Office has reduced sparing requirements by 15 to 20 percent, resulting in immediate and significant fiscal savings.

To provide maximum useful life of the hardware inventory, we minimized ground processing to only those tests that truly screen for proper performance. This results in a reduction in processing time from about 53 days to 7 days, and lowers overall program costs by reducing the total number of EMUs processed each year from about 22 to 16.

We also reviewed EMU on-orbit logistics to maximize on-orbit hardware life and to maximize interchangeability. This approach accommodates crew sizes and preferences with the minimal amount of hardware on orbit. It also provides the most EVA capability should there be on-orbit hardware failures.

These new ways of viewing the EMU system will result in approximately $60M in savings over the 6-year budget horizon, all accomplished without increasing risk toward safe operation of the spacesuit. The EVA Project Office is currently expanding this effort to improve efficiencies by looking at the processing and sustaining of EVA tools and requirements associated with EVA training.

Astronauts John M. Grunsfeld (right) and Richard M. Linnehan, STS-109 payload commander and mission specialist, respectively, are photographed near the Hubble Space Telescope.

Astronauts James H. Newman, on Columbia's remote manipulator system robotic arm, and Michael J. Massimino participate in the Advanced Camera for Surveys science instrument upgrade during the STS-109 HST servicing mission.

Mission Operations

Jon C. Harpold
Manager, Mission Operations

Reinvention Leads to Flexibility and Reduced Cost

NASA's Space Shuttle Program is continuously improving to make America's space shuttle more efficient and cost-effective. One major Program objective is to reduce the time required to design, integrate, and launch a shuttle mission. Responding to this objective, the Mission Operations Directorate and United Space Alliance formally initiated a continuous improvement effort. This effort is paying big dividends and, when fully implemented, will reduce the flight preparation timeline from over a year to about 7 months.

Several innovations have led to greater efficiencies, such as the new Cargo Support System, which allows a shuttle payload to be operated from a portable laptop computer, the Cargo PC℠, instead of the space shuttle's on-board computers. Decoupling payload operation processes from the shuttle on-board computers can help ensure that flight operations processes are no longer the "long pole" in the shuttle flight preparation process. The new Cargo Support System is scheduled for final shuttle program review and acceptance in December 2002.

Other innovations include the just-in-time flight design (JITFD) process, which allows the shuttle flight design to be deferred closer to the launch date and allows the program more flexibility to change the flight manifest. JITFD reduced the time it takes to design and produce the flight design products for a shuttle mission by 17 weeks and enabled significant cost savings for the program. The JITFD process changes have already been approved by the Mission Operations Directorate, and were used for flight design beginning with STS-112. Another important improvement is the Orbiter-in-a-Box, which is a portable computer platform with an embedded real-time model of the Shuttle avionics. Using the Orbiter-in-a-Box with a Cargo PC℠ allows customers to test their payloads with actual shuttle flight software at their own facilities. Orbiter-in-a-Box systems are already being sent to customers for possible support of future shuttle flights.

Flight Operations Reinvention is one of the SSP's most significant continuous improvement initiatives, and has resulted in cost savings to the program of nearly $5 million per year. In the words of Shuttle Program Manager, Ron Dittemore, "The success of the Space Shuttle Program is built around our commitment to safety, our exceptional teamwork, strategic implementation of the best technologies, and our continuous process improvements. Flight Operations Reinvention has provided significant new capabilities and cost-reducing innovations that can dramatically streamline our flight preparation process, and it exemplifies our strong commitment to continuous improvement."

Using the Orbiter-in-a-Box with a Cargo PC℠ allows customers to test their payloads with actual shuttle flight software at their own facilities.

Shuttle Processing

David A. King
Director, Shuttle Processing

Infrastructure Revitalization Reduces Risk

Upgrades and New Development

INFRASTRUCTURE REVITALIZATION INITIATIVE

NASA created the Infrastructure Revitalization initiative in FY 2000 to objectively understand the risk to the shuttle manifest from aging facilities and equipment, to prioritize the highest-ranking-risk projects, and to propose an implementation plan to SSP management that would most effectively mitigate these risks.

In FY 2001, the SSP funded 20 projects across nine elements of the Program. In FY 2002, the SSP continued this commitment by funding eight projects. The following are representative examples of projects implemented at various NASA Centers with this funding:

Kennedy Space Center – Implementing the restoration of low-voltage (480 Vac) power systems at Launch Pads A and B.

Michoud – Implementing repairs to the shipping docks at which the ET barge loads ETs for shipment to KSC.

Stennis Space Center – Continued the rehabilitation of the A-2 test stand for SSME testing.

Additionally, in late FY 2002, the Program began the rehabilitation of the Vehicle Assembly Building at KSC. The design phase of these projects has been initiated with anticipated initial implementation in early FY 2003.

CONVOY COMMAND VEHICLE DELIVERED

A new convoy command vehicle was delivered, replacing the 15-year-old model. The vehicle will be used during launch and landing operations, with its first use scheduled for the STS-112 launch. The vehicle will be used following shuttle landings as the prime vehicle to control critical communications between the orbiter, the crew, and the Launch Control Center, monitoring the health of the systems and directing postlanding convoy operations at the Shuttle Landing Facility.

HAZARDOUS GAS DETECTION SYSTEM 2000 INSTALLATION COMPLETED

The new hazardous gas detection system (HGDS 2000) was successfully deployed and initially supported during the STS-109 pad flow and countdown. Subsequently it has successfully supported the STS-110, STS-111, and STS-112 pad flows and countdowns. The new systems greatly increase the reliability, maintainability, and supportability of the hazardous warning systems on the Mobil Launch Platforms. Final responsibility transition from NASA to United Space Alliance is in work.

MOISTURE BUILDUP PREVENTION PROCESS DEVELOPED

A process that eliminates the buildup of moisture in the thruster combustion chambers of the primary reaction control system used by each of the orbiters has been developed at KSC. The combustion chambers are purged with gaseous nitrogen, which precludes the buildup of moisture in the chambers. Maintaining an active purge will preclude the need to replace thruster desiccants. It is projected that this will save $500,000 in desiccant cost over a five-year period and provide a cost avoidance in associated labor.

E-Business

The following three items support the President's government-wide initiative to expand electronic government. Automating these processes will create easy-to-find, single points of access for this information, reduce the burden of reporting this information on the individuals who own these processes, and make the sharing of information across departments more efficient and convenient.

CONSTRAINT AUTOMATED TRACKING SYSTEM ACTIVATED

The newly developed Constraint Automated Tracking System was activated on August 12, 2002. This Web-based system provides viewing capability of active shuttle flight hardware and ground support equipment work authorizing document constraints. The new tracking system provides an automated source to track and display shuttle testing constraints. This provides more timely updating and distribution of test constraints while reducing the labor required to maintain and update the constraints list.

Shuttle Processing (continued)

AUTOMATED CHANGE PROCESSING SYSTEM (CHANGE EXPRESS)

The United Space Alliance ground operations and NASA shuttle processing change management system for program requirements has been automated. The system is paperless, Web-based, and provides a single point of access for data reports and queries. The system greatly enhances data entry capabilities. The change request and evaluation data are stored in a database, and related documentation is stored on a document server. The ground operations change request process improvements recognized include:

- Eliminates hand-offs between change controller and others in the process
- Eliminates the need for reviewer organizations to retain file copies
- Eliminates the need for reviewer organizations to maintain internal tracking
- Reduces official record documentation (only retains signed change request)

TIME, AGE, CYCLE CONTROL SYSTEM MIGRATED TO SILVERSTREAM

The Time, Age, Cycle Control System (TACCS) was migrated from an obsolete mainframe to Silverstream (client/server application). TACCS tracks orbiter and mission equipment hardware that has time, age, and cycle requirements. In addition, TACCS maintains the related event records for approximately 44,000 serialized components. It was essential that historical data be maintained and successfully migrated to the new system, requiring extensive data validation effort on the part of the TACCS analysts who are the most knowledgeable about the data. System migration included requirements definition, development, user testing, and data migration.

Atlantis is lowered to the external stack in the Vehicle Assembly Building.

Shuttle Integration

Jolene Martin
Manager, Shuttle Integration Office

SSP elements continue to identify environmental and obsolescence threats that could have adverse effects on mission safety and supportability. The Shuttle Environmental Assurance (SEA) Team, comprising representatives from all SSP elements and supporting organizations, is responsible for identifying and mitigating environmental and materials obsolescence concerns through communication, information sharing, and collaborative efforts. This integrated approach reduces redundant tests and overall testing requirements and costs, improves the availability of technical expertise across the program, provides early warning information for emerging concerns, and supports interfaces with outside agencies.

Materials obsolescence issues are driven by many factors, including vendor economics and restrictions on the use of ozone-depleting chemicals, air pollutants, and hazardous materials. These restrictions drive vendor changes that require materials replacement and requalification. SEA members continually review current and emerging environmental regulations for potential SSP operational impact, including regulations under the Clean Air and Water Acts, Toxic Substances Control Act, Occupational Safety and Health Act, and Executive Orders.

Members of the SEA team systematically analyze potential issues across the SSP, evaluate risks, share relevant data, develop mitigation plans, and facilitate collaborative efforts. Major efforts in 2002 included investigating replacements for HCFC 141b foam-blowing agent, trichloroethane (TCA) solvent, and the hexavalent chromium used in primers and conversion coatings.

- HCFC 141b, an ozone-depleting chemical, is used for foam insulation on the ET, the orbiter, and the SRB. The ET Project and Marshall Space Flight Center are developing an alternate foam that will not contain ozone-depleting chemicals. The results of these efforts are being shared with the Orbiter and SRB Projects. Additional collaborative studies are being evaluated.

Combined Efforts Save Program Costs

- TCA is another ozone-depleting chemical required in critical orbiter and reusable solid rocket motor (RSRM) processes. Since 1993, the RSRM Project has reduced the use of TCA by 93 percent, and is working on additional replacements to further reduce usage. The Orbiter Project has eliminated the use of TCA in 247 procedures, with one critical process requiring TCA remaining. The Orbiter Project has stockpiled sufficient TCA to meet its needs for the remaining critical application. Information exchange between the elements has helped to identify potential replacements and reduce TCA use.
- All shuttle elements are working to replace toxic hexavalent chromium presently used to prevent corrosion of aluminum substrates. The SRB Project has qualified and implemented replacements for both chromated primers and conversion coatings. The Orbiter Project is testing a non-chrome primer on Space Shuttle *Columbia*. These successes support identification of replacement materials by the other elements.

Shuttle Integration takes outreach, education, and shuttle benefits seriously with a presence at national aerospace and manufacturing exhibits throughout the United States.

External Tank

Jerry W. Smelser
Manager, External Tank

Increased Producibility and Reliability With Friction Stir Weld and Lean/Six Sigma

In 2002, the ET Project, including its industry partner, Lockheed Martin, implemented changes to enhance its production processes. These changes increased producibility, reducing cycle time and cost while increasing overall reliability of the hardware.

Specific steps taken to increase producibility included substituting Al 2219 for Al 2195 on domes and ogive structures. In conjunction with this change, the ET Project combined the current fusion welding process for domes and ogives with the implementation of friction stir welding (FSW) for Al 2195 barrels.

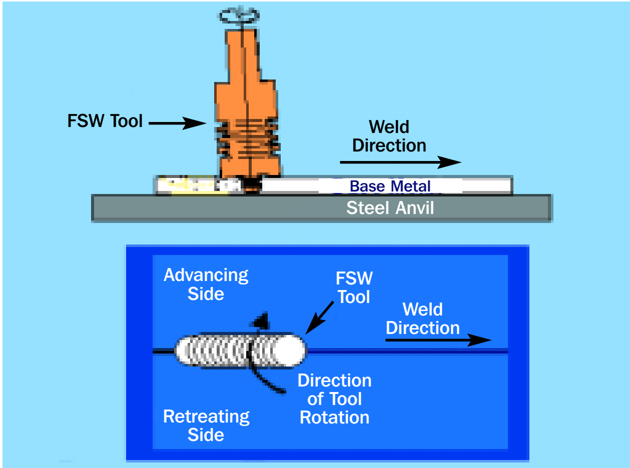
FSW IN PRODUCTION

The ET Project developed and implemented a revolutionary welding technique that vastly simplifies and greatly enhances the strength and quality of the ET's welded joints. FSW is a solid-state welding method that joins two members through frictional forces combined with forging pressures. Since the existing ET welding tools could not be readily adapted to accommodate these new requirements, new tools were designed and built to allow for the structural loads associated with FSW.

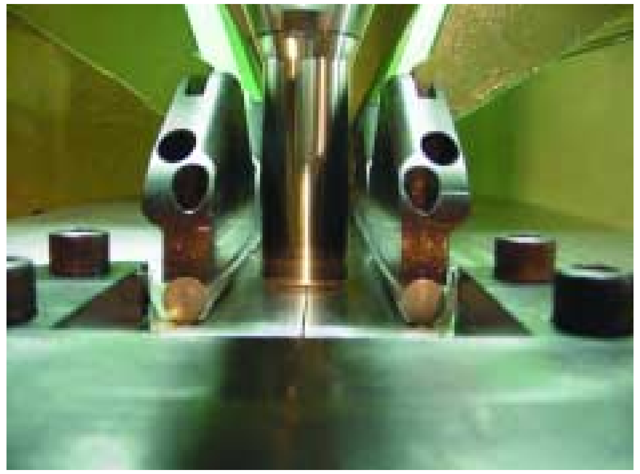
This year, the ET project achieved a critical milestone in the FSW project when we activated the first of two FSW tools. These tools are being used to weld the longitudinal barrel welds for both the hydrogen and oxygen tanks. The first tool was activated in late October and is currently welding ET flight hardware. The second tool will be activated in January 2003.

The result of this process change has been nothing less than remarkable! To date, the welds made with FSW are virtually defect-free and are approximately 48 percent stronger than previous fusion weld techniques were capable of achieving. Additionally, the actual welding time has been cut in half due to the robustness of the process and the reduced number of welding passes. The result is a safer, more reliable welded joint for the space shuttle's ET.

The FSW Project has been a major success for the Shuttle Program by achieving all of its technical objectives, schedule projections, and cost targets.



Friction stir welding process schematic



Friction stir weld in process on training unit

LEAN/SIX SIGMA AND BUILD PROCESS TEAMS

In 2002, NASA and Lockheed Martin continued their aggressive plan to implement Lean/Six Sigma and Build Process Teams (BPT) in manufacturing. Lean/Six Sigma focuses on reducing/eliminating defects and taking variables out of the process, thus making the process more predictable and improving overall quality of the product. BPTs have been established in 41 manufacturing work centers and consist of technicians, inspectors, supervisors, and essential technical support personnel. Each BPT is chartered to improve quality, safety, cost, and schedule performance within the work center. Over 1000 employees are assigned to BPTs.

Increased Productivity – Reduced Cost

Five Six Sigma SPC Teams are actively pursuing process improvements to minimize rework, prevent defects, and improve quality trends in a wide variety of process areas. Lean/Six Sigma initiatives continue to deliver programmatic benefits with cumulative labor hour reductions running in the 11- to 13-percent range. Lean/Six Sigma improvements, combined with BPT initiatives, resulted in an average 13,000 fewer build hours for the last four ETs in the Fifth Buy Production Contract (which concluded in September).

First part results: 85 percent decrease in machining time

Utilizing existing equipment, Process teams have saved time and cut costs by automating super-light ablator trimming operations.

MICHOUD ASSEMBLY FACILITY ENVIRONMENTAL MANAGEMENT PROGRAM

The Michoud Assembly Facility Environmental Management program continues to demonstrate sustained outstanding environmental compliance and operations. In FY 2002, this sustained performance was substantiated by unannounced regulatory agency inspections of Michoud's Hazardous Waste Management and Clean Air Act Compliance Programs. No violations or issues were identified. Since the program's inception in 1982, the site has never had a compliance violation or enforcement issue.

The ET manufacturing process uses hazardous materials and generates waste and air emissions. Michoud has an aggressive program to reduce these site emissions and wastes. Proactive pollution prevention and waste reduction programs have yielded a 93 percent reduction (from EPA's 1988 baseline) in air emissions and off-site disposal of EPA targeted chemicals. Hazardous waste generation has decreased 38 percent since 1995. Manufacturing process improvements and material substitutions resulted in Governor's Awards for Environmental Leadership three years in a row. Michoud received its fourth Governor's Award in 2002 for implementing a materials recovery program that has recycled over two million pounds of nonhazardous waste since its initiation in April 2000. As a result of this aggressive approach, industrial waste generation has decreased by 19 percent.

From left to right: Dale Givens, Secretary, Louisiana Department of Environmental Quality; Jeffrey Irby, NASA; Rebecca Jordan, L-M; Rey Abadie, L-M; Richard Hammant, Legacy Project; Daniel Swords, L-M; Jennifer Wall, L-M; Mike Foster, Governor of Louisiana

Reusable Solid Rocket Motor

Michael U. Rudolphi
Manager, Reusable Solid Rocket Motor

Solid Rocket Motor Safety, Ergonomic, and Reliability Enhancements

Several enhancements have been recently incorporated into processing of the space shuttle Reusable Solid Rocket Motor (RSRM). These enhancements are significant because of their improvements in risk reduction as well as personnel and hardware safety.

Safety continues to be a principal focus in the manufacture of the Space Shuttle Program's RSRM. This is reflected in the job-related accident rates at ATK Thiokol Propulsion (Promontory), which have been well below the rates for similar industries.

ATK Thiokol Propulsion (Promontory) reached a number of significant safety milestones this past year. The Final Assembly Work Center surpassed 2,000,000 hours or 8 years without a lost time accident. In addition, the Quality Assurance Department completed over 1,000,000 hours or 1.3 years without a lost time accident. Because of the low accident frequency rates, ATK Thiokol Propulsion received the following awards this past year:

- Occupational Hazards Magazine (November 2001 Issue) "Champions of Safety" award for CY 2001
- Utah Labor Commission's "Workplace Safety Award for Self-Insured Employer"

PROCESS AUTOMATION

Automating critical flight hardware processes offers substantial returns regarding hardware acceptability and reliability. For metal parts, where flaw detection is imperative and refurbishment damage must be minimized, the automated eddy current inspection and grit blast processes offer great improvement.

The automated eddy current inspection system is an electronic sensor-based inspection capability that will replace current visual-based, manual, nondestructive evaluation. Benefits include minimizing human inspector variability and subjectivity, and digital evaluation of indications. Testing of the new system is nearing completion. Implementation of the new system is planned for later this year.

Current manual glass bead cleaning operations have inherent safety and ergonomic hazards, including working directly with high-pressure equipment. Additionally, the hardware is at risk due to human variability and operator technique, which contribute to inconsistent repeatability and excessive material erosion in critical features. New automated robotic systems are undergoing checkout and testing. All systems will be qualified for flight hardware in 2002.

Automating critical flight hardware processes offers substantial returns regarding hardware acceptability and reliability.

RSRM Test and Component Development Accomplishments

FULL-SCALE RSRM TEST MOTORS

During the past year, the RSRM Project completed several major milestones in efforts to improve RSRM design robustness and address future obsolescence issues. A cornerstone of these initiatives was the successful static-test of engineering test motor 2. The Engineering Test Motor Project is an ongoing initiative to test in full-scale those design elements that are not yet ready for certification testing or are exploring "fault tolerant" performance characteristics. The RSRM Project's second full-scale engineering test motor was static-tested November 1, 2001.

Recent Enhancements Increase Safety

Major test accomplishments included:

- Successful demonstration of carbon fiber rope (CFR) as a new nozzle joint thermal barrier
- Successful demonstration of a new, robust bolted joint design for Nozzle Joint 5, which will eliminate both joint skip and plastic deformation of washers
- Demonstration of rayon carbon cloth processing enhancements designed to eliminate the potential for throat pocketing
- Evaluation of several rayon replacement candidates

24-INCH SOLID ROCKET TEST MOTOR

In past years, the modified NASA motor has been the only large subscale test vehicle available to the RSRM Project for validation of material changes or design concepts before full-scale static testing. The solid rocket test motor (SRTM) was recently developed as a low-cost test bed for RSRM nozzle and insulator components to supplement the modified NASA motor. The SRTM typically enables gathering approximately 90 percent of the data a modified NASA motor provides at roughly one-third the cost.

In developing the SRTM, particular care was taken in the design of the aft dome and submerged nozzle region to provide flow similarity with the full-scale RSRM aft dome environment. The result is a test bed providing the same heating and erosion environment as a full-scale RSRM in the aft dome and nozzle entrance regions for evaluation of new insulation and nozzle materials. Additionally, the SRTM is the only subscale test motor capable of being fired nozzle down to simulate slag pooling in the aft dome region.

To date, static tests conducted at Marshall Space Flight Center have supported a variety of objectives, including development of CFR for RSRM nozzle joint application, RSRM aft dome candidate insulation erosion performance, and rayon replacement project material screening.

	MNASA	SRTM
Propellant Wt. (lb)	10,000	1,780
Throat Dia. (in.)	10	5
Burn Time (sec)	25	20
RSRM Flow Similarity	No	Yes
Nozzle Down Testing	No	Yes

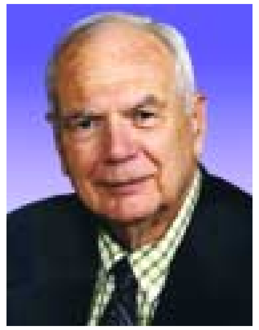
The RSRM Project's second full-scale engineering test motor was static-tested November 1, 2001.

NEW THERMAL BARRIER FOR RSRM NOZZLE JOINTS

The RSRM nozzle contains five major joints where subassemblies are brought together to form the nozzle assembly. The RSRM design currently uses room-temperature vulcanization as a thermal barrier in these joints. Installation of room-temperature vulcanization into the nozzle joint requires significant operator skill and timing to ensure that the joint is adequately backfilled. Use of CFR in development testing, which includes full-scale static-test motors, has proved to be a more simplified and thermally improved approach to thermal barriers in the RSRM nozzle.

Following three years of development and demonstration effort, a new thermal barrier for Joints 2 and 5, based on CFR, is now ready for certification on Flight Support Motor-10 with plans for flight implementation on STS-125. Implementation of the CFR thermal barrier will provide a major increase in design robustness and joint performance repeatability. Extensive testing in SRTM and in modified NASA subscale and full-scale motors has shown the CFR thermal barrier system cooling performance to be insensitive to gas blowby or flaws in the rope.

Space Shuttle Main Engine



George D. Hopson, Manager, Space Shuttle Main Engine

The development history of the SSME and results of probabilistic risk assessments are consistent in indicating that the high-pressure turbopumps are the largest contributors to SSME catastrophic ascent risk. The Advanced Health Management System (AHMS) Phase 1, when implemented, will reduce this risk 23 percent by providing a reliable turbopump vibration redline capability.

AHMS Phase 1, which consists of upgrades to the existing Block II SSME controller, made substantial progress in 2002. The three new AHMS circuit card designs were successfully fabricated, assembled, and integrated into two flight-configuration controllers. The first of these units is to begin qualification testing in November; the second will be used for engine hot-fire certification testing at Stennis Space Center beginning in April 2003. SMME also completed development of the AHMS digital computer unit flight software in 2002. The rigorous verification and validation efforts for this software began on schedule in August and will continue through 2003. The first four flight SSME controllers to receive the AHMS upgrade have been removed from fleet service and are in the process of being retrofitted. The project remains on schedule to support first flight in June 2004, while maintaining its full budgetary reserve for future unforeseen problems.

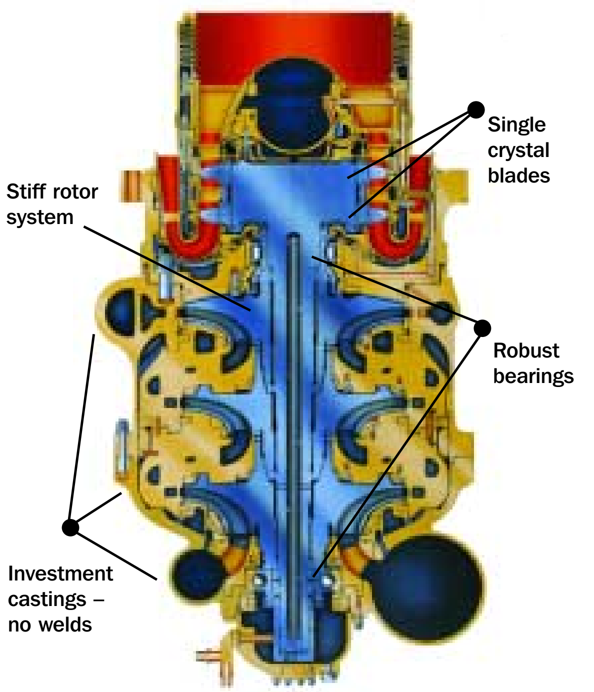
More Robust – Greater Safety Improvements

SSME BLOCK II HIGH-PRESSURE FUEL TURBOPUMP FULL IMPLEMENTATION

SSME has completed the full implementation of the Block II High-Pressure Fuel Turbopump (HPFTP/AT) into flight. The Block II HPFTP improves the engines' reliability, safety margins, and life, and reduces maintenance and overhaul costs. Incorporating the Block II HPFTP improves the reliability of the SSME 28 percent, relative to the previous design. Extensive use of investment castings eliminated 469 welds and eliminated all flow path sheet metal shielding. An improved bearing design completely eliminated wear issues and increased the load capability for rotor support system. The rotor system is very stiff and, with improved balancing techniques, the synchronous vibrations are reduced by a factor of 2 to 4. A single-piece rotor and disk along with robust bearings result in a turbopump that is very tolerant to damage.

Beginning with STS-110 on April 8, 2002, all three engines flew as the Block II configuration, which included the new Pratt and Whitney HPFTP/AT. All flights subsequent to STS-110 have been Block II and will be in the future. To date, all flown Block II HPFTP/ATs have performed flawlessly.

BLOCK II HPFTP/AT



A technician performs his work within the 7.5-foot-diameter SSME nozzle.

Each SSME produces approximately 500,000 pounds of thrust and runs until the shuttle reaches orbit at 8.5 minutes.

Engines are tested for flight acceptability at Stennis Space Center in Bay St. Louis, Mississippi.

Florida foliage frames the distant Space Shuttle Endeavour as it lifts off into an afternoon sky to begin the STS-108 mission to the International Space Station.

Solid Rocket Booster

Alex A. McCool
Acting Manager, Solid Rocket Booster

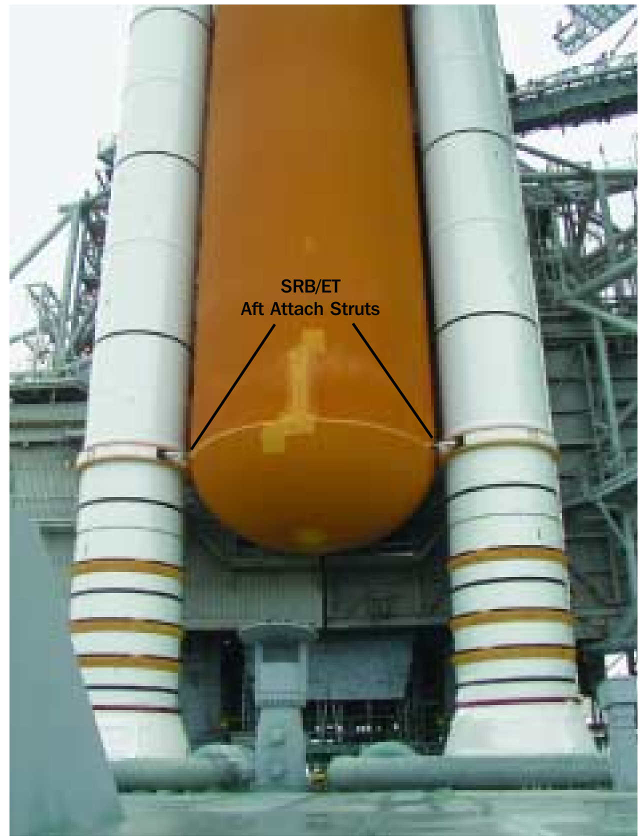
SRB Requirements Change Reduces Cost and Risk

Collaborators between Marshall Space Flight Center and United Space Alliance (USA) determined that a design change on the aft attach struts of the shuttle's SRB could reduce costs and mission risk.

Each SRB is attached to the ET by a single forward bolt and by three aft attach struts. These struts are critical hardware, which must function as designed to ensure successful, safe, and reliable launch of and separation from the space shuttle. Each attach strut contains a separation bolt. Approximately 2 minutes after liftoff, these bolts are fractured by pyrotechnics and allow the SRBs to separate from the shuttle.

The evaluation of the aft strut design loads determined that the mean bolt strength could be reduced, resulting in a significant decrease in mission risk.

According to the study, optimizing the mean bolt strength and trading "failure to separate" risk against "premature separation" risk realizes a 27 percent decrease in SRB mission risk. Consequently, reduction in time and hardware expenditure during the build and test of each lot will realize schedule improvements and cost savings.



Each SRB is attached to the ET by a single forward bolt and by three aft attach struts.

SRB INTEGRATED ELECTRONICS ASSEMBLY SUPPORTABILITY UPGRADE

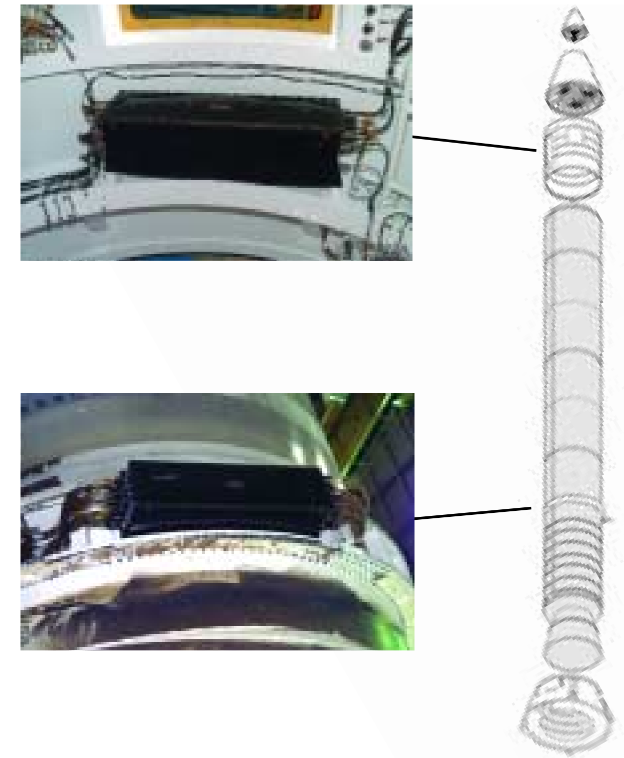
The SRB Project has initiated an effort to maintain safety and integrity of the shuttle by updating the SRB integrated electronics assembly (IEA). The IEA is a "black box" approximately one foot square by four feet in length, weighing almost 200 pounds. Each booster has two IEAs – one mounted inside the forward assembly and one mounted externally on the ring that attaches to the ET. They serve as a conduit between the orbiter and the boosters to distribute power, provide data transmission, and route command signals. Critical IEA functions include operating the booster's thrust vector control system, separating the boosters from the shuttle vehicle, and initiating the recovery sequence (including parachute deployment).

The SRB IEAs were originally designed in the 1970s with a design life of ten years and were qualified for 20 flights. Currently, the average IEA has had 11 flights and is 18 years old. The operating environment is harsh – with rigorous in-flight vibration, impact shock when the boosters land in the ocean at 60 mph, and exposure to salt water during the 24- to 48-hour booster recovery operations. Since it is mounted externally, the aft IEA, in particular, receives full exposure to these environments.

The IEA Supportability Upgrade addresses concerns related to increasing repair and maintenance of the wiring harness assemblies. These harness assemblies comprise over 2000 individual wires that, if laid end to end, would stretch approximately 0.8 mile in length. An increase in certification test failures can be attributed to the multiple uses, repetitive handling operations, and associated cumulative damage that these harnesses have experienced. As a result, the harnesses are the highest IEA supportability concern. Replacing the internal IEA wiring harness assemblies will mitigate these concerns.

The IEA Supportability Upgrade will increase reliability while reducing repair and maintenance, thereby ensuring that the IEA will continue to meet Program goals.

Productivity Gains, Reduced Risks, Lower Cost



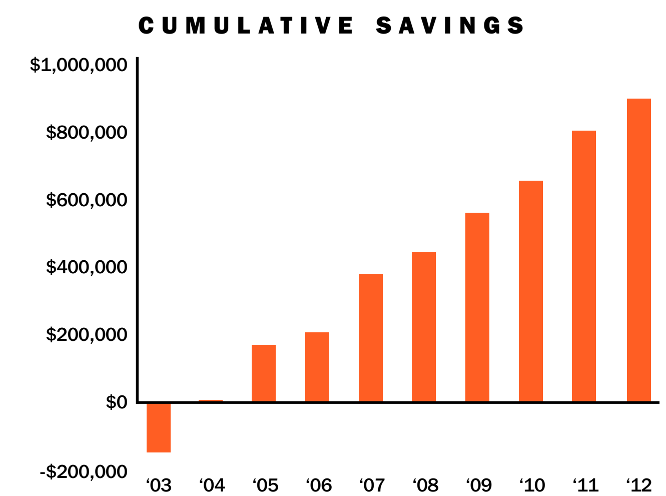
Each booster has two IEAs – one mounted inside the forward assembly and one mounted externally on the ring that attaches to the ET.

Close-up view of IEA shows intricacies of wiring.

PRODUCTIVITY GAINS IN REFURBISHMENT OPERATIONS

Marshall Space Flight Center is supporting a USA initiative to implement a high-pressure, low-volume waterblast system. This system removes protective finishes – paint, thermal protection, etc. – from major flight structures after they are retrieved from the ocean and disassembled. Incorporating this system will benefit many areas, including:

- cost – lower refurbishment cost (refer to chart)
- reduced schedule risk – the high-pressure, low-volume system will be a USA operation in the refurbishment area, which will eliminate reliance on and schedule problems with subcontractors
- reduced technical risks and environmental exposure – hardware handling is reduced, with 8 critical hardware lifts eliminated per flow



UNITED SPACE ALLIANCE RECEIVES OSHA STAR CERTIFICATION

The SRB Project kicked off another safety initiative with USA by hosting an Occupational Safety and Health VPP audit at KSC. USA successfully passed this audit and was recommended for VPP STAR certification. The Assistant Secretary of Labor for OSHA recently signed the official paperwork. OSHA's VPP brings the customer, contractor employees, management, and OSHA together to make the work environment safer by establishing "best safety practices." Only the top 50 percent of companies with the best safety rating may apply for certification. Only 1 percent of these have achieved VPP STAR certification.

Solid Rocket Booster (continued)

LARGEST KSC HAZARDOUS WASTE ELIMINATED

During the past year, the SRB Project has made tremendous strides toward eliminating hazardous waste. The current in-use alodine was replaced with a new, environmentally friendly alodine, which also significantly reduces risks for personnel safety and health. Alodine is a chemical primer put on large and small metal parts before applying paint and/or a thermal protective coating. Using the new alodine eliminates toxic metal, which its predecessor contains. Because alodine rinse water is the largest hazardous waste at KSC and constitutes 25 percent of the overall USA Florida waste and more than 40 percent of the SRB element waste, this replacement virtually eliminates the hazard. This reduction exceeds USA's and the federal government's goals. In FY 2000, NASA spent more than $25,000 on off-site disposal for this waste.

This change also greatly reduces the risks to potential employee exposure, fire hazards, and liability associated with environmental contamination. The change also eliminates regulatory burdens on tank certification, compliance inspections, and environmental reporting.

NASA and USA partnered to qualify this material, which will have application in public and private sectors.

SRB RETRIEVAL OPERATIONS SAFER

The SRB Project requested and received funding this year from Shuttle Program IES to incorporate safety upgrades into the two SRB retrieval ships and to diver equipment. In one upgrade, a NITROX system was installed that allows more oxygen in the air that the divers breathe, thus decreasing the risk of decompression illness. A pneumatically operated, enhanced, diver-operated plug (EDOP), which increases diver safety during underwater operations, was also upgraded. The EDOP is used to install a plug in the SRB nozzle, which is 100 feet under the water during the installation.

Air is then pumped into the SRB, allowing it to go from a vertical position in the ocean to a log-like horizontal position necessary for towing the SRB back to KSC for refurbishment and reuse. In addition to these enhancements, state-of-the-art dive equipment was purchased and several safety modifications were incorporated on both ships.

SRB retrieval ship.

Divers installing EDOP.

Outreach Activities

FREDRICKSBURG HIGH SCHOOL ROCKETRY PROGRAM

In the rural and ranch community of Fredericksburg, Texas, west of San Antonio, juniors and seniors at Fredericksburg High School have been designing (from scratch), developing, building, testing, and launching rockets in an innovative aeroscience program that has been in existence for the last 6 years. The students learn the importance of project management, design verification, scheduling, communications, public relations, teamwork, safety, and, especially, frugalness, due to an extremely limited budget.

The U.S. Congress has recognized the achievement of the Fredricksburg High School Rocketry Program as being the first high school students to build and launch a 2-meter rocket that broke the sound barrier.

In this community effort, local machine shops lend volunteer support, fabricating the students' design hardware. Engineers volunteering from the SSP Office, Johnson Space Center, Marshall Space Flight Center, Stennis Space Center, White Sands Missile Range, and the U. S. Army, as well as several aerospace companies, provide insight of design and technical consultation for various aspects of the project.

The program's success is remarkable. The students have received a letter of congratulations from President Bush acknowledging their accomplishments. In 1998, the U.S. Congress recognized their achievement of being the first high school students to build and launch a 2-meter rocket that broke the sound barrier. In addition, the American Institute of Aeronautics and Astronautics, Hybrid Technology Research Committee recognized the program for creating a propulsion system using hydroxyl-terminated polybutadiene and nitrous oxide that could be tested and handled safely within their high school facility.

Inspiring the Next Generation – and Beyond

Their most ambitious launch from the White Sands Missile Range was Red Bird 8, a 28-foot rocket, which is the largest and fastest vehicle ever built and launched by high school students. This demonstrated what can be accomplished when students are challenged and given the opportunity to achieve extremely complex tasks.

The students' motto was taken from President John Kennedy: "We do these things, not because they are easy, but because they are hard." SSP takes pride in mentoring these exceptional students.

AMERICA'S BEST GETS BETTER – EDUCATIONAL OUTREACH

What better way to contribute to the future success of the SSP than to teach our youth of today through hands-on experience, by learning from the experts, and by becoming familiar with all aspects of working in a professional environment? ATK Thiokol Propulsion sponsored several programs to do just that. Thiokol conducted a one-day science and mathematics conference called "Expanding Your Horizons" for approximately 320 girls from over 50 Utah schools from grades 6 through 9. A variety of workshops were conducted with the help of numerous volunteers that proved to be both educational and fun.

The Student Internship Program at ATK Thiokol Propulsion provided the opportunity for qualified college or graduate students, enrolled in a bachelor's, master's, or Ph.D. program,

Approximately 320 girls, grades 6 through 9, from over 50 Utah schools attended a variety of educational and fun science and mathematics workshops.

Outreach Activities (continued)

to gain knowledge and work experience on the Space Shuttle Program through practical applications of specific objectives within their desired field of study. Both summer and year-round internships were sponsored. In turn, the company gained benefits by supplementing employee resources while preparing the student for the possibility of future employment at the company. This program provided interns with financial benefits, tools, knowledge and experience needed to be successful in today's professional arena.

The Student Internship Program at ATK Thiokol provides interns with financial benefits, tools, knowledge, and experience needed to be successful in today's professional arena.

SRB FAMILY COMMUNITY OUTREACH

The SRB Project family includes individuals working at both NASA and USA, and in both Huntsville and Florida. The time, effort, and money raised to support worthy projects is enormous. During the past year volunteers raised $39,000 to build a Habitat for Humanity house for a needy family in Brevard County and spent more than 440 hours building this home. Other humanitarian efforts included filling a 2-1/2 ton truck with "Toys for Tots" in support of the U. S. Marine Corps; providing a "complete Christmas" for five people in a local nursing home; supporting Special Olympics; painting and constructing an athletic field for Combined Federal Campaign Community Service Days, CASA (Care Assurance System for the Aging and Homebound), and Sandi Childer's Ovarian Cancer Benefit. Our family enjoys "reaching out" and understands the true meaning of "it is better to give than receive."

The SRB Project family raised funds and built a Habitat for Humanity house for a needy family in Brevard County, FL.

DISTRESSED DIVER RESCUED BY RETRIEVAL SHIP *FREEDOM STAR*

On September 11, 2002, the SRB retrieval ship *Freedom Star* was approximately 20 miles offshore conducting crane certification training when The Coast Guard requested that the *Freedom Star* respond to a distress call from an amateur diver in the area. Coincidentally, a USA diver medical technician was on board training to be a crane operator. After consultation with the Diver's Accident Network and the KSC physician, and evaluation by the diver medical technician, the diver was placed in the decompression chamber aboard the *Freedom Star*. Upon arrival in Port Canaveral, the diver was airlifted to Holmes Regional Medical Center for treatment.

SRB retrieval ship Freedom Star.

The Space Shuttle Endeavour *lifts off, creating billows of smoke and steam, on its way into space for mission STS-111 to the International Space Station. The image was photographed from the rear station of a Shuttle Training Aircraft, which flies near the launch area for weather monitoring and other support to the mission's liftoff phase.*