The Coalition for

High Reliability Organizations

Presents:

Grouping For Solutions:

Increasing Organizational Reliability by Bringing Academicians and Practitioners Together

A workshop on organizational reliability for managers, researchers, and all involved in risky industries

April 2-4, 2006
Ontario Hilton
Ontario, California

www.highreliability.org
Conference Take-Aways

Grouping For Solutions
April 2-4, 2006

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Conference Sponsors
Welcome Conference Attendees:

Thank you for coming to our second HRO Conference. The goals of these conferences are to support practitioners in high risk fields and to interact with academicians in mutual support.

This conference furthers our work by demonstrating that HRO applies to any organization that deals with uncertainty regardless of time dependence. The techniques found in highly reliable organizations will work for everyday activities and can smoothly expand in response to increasing uncertainty and time dependence. The methods for long-term management of lung disease with uncertain response to therapy, or diet modification for chronic illness, are also used for fire fighting, resuscitation or operating nuclear power plants.

Individuals across an organization’s hierarchy have vital information for guidance of decisions and actions. Authority migration to those in the best position to make a decision will mitigate risk. This supports a paradox in safety – bottom up management ensures capture of knowledge for response to uncertainty.

Over the last several decades much discussion about safety, risk and reliability has occurred in public and private from across industries. However, little forward movement has occurred. In this, our second conference, we would like open discussion between academicians, regulators, and practitioners on how to implement reliability. We will strive for linkage between street smarts and academics, the creation of a blue collar ivory tower.

Daved van Stralen, MD
April 2, 2006
Grouping for Solutions:  
*Increasing Organizational Reliability by Bringing Academicians and Practitioners Together*  
Ontario Hilton Hotel • Ontario, California  
April 2-4, 2006  

**Conference Agenda**

**Sunday, April 2**

**9:00 – 10:30**

**Plenaries**

**Convener:** Daved Van Stralen, MD, Assistant Professor Pediatrics, Loma Linda University; Medical Director, Totally Kids Specialty Healthcare, San Bernardino County Fire Department and American Medical Response (San Bernardino County)

Peter Angood, M.D. Vice President, Joint Commission on Accreditation of Healthcare Organizations, Chief Patient Safety Officer, Joint Commission International Center for Patient Safety  
Title: “Overlapping Strategies for Influencing Change in Healthcare: The Joint Commission Perspective”

R. Bruce Mathews, PhD. Member, Defense Nuclear Facilities Safety Board  
Title: “Nuclear Safety: Expect the Unexpected”

**10:30 – 10:45**

**Break**

**10:45 – 11:45 (Concurrent Sessions)**

**High Reliability Organizations – The Basic of High Reliability Organizations:**  
*Making Your Organizations Safer and More Effective (a primer)*  
*If you have not had experience implementing HRO practices this is a good place to start*

Anthony Hare, PhD, Oakland, CA Police Department (ret.)

Dennis Kowal, PhD, Analyst, Institute for Defense Analysis, US Army Col. (ret.)

Pete Sarna, Capt., Oakland, CA Police Department (ret.)
Take aways: Further Reading List
Student note taker: Vinit Desai PhD student University of California, Berkeley

High Reliability Organizations – Intermediate Approaches to High Reliability: Advanced Concepts on Reliability (a primer)

Robert Bea, Professor, Department of Civil and Environmental Engineering, University of California, Berkeley
Gerard Koenig, PhD, Professor of Management, Dean, Paris XII University Graduate School of Management, and Normandy Business School
Karl Weick, PhD, Rensis Likert Distinguished University Professor Ross School of Business, University of Michigan

Take away: Further Reading List
Student note taker: Kuo Yu, PhD student, University of California, Berkeley

11:45 – 12:45

Luncheon

Lessons Learned from Catastrophe: How Organizations Responded to Hurricane Katrina

Convener: Karlene H. Roberts, PhD, Professor, Walter A. Haas School of Business, University of California, Berkeley

Robert Bea

Charles Cowley, HSSE Competence and Culture Manager, Shell International Petroleum Co - Downstream

Carolyn Merritt, Chair and CEO, U.S. Chemical Safety and Hazard Board

Reto Schneider, Dr. Reto Schneider Head Casualty Risk Engineering Swiss Re Insurance Company

Skip Skivington, Director of Operations, Procurement & Supply, Kaiser Permanente

Take away: Notes on the session
Faculty note taker: Barry Strauch
Student note taker: Dan Wong

12:45 – 2:15

Research and Theoretical Approaches to High Reliability (a panel)
Chair: W. Earl Carnes, BS, MA, Nuclear Industry Liaison, U.S. Department of Energy (DOE)

Philippe Baumard, PhD, Professor of Strategic Management at Aix-en-Provence Graduate School of Business

Pascale Carayon, PhD, Professor, Industrial and Systems Engineering, University of Wisconsin, Madison

Ruth Fanning, M.D. D.S. Department of Anesthesiology, School of Medicine, Stanford University

Kathleen Sutcliffe, PhD, Professor of Management and Organization, Ross School of Business, University of Michigan


Faculty note taker: John Carroll
Student note taker: Kuo Yu

2:15 – 2:30

Break

2:30 – 4:00

Turning Unreliability into High Reliability: Implementing and Sustaining Change (a panel) Concurrent Sessions

Session 1 Chair: John Carroll, PhD, Professor of Behavioral and Policy Sciences, Sloane School of Management and Engineering Systems Division, MIT

Jeffery Cooper, PhD. Director of Biomedical Engineering Partners Health Care System, Associate Professor of Anesthesia, Harvard Medical School

Douglas Padgett, President and CEO Totally Kids Specialty Healthcare

Charles Taylor, Director of Operational Risk for the Risk Management Association (RMA)

Take away: Meeting notes
Faculty note taker: Colin Reid
Student note taker: Dan Wong

Session 2 Chair: Sam Stringfield, Distinguished University Scholar, Acting Chair of the Educational and Counseling Psychology Department, and Director of the Grawemeyer Award in Education, University of Louisville.
Michael Harrison, Sr. Research Scientist – Organization and Systems, Agency for Healthcare Research and Quality (AHRQ)

Christopher Hart, JD, Deputy Director Air Traffic Safety Oversight Service, Federal Aviation Administration

Michael Rosenblatt, M.D. General Surgeon, Director of Trauma Service, Vice Chair, Division of Surgery, Lahey Clinic

Bert Slagmolen, PhD, Managing Partner, IME Consultants (Netherlands)

*Take away*: Van Stralen, D. “Creation of a Pediatric Intensive Care Unit” (unpublished)

*Faculty note taker*: Tony Ciavarelli  
*Student note taker*: Kuo Yu

**4:00 – 5:30**

**High Reliability Across Worlds: Comparing Military and Civilian Communities (a panel)**

*Chair*: Thomas Mercer, Rear Admiral (ret.), USN, Superintendent of the Naval Postgraduate School, Executive Director, Center for Risk Mitigation, University of California, Berkeley

Robert Burg, MBA, Executive Vice President and Managing Director of Healthcare, Emergency Management and Human Services, Ralph Andersen and Associates

Dennis Kowal

Joe Martin, Battalion Chief (ret.), Los Angeles Fire Department

*Take Away*: Meeting notes  
*Faculty note taker*: Chris Hart  
*Student note taker*: Peter Madsen, Assistant Professor, Brigham Young University

**5:30**

**Social get Together Theme: “Are the Stars out Tonight”**

*Take away*: Learning from Others Who Are Not Like Me

**Monday, April 3**

**8:00 – 9:00 Breakfast**
9:00 – 10:30

Changing Organizations Following a Major Catastrophe (a panel)

Chair: Barry Strauch, PhD Associate Director, Office of Marine Safety U.S. National Transportation Safety Board (NTSB)

Carolyn Merritt

Najm Meshkati, PhD, Associate Professor of Civil/Environmental Engineering, University of Southern California

Colin Reid, Manager, High Reliability Operations (HRO) British Petroleum, Inc.

Dave Thomas, Regional Fuels Specialist, Intermountain Region, USDA Forest Service


Faculty note taker: Kathleen Sutcliffe
Student note taker: Peter Madsen

10:30 – 10:45

Break

10:45 – 11:45

Reliability from the Ground Up: Working with Users to Implement Reliability Standards (a discussion with)

Bruce Barton, BS, Director, Riverside Division of American Medical Response, Inc.

Don Hiett, Assistant Chief (ret.) Atlanta GA, Fire Department; Senior Principal, Organization Strategic Solutions Group

Gary Provensal, Division Chief, Special Operations, San Bernardino County Fire Dept.

Take Away: Meeting Notes: (Faculty note taker: Tracy Thompson)
Student note taker: Peter Madsen

11:45 – 12:45

Luncheon
A Case Study of High Reliability in a Multi System Hospital Organization

Julie Nunes, RN, Director of Risk Management, Northern California Region, Kaiser Permanente

Sharon McFerran, RN, PhD, Group Leader, Northern California Regional Risk Management, Kaiser Permanente

Take Away: Materials about the Kaiser Project
Faculty note takers: Henry Christen, Ruth Fanning
Student note taker: Peter Madsen

12:45 – 1:45

High Reliability in Highly Unlikely Places (a discussion with)

Robert Bilicke, BS, Director, Facilities Management, Totally Kids Specialty Healthcare

Carol Baker Briggs, MBA, RD, Executive Director of Nutritional Services, Loma Linda University Children’s Hospital and Medical Center

Racquel Calderon BS, Director, Respiratory Services, Totally Kids Specialty Healthcare

Take Away: Meeting notes
(Faculty note takers: Bob Bea
Student note taker: Dan Wong

1:45 – 2:45

Town Meeting: Issues from the Floor

Conveners: Daved Van Stralen and Dennis Kowal

Take away: Meeting notes
Faculty note takers: Tony Hare, Earl Carnes
Student note taker: Peter Madsen

2:45 – 3:00

Break

3:00 – 4:30

How High is High?: Approaches to Measuring Reliability in your Organization or Research Project (panel) Concurrent Sessions
**Session 1 Chair:** Daved Van Stralen

Robert Bea

Jim Conway, Sr. Fellow, Institute for Healthcare Information (IHI), Senior Consultant, Dana-Farber Cancer Institute

*Take away:* [www.HFA-OSES](http://www.HFA-OSES)  
*Faculty note Takers:* Karlene Roberts, Jim Holbrook

**Session 2 Chair:** Tony Ciavarelli, PhD, Professor of Psychology, Naval Postgraduate School, Monterey, CA and Principal, Human Factors Associates

Ruth Fanning

Charles Taylor

Tracy Thompson, PhD, Associate Professor of Business, Milgard School of Business, University of Washington, Tacoma

*Take Away:* [www.HFA-OSES](http://www.HFA-OSES)  
*Faculty note takers:* Pascale Carayon, Carolyn Merritt

**4:30 – 5:45**

**HRO and Community Emergency Services (panel)**

**Chair** Margaret Parker M.D. Professor of Pediatrics State University of New York, Stoneybrook (Past President, Society of Critical Care Medicine)

Robert Burg

Matt Gross, MD, Assistant Professor, Pediatrics, Loma Linda University School of Medicine

Jim Holbrook, EdD Professor of Emergency Services, Crafton Hills College

Gary Provensal

Don Hiett

Joe Martin

*Take Away: Meeting notes*  
*Faculty note takers:* Henry Christen, Michael Rosenblatt
Social Get Together Theme: “Say it with Flowers”

*Take Away:* Ideas from folks who are not like me

**Tuesday, April 4**

9:00 – 9:45

**Perspectives on Reliability from the News Media (a presentation)**

Randy Paige, MA, CBS News, Investigative News Reporter

9:45 – 11:30

**Wrap Up (a mixed bag)**

A Report from the Faculty and Business People who met Saturday, April 1 about the Research and Implementation Challenges They Face Concerning Risk Reduction and Mitigation (9:45 – 10:30)

**Reporting team:** Tony Hare, Charles Taylor, and Karl Weick

*Take Away:* Summary (Tony Ciavarelli)

Wrap up to and Challenges Uncovered by this Meeting (10:30 – 11:30)

**Reporting team:** Kathleen Eisenhardt, Earl Carnes, John Carroll, and Najm Meshkati

*Take Away:* Summary (Jeffrey Cooper)
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Faculty Biographies

**Peter Angood**, MD, is vice-president, Joint Commission on Accreditation of Healthcare Organizations and chief patient safety officer of the Joint Commission International Center for Patient Safety. He also serves as president of the Society of Critical Care Medicine. He is a Professor of Surgery, Anesthesia, and Emergency Medicine at the University of Massachusetts Medical School. He is the author of approximately 100 peer-reviewed articles, abstracts, editorials and book chapters. He has a history of active committee involvement with numerous societies of organized medicine. He received his BA/S from University of Winnipeg in Canada, and his MD from the University of Manitoba, Canada, his General Surgery Residency and his Trauma and Critical Care Fellowship at McGill University, Montreal, and the University of Miami/Jackson Memorial Hospital, Miami, Florida.

**Carol Baker Briggs**, MS, MBA, RD is Executive Director of Nutritional Services, Loma Linda University Children’s Hospital and Medical Center. She received her Bachelor’s degree from Andrews University in Michigan and her MS in Dietetics from Loma Linda University Graduate School. She earned her MBA from the University of Redlands. Current responsibilities include oversight of clinical care of patients and food systems operations for five facilities associated with Loma Linda University Medical Center.

**Bruce Barton**, BSEd, EMT-P, is Director of Riverside Division of American Medical Response, Inc.

**Philippe Baumard**, PhD, is Professor of Strategic Management at Aix-en-Provence Graduate School of Business. He is currently a visiting professor at the Haas School of Business at the University of California, Berkeley. His research addresses the collective use of tacit knowledge by executives in times of crisis. He authored 8 books, ranging from Tacit Knowledge in Organizations (Sage, 1999) to strategic management, long-range forecasting, and expert systems applied to strategy implementation. He also served as Corporate Strategy Advisor for France Telecom Group, from 2000 to 2004, prior to joining the Berkeley HRO team. A fellow of the Oxford-Sorbonne Chancellors grant, Philippe has been a visiting faculty in New York University, Lund University (Sweden), University of Technology, Sydney.
Robert Bea, PhD, is Professor of Civil and Environmental Engineering at the University of California, Berkeley. His areas of research are risk assessment and management, reliability, and human and organizational factors. Prior to coming to Berkeley Bea spent twenty years with Shell Oil, Shell Development, and Royal Dutch Shell. In 2002 he received the Ralph Peck Medal from the American Society for Civil Engineers. He is a member of the National Academy of Engineering, Life Member and Fellow of the American Society of Civil Engineers, and Fellow of the American Society of Mechanical Engineers. Bea received his BCE and MCE from the University of Florida and his PhD from the University of Western Australia.

Robert Bilicke, BS, is Director of Facilities Management for Totally Kids Specialty Healthcare, a pediatric subacute care facility in San Bernardino, California. He oversaw facility operations as it evolved from a skilled nursing facility to a chronic intensive care facility using the principles of HRO. He earned his Bachelor’s degree in business from the University of Phoenix, Southern California Campus.

Robert J. Burg, FACHE (Fellow, American College of Healthcare Executives) is Executive Vice President and Managing Director of Healthcare, Emergency Management and Human Services of Ralph Anderson & Associates, Rocklin, California. He retired with the rank of Commander from the US Navy where he had numerous operational assignments from inpatient care to ambulatory care. Before that he served as Administrator of the Attending Physician’s Office, United States Capitol, where he managed the healthcare delivery system serving Members of Congress, Justices of the Supreme Court, all staff and visiting dignitaries. He currently teaches for the Department of Homeland Security/Federal Emergency Management Agency and is currently the interim director for Bio-Defense Maricopa County, Phoenix Arizona. He received his BA in Economics and his MBA from the University of Miami, Florida

Racquel Calderon, BS, is Director of Respiratory Services, Totally Kids Specialty Healthcare, San Bernardino, California. She used the principles of HRO to develop a freestanding pediatric subacute care facility (with four home mechanical ventilators) into a chronic intensive care facility (with 45 ICU-level mechanical ventilators). She uses HRO to give simultaneous delivery of high risk respiratory care with growth and development for profoundly handicapped children (a child’s smile is the end-point of ventilator management). She received her AS in Respiratory Care from Crafton Hills College (Yucaipa, CA), an AS in Cardiopulmonary Sciences from School of Allied Health Professions, Loma Linda University, and her BS in Business from the University of Redlands, Redlands, California.

Pascale Carayon, PhD, is Proctor and Gamble Bascom Professor in Total Quality in the Department of Industrial and Systems Engineering and the Director of the Center for Quality and Productivity Improvement at the University of Wisconsin, Madison. Her research areas include human factors and ergonomics in health care/patient safety and computer security, job and organizational design, quality and productivity improvement, and technological and organizational change. She is the editor of the *Handbook of Human Factors and Ergonomics in Healthcare and Patient Safety*. She received her Engineer diploma from Ecole Centrale de Paris, and her PhD in Industrial Engineering from the University of Wisconsin, Madison.

W. Earl Carnes, BS, MA. Is the Human Performance Center lead for the U.S. Department of Energy and is responsible for leading the implementation of Human Performance principles, concepts and tools for DOE and DOE contractor operations. In this capacity he collaborates with U.S. and international government agencies as well as industry and academia on human performance issues and initiatives. Previous DOE responsibilities included the nuclear safety policy and emergency management. He has served as co chair of the Federal Knowledge Management Working Group,
Chair of the International Atomic Energy Agency (IAEA) working group on the “Ageing Nuclear Workforce and Transfer of Knowledge to the next Generation,” and currently supports IAEA in reviewing international nuclear knowledge management efforts and developing IAEA guidance documents on knowledge management and human performance.

John Carroll, PhD, is Professor of Behavioral and Policy Sciences at the MIT Sloan School of Management and the MIT Engineering Systems Division. He is Co-Director of the MIT Lean Aerospace Initiative. His research is concerned with team, individual, and organizational learning in high hazard situations (e.g., nuclear power, petrochemical plants, hospitals), including organizational self-analysis practices, safety culture, leadership, systems thinking, relational communication in nursing shift reports, and simulation-based team training for improving communication skills. He received a BS in Physics from MIT and a PhD in Social Psychology from Harvard University.

Anthony Ciavarelli, PhD, is Professor of Psychology at the Naval Postgraduate School. Over the last several years he has worked on the development and validation of a safety culture climate measure for the Navy, the Command Safety Assessment Survey (CSAS), and for other organizations (the Organizational Safety Effectiveness Survey—OSEs). The OSES can be viewed at www.HFA-OSES. Prior to joining the Naval Postgraduate School he had positions as Staff Scientist and Research and Development Manager for Cubic Corporation. His BA and MA in Psychology are from California State University at Los Angeles (CSULA), and his Ed.D. is from the University of Southern California.

Jeffrey B. Cooper, PhD, is Director of Biomedical Engineering for the Partners Health Care System and Associate Professor of Anesthesia at the Harvard Medical School. He is also founder and Executive Director of the Center for Medical Simulation in Cambridge, MA, co-founder and Executive Vice President of the Anesthesiology Patient Safety Foundation and Chair of the Research Program of the National Patient Safety Foundation. He is one of the nation's leaders in the patient safety movement. Cooper received his BS and MS in 1968 and 1970 respectively from Drexel University and his PhD in Engineering from the University of Missouri in 1972.

Charles Cowley is the HSSE Competence and Culture Manager at Shell International Petroleum Co – Downstream.

Ruth M Fanning, MB, is a Clinical Instructor in Anesthesiology and Post-doctoral fellow with Dr Gaba's group at the Center for Immersive and Simulation Based Learning, Stanford University School of Medicine. Her research interests include medical education, and patient safety. She is currently working on the Anesthesia Patient Safety Foundation HRO project. Her medical degree is from University College Dublin, Ireland. She is a fellow of both the Royal College of Physicians, and the College of Anesthetists of Ireland.

Matthew Gross, MD, is Assistant Professor, Pediatrics, Loma Linda University School of Medicine, Loma Linda, California where he is currently Assistant Director, Pediatric Critical Care Division. He is also Director of the Pediatric Cardiac Intensive Care Unit and the Intermediate ICU. He serves as Chair of Pharmacy and Therapeutics Committee, Loma Linda University Medical Center. He earned his BS in Biology from University of Illinois at Urbana-Champaign and his MD from University of Illinois at Chicago, College of Medicine.

Anthony Hare, PhD, is completing a post-doctoral internship in cognitive behavioral therapy for high risk sex offenders. He served with the Oakland Police Department for 24 years, where he was the coordinator of the hostage negotiation team. His techniques for applying HRO principals to police critical incidents have been presented to police and military audiences around the world. Hare received
his BA in Psychology from the University of California, Berkeley. His MS is in Counseling from California State University Hayward and his MS and PhD in Psychology are from the Wright Institute. Dr. Hare served as an infantry commander in Viet Nam and was recalled to service in the first Gulf War.

Michael I. Harrison, PhD, is Senior Research Scientist in the Center for Organization, Delivery and Markets at the Agency for Healthcare Research and Quality (AHRQ) in Rockville, MD. He is the Agency lead for research on Health System Redesign and contributes to AHRQ's Health Information Technology initiative and its HRO Learning Network, which encompasses 19 health care systems across the United States. Previously he was a university-based researcher and organizational consultant. His research concerns health information technology implementation, organizational improvement processes, and policy implementation. His publications include two books on organizational diagnosis and change management and a study of market reforms in European health systems. He holds a B.A. from Columbia College and a doctorate in Sociology from the University of Michigan.

Christopher Hart, JD is currently the Deputy Director of the Federal Aviation Administration Air Traffic Safety Oversight Service. Before that he was Assistant Administrator for System Safety for the FAA, Deputy Administrator for the National Highway Traffic Safety Administration, a Member of the National Transportation Safety Board, and a practicing attorney. Hart's MSE and BSE are from Princeton University and his JD is from the Harvard Law School. Since 1995 Mr. Hart has spearheaded programs at the FAA and in the worldwide aviation community to (a) address legal and cultural barriers that have historically discouraged the industry from collecting and sharing information to improve safety, and (b) develop more effective analytical tools and processes for converting very large quantities of data into useful information to help safety analysts (i) identify potential safety issues, (ii) prioritize them, (iii) develop interventions for the higher priority issues, and (iv) evaluate the effectiveness of the interventions.

Donald Hiett, Jr., BS, Assistant Chief (retired) of the Atlanta, Georgia, Fire Department, is a Senior Principal of the Organizational Strategic Solutions Group. While with the Atlanta Fire Department he managed the Field Operations, Training, Aviation and the Special Operations Section over-seeing units such as the Rescue Medical Services, the fire service staff, and visiting dignitaries. He also was the Olympic Planning and Operations Officer for the 1996 Olympic Games. He has over 38 years’ experience in government, emergency management, human services and emergency response spanning all branches of the public safety emergency services system including law enforcement, EMS, Public Health and the fire service. He currently is adjunct instructor at Louisiana State University’s National Center for Biomedical Research and Training in Baton Rouge and the U.S. Department of Homeland Security’s Emergency Management Institute at the Noble Training Center in Anniston, Alabama. He is a Program Reviewer with Oak Ridge Associated Universities’ DOE/DHS program and is an advisor to the Defense Advanced Research Project Agency (DARPA) and the Defense Science Research Council (DSRC). He is the recipient of the Distinguished Service Cross from the Finnish Fire Chiefs. Hiett holds a BS in Life Science from the University of St. George.

Jim Holbrook, EdD, is Professor of Emergency Services, Crafton Hills College (Yucaipa, CA) and Adjunct Professor of Emergency Medical Care, School of Allied Health Professions, Loma Linda University. His research is in decision-making under stress and use of brain-based behaviors in paramedic education. He earned his paramedic certification from Loma Linda University, his Bachelor of Vocational Education and MA in education from California State University, San Bernardino, and his Doctorate in Education from Nova Southeastern University, Ft. Lauderdale, Florida.
Gérard Koenig, PhD, HEC, is a leading researcher in France in strategic management. Six years ago he engaged himself in safety related projects. He worked on food safety on the French Department of Agriculture's behalf and on road safety with the French National Institute specialized in safety at work. He is now pursuing with the Normandy Business School and the European Risk Institute the project of creating a Master program dedicated to technological risks' prevention and organizational reliability. His "Anti-Handbook of Strategic Management", coauthored with Prof. Patrick Joffre has become a classic in French management literature. Koenig is also the Director of the MSc in Management Research of the University of Paris-XII, in cooperation with the Ecole Centrale de Paris.

Dennis M. Kowal, PhD, Colonel (ret.) is an analyst for the Institute for Defense Analysis where he conducts research for the Department of Defense in a variety of areas that include human factors assessment of enhanced human performance technology to the development of strategies to assess intentions of terrorist groups. Before that he was command Psychologist for a Special Mission Unit and the US Army Intelligence Command at Ft. Belvoir, VA. He has conducted training in negotiation strategies, conflict resolution, stress operations, and remote profiling of target individuals. He co-authored a study of the “at risk” factors of individual’s who committed espionage against the US during the 1980s, and the NRC recently published his article entitled: “The Insider Threat.” Kowal received his BS in Psychology from the University of California, Santa Barbara, his MA in Physiological Psychology from California State University, San Jose, and his PhD in Physiological Psychology from The Claremont University, Claremont, California. He received further clinical training at Boston University and a post-doctoral residency in neuropsychological assessment at Walter Reed Medical Center and Georgetown University Medical School, Washington, DC.

Joe Martin, Battalion Chief (ret.), Los Angeles Fire Department, served 30 years in the Fire Service and Emergency Medical Service (EMS) including paramedic service. He has experience in several disasters (EMS supervisor for the first 24 hours of the Los Angeles riots, the Northridge Earthquake, and in strike teams during the Southern California Fire Storms). He has also managed or participated in more than 30 large scale multiple casualty incidents of greater than 20 victims. With LAFD he served as Quality Improvement officer, training officer for new paramedics, drill master and recruit training chief. He also assisted in development of the airborne (helicopter) rescue teams. The last 13 years with the fire service he based his approach on a high reliability model. He was also principal in a company that provided civilian corporations with emergency and disaster training. He is a former para rescue technician for the US Air Force where his duties included standby for the Apollo space program launches.

R. Bruce Matthews, PhD, is a Board Member of the Defense Nuclear Facilities Safety Board and has more than thirty years experience in nuclear technologies with a primary focus on special nuclear materials, weapons plutonium, and nuclear reactor fuels. He earned his BS in Metallurgy from Penn State, an MS in Materials Science from the University of Denver and his PhD in Materials Science from the University of Wales.

Thomas A. Mercer, MS, Rear Admiral (ret.) was Superintendent of the Naval Postgraduate School at Monterey, California. He was also Executive Director of the Center for Risk Mitigation at the University of California, Berkeley. Before that he was on the Joint Chief’s Staff for interoperability, strategy, connectivity and operational planning. Mercer received BS from the U.S. Naval Academy him his MSAE from the Naval Postgraduate School. He also graduated from the Navy’s nuclear propulsion school. Mercer was an A-7 carrier pilot.

Carolyn W. Merritt is Chair and CEO of the U. S. Chemical Safety and Hazard Board (www.csb.gov), an independent Federal agency that investigates industrial chemical accidents. Merritt served as Senior Vice President, Environment, Health and Safety at IMC Global Inc in Lake Forest, IL. Prior to that,
she served in management positions with RMT/Jones and Neuse and Champion International Paper in
Houston, TX, and as manager of Solid Waste in Champion's corporate offices in Stamford, CT. Her
mining and chemical manufacturing experience was gained in Copperhill, TN at the former Tennessee
Chemical Co. She received her BS in Analytical Chemistry from Radford University.

Majmedin (Najm) Meshkati, PhD. is Associate Professor of Civil/Environmental Engineering and
Associate Professor of Industrial and Systems Engineering at the University of Southern California.
Meshkati’s research and practice are concerned with the human, organizational and regulatory factors
affecting the safety and operation of large-scale, complex, technological systems (e.g. nuclear power,
chemical processing, and aviation). Meshkati simultaneously received his BS in engineering and BA
in Political Science from sheriff (Asya Meher) University of Technology and Shahid Beheshti
University and his MS and PhD. in Industrial and Systems Engineering from the University of
Southern California.

Doug Padgett, BS, is the Chief Executive Officer and co-owner of Totally Kids Specialty Healthcare,
a corporation serving medically fragile children and developmentally disabled children and adults
throughout Southern California. Using his background in subacute care for seniors, he instituted
changes in licensure in existing facilities to provide for increasing medical needs of children. He
worked with State of California Department of Health officials and State legislators to help write
pediatric subacute clinical and rate-setting regulations. As the first to contract with Medicaid for
pediatric subacute services on the West Coast, he supported education, safety climate and research that
enabled the company’s growth to a level of service beyond that which is common in skilled nursing
facilities. He has been a community representative on the Institutional Review Board at Loma Linda
University. He earned his Bachelors degree in Human Relations and Organizational Behavior from
the University of San Francisco.

Randy Paige, MS, is a KCBS Investigative News Reporter highly respected by local firefighters and
paramedics. He received the 2000 Alfred I DuPont Columbia University Silver Baton award
(considered to be the broadcast equivalent of the Pulitzer Prize), named the 2001 Reporter of the Year
by Los Angeles Press Club and received Emmies for his environmental, feature and investigative
reporting. His awards also include a Gold Medal of Honor as Reporter of the Year from the New
York Film Festival, RTNDA-Best News Documentary; AP Bill Stout Memorial Award for Enterprise
Reporting; Three Golden Mikes from the Radio and Television News Association; Associated Press
1999 Best Spot News. Paige’s BA in Criminology and Sociology from the University of California at
Santa Barbara and an MS in Mass Communications from California State University, San Jose.

Margaret M. Parker, MD. FCCM, is Professor of Pediatrics, Department of Pediatrics, Stony Brook
University, Stony Brook, New York, and Past President of the Society of Critical Care Medicine. She
is the Director of the Pediatric Intensive Care Unit at Stony Brook University Hospital. She received
her Bachelor of Science and her MD degrees from Brown University. She trained in Internal
Medicine at Roger Williams General Hospital in Providence, RI, and did her fellowship in Critical
Care Medicine at the National Institutes of Health, in Bethesda, MD.

Gary Provansal, Division Chief, Special Operations, San Bernardino County (CA) Fire Department, is
responsible for counter-terrorism, Emergency Medical Services, Urban Search and Rescue, Hazardous
Materials, and training. He serves on the Joint County Terrorism Oversight Committee for Riverside
and San Bernardino Counties. He also administers FAA’s Western Region Air Crash Rescue Training
School. He served on a Federal advisory group for counter-terrorism training for the national fire
service. He represents San Bernardino County for the low-level nuclear waste program for DOE. He
was the Director of the County Emergency Operations Center for the fire siege of 2003, staff of 500,
evacuations of 155,000, and several hospitals and the Operations Chief for the EOC during the subsequent floods that killed 14 people. Earlier in his career he served as a fire department paramedic.

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Mitigating Hazards Through Continuing Design: The Birth and Evolution of a Pediatric Intensive Care Unit

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Often, researchers study organizations in which design is largely in place and the design process is shrouded in the distant past. However, the design process can have dramatic implications for how organizations function. This paper reports a specific attempt to design one organizational subunit, a pediatric intensive care unit (PICU), to function under difficult circumstances. The founders aimed to create a highly reliable and safe unit, but implementing their vision required continuous effort. The unit needed constant buffering from external pressures and a dissimilar parent organization, and these forces shaped the unit’s ultimate design. Through the presentation of this case, we discuss the impact of design on the organization, its members, and the larger hospital organization to which the unit belonged. The study reveals that the PICU’s design was an ongoing effort and its most stable component was a vision of distributed knowledge and decentralized intensive care. We conclude by discussing implications of the case for organizational design theory and practice.

Keywords: high-reliability organizations; design; pediatric intensive care; healthcare; safety; organizational design

Introduction

A recent report published by the Institute of Medicine (IOM) found that medical errors kill as many as 100,000 people each year in American hospitals (2000). The report argues that many medical errors stem from structural problems in healthcare organizations and the U.S. healthcare system, suggesting that increasing patient safety is (at least in part) an organizational design problem. To the surprise of interested healthcare managers and professionals, the literatures on organizational safety and design offered little guidance on how to design a safe hospital and on designing organizations for hazardous environments more generally.

While several studies examine organizations in which safety-enhancing characteristics and structures already exist (e.g., Bigley and Roberts 2001, LaPorte 1988, Roberts 1990), details of the design processes that allowed these organizations to become reliable are shrouded in the past. Given this gap in the literature, a renewed examination of organizational design processes seems overdue. To address the gap, this paper focuses on a specific attempt to design a new organizational unit and examines how the design evolved over time. We present a case study detailing the design of a new pediatric intensive care unit (PICU), the evolution of the unit’s structure and processes over time, and the impact of the unit’s design on its performance. Based on the case, we discuss the process of design and highlight practical concerns in the quest to manage organizations as their designs evolve.

WHTCH Pediatric Intensive Care Unit: Research Setting and Methodology

Pediatric intensive care is a complex and unpredictable domain. The potential for treatment-induced complications abounds. Children often react differently than adults. Even minor procedures such as injections or intravenous line insertions can cause patients to become agitated and move in unpredictable ways.

To meet the challenges associated with treating children in critical condition, William Howard Taft Children’s Hospital (WHTCH)1 established a new PICU in 1988. WHTCH is the tertiary children’s hospital for a
geographic area more than three times the size of Vermont. The population is 2.5 million, with 500,000 under the age of 15. In 1988 WHTCH brought in a pediatric intensivist as the director of the new PICU. A second intensivist joined the unit a year later, and these two physicians headed the unit until 2000, when they both left the hospital. During their tenure, the PICU grew from an initial size of 8 beds to 25 beds with an average daily census of 21 children, including an average of 9 on ventilators. By 1999, the PICU had more than 1,300 admissions per year, making it one of the largest PICUs in the United States in terms of both number of beds and admission rate.

Our activities in the focal PICU did not begin as an organized research effort, but rather as a collaboration between scholars and practitioners to exchange knowledge. One of the authors met the two intensivists a few years after the PICU was founded. This author observed activities in the PICU repeatedly over a number of years, often discussing practices with the intensivists and providing them with relevant academic literature. The dialogue continued following the intensivists’ departures from the focal unit. As part of this dialogue, the other authors were introduced to the intensivists as well as to several current and former employees of the PICU and the broader hospital organization that interacted with the PICU. Because of the informal nature of our contact with the unit over the years, we did not collect detailed observational data. Therefore, the description of the PICU’s design and development that follows is derived from the authors’ intimate familiarity with the unit and from recent conversations with former and current PICU personnel. Our description of the PICU setting also draws, with permission, on an unpublished paper authored by the two lead intensivists (the paper is not cited to preserve confidentiality). In addition, literature on the design and operation of medical organizations in general and PICUs in particular was reviewed to develop an understanding of the typical structure and functioning of such units, and characteristic studies are cited where appropriate.

In presenting and analyzing the case study, we follow a grounded theory approach (Glaser and Strauss 1967). Grounded theory treats research findings as emergent. Hypotheses are not tested; rather, an empirical setting is examined for patterns or unique properties. These elements are compared to existing theory so that theory can be expanded or refined. This approach is particularly appropriate in the present study, as we seek to refine theoretical knowledge regarding organizational design.

The Evolution of Organizational Design in the PICU

The Setting
Many medical organizations follow a model of treatment that delineates the attending physician as the primary decision maker, more or less solely responsible for the care of his patients and the management of their medical outcomes (see Harvey et al. 2000). Therefore, if one physician establishes a care plan but is unavailable when another physician sees the patient, the second physician may change the care plan without any interaction with the first. Because traditional physician roles in this model are highly individualistic, the teamwork aspect of care is often missing. In this model, physicians may be unaware that each one works differently, and there is no incentive for doctors to forge agreed-upon plans. The physician answers to the patient, not to another physician, and medical doctors rarely accept advice from peers on how to practice medicine. At the extreme, aggressive, inflexible postures dominate conflict resolution, with settlements often reached by imposed authority (Harvey et al. 2000). Furthermore, while a physician’s relationship to other doctors is one of independence and individual responsibility, her relationship to nurses and other healthcare personnel is usually one of hierarchy and authority. This model dictates unidirectional planning and communication, with the physician as director in a vertical hierarchy (Harvey et al. 2000). The physician remains the “final common pathway” for decision making regarding the patient’s care (Herbertson and Walley 1998). In the PICU director’s experience, many physicians underscored their authority through belligerence and criticism, leading nurses and other support staff to live in fear of physicians. He had seen that the culture of fear encouraged nurses to think independently as little as possible and focus instead on avoiding physician notice. In this environment, nurses, therapists, and residents quickly learned that the path of least resistance was to follow physician instructions to the letter. The PICU director observed how interactions among physicians and staff unnecessarily complicated patient care.

The Birth of a PICU

With these experiences in mind, the first pediatric intensivist came to WHTCH as PICU director in 1988. At this time, the PICU did not exist as a distinct unit within the broader 627-bed medical center. Prior to this, critically ill children were either treated in the adult ICU or transferred to other hospitals with pediatric facilities. With the intensivist’s arrival, the adult ICU donated eight beds and the PICU began to function independently.

From the beginning, the new PICU director saw founding a new unit as an opportunity to diverge from the traditional design of critical care units as he had seen it. He was a Navy combat veteran from the Vietnam War. As a pilot, he had witnessed firsthand how a rigid hierarchy with authority enforced through verbal abuse caused accidents in hazardous situations. When he left the Navy and entered medical school, he found a very similar design in place.
During his training, the first intensivist noticed a sharp distinction between the bedside caregiver, typically a resident nurse who spends long hours monitoring individual patients or small groups of patients, and the physician, whose responsibilities include attending to a larger number of patients, with less time spent monitoring each individual patient. Because of their experience with individual patients over long periods of time, bedside caregivers such as nurses are often the first organizational members to detect slight changes in patient conditions that signal latent health problems. Therefore, while the information necessary to provide care for a child may come from advanced knowledge of disease processes or from discussions with other experts, it may also come from intimate knowledge gained by bedside nurses. The intensivist noted that physicians with whom he was familiar relied on information from laboratory values, radiographic findings, and physician colleagues as resources to make effective decisions, but often overlooked information from bedside staff.

The intensivist wanted to design a unit that avoided the mistakes of the U.S. Navy and departed from the worst aspects of organizational design in traditional medical units as he saw them. To this end, he believed that the unit’s design should involve nurses and other support staff more equally in patient care decisions. When the PICU began admitting patients, the intensivist began asking nurses for their opinions on patient treatment options and inviting them to perform some tasks traditionally reserved for doctors. This approach was not well received at first. Accustomed to traditional roles, some nurses became resentful, suggesting that the intensivist was asking them to work too hard or to do his job as well as their own. Other nurses saw the intensivist’s behavior as a sign of incompetence or lack of confidence and became concerned about his abilities as a physician. This initial reaction surprised the new PICU director and convinced him that instituting his desired participative organizational design in the unit would require a long-term commitment and evolving effort. He came to see that many of the nurses did not feel adequately trained to take on the added responsibilities he was offering them.

During the PICU’s first months, nondedicated nurses and respiratory care practitioners worked some of their shifts in the PICU and others elsewhere in the hospital. Based on the resistance encountered in delegating some decision-making responsibilities to nurses, the intensivist decided that his design interventions could work only with dedicated support personnel. This was true for two reasons. First, because people resisted roles other than those to which they had become accustomed through training and experience, only dedicated staff members could accumulate enough experience with a new design to begin to trust it. Second, even if nurses could be convinced to participate in patient treatment decisions, they needed additional training to do so successfully. This type of training would be possible only with a relatively small number of dedicated nurses.

Early in his tenure, the PICU director approached hospital administration to request a dedicated nursing staff. Administrators granted the request. Later, the director also asked for dedicated respiratory care practitioners. While initially resistant, administrators also eventually granted this request.

As the intensivist continued encouraging nurses to assist in making patient care decisions, many of the dedicated nurses (and later the dedicated respiratory care practitioners) began warming to his approach. At this point, participative decision making in the unit was quite informal and largely involved queries for staff members’ observations about patients and requests for their opinions about appropriate treatment options. Several nurses and respiratory care practitioners working in the unit at the time report that the intensivist’s approach made them feel valued, but that they did not feel qualified to offer suggestions on patient treatment options at that time. In response to this concern, the intensivist started teaching staff members about medical decision making. He introduced lessons through conversations with care staff and increasingly invited staff members to attend his physician’s rounds.

**Growth**

The PICU director’s inclination to involve the support staff in patient care decisions was reinforced by necessity. He made an early policy decision to not turn away any children referred to the PICU. This policy contrasted sharply with prior practices in the original adult ICU, which resulted in the admission of only 40% of referred children (the ICU turned away children that they could not treat with available equipment and also deemed some children to be in insufficiently critical condition for admission). The new PICU policy quickly raised the admission rate to more than 90% (and eventually as high as 99%) of referred children.

WHTCH’s PICU admitted more than 500 children during its first year, while the PICU director was its only physician. This is a heavy workload for a pediatric intensivist. For reference, an average PICU has one physician for every 4–5 beds and roughly 200–300 admissions per year. The focal PICU, at 8 beds and more than 500 admissions, had roughly double this ratio in its first year. Thus, in addition to involving staff members to improve patient care, the intensivist realized that he simply needed their help.

Eleven months after the PICU’s establishment, a second intensivist came to the unit as assistant director of critical care. The PICU director recruited him specifically because of his background in fire department emergency medical services. The second intensivist independently concluded that organizational structures in fire departments could handle emergencies more
effectively than those in the medical centers with which he had experience.

Despite the addition of a second intensivist, the patient/physician ratio at the PICU remained high. The PICU admitted roughly 900 children in its second year, nearly 1,200 in its third, and 1,400 in its fourth. The unit’s growth quickly outstripped its allotted 8-bed space in the adult ICU. During its second year, the PICU moved into a new building with 25 beds. A study published shortly thereafter found that 40% of PICUs in the United States have 4–6 beds, while those with more than 18 beds comprise less than 6% of the national total (Pollack et al. 1993). The latter averaged 1,277 ± 63 patient admissions per year. According to these numbers, WHTCH’s PICU was one of the largest PICUs in the country by its third year. Part of this growth resulted from a pediatric critical care transport system established by the second PICU intensivist in 1989, allowing the unit to transport and accept highly critical children from other less-equipped hospitals. WHTCH’s pediatric critical care transport system quickly grew into one of largest of such systems in the country (McCloskey and Johnston 1990).

At the end of 1994, an intermediate ICU was established as a separate unit at WHTCH. The intermediate ICU served three purposes related to the functions of the PICU: It admitted children who required a high level of nursing attention but not the same level of critical care as patients in the PICU, it took recovering PICU patients who no longer required intensive care, and it housed the WHTCH cardiothoracic ICU, where children with heart conditions were treated. The establishment of the intermediate ICU served to increase the severity of conditions treated in the PICU because the less critical patients were referred directly to the intermediate ICU.

Staff Training as Continuing Design

Because of his background, the second intensivist became an enthusiastic supporter of the PICU director’s push to delegate care decisions and functions to nurses, respiratory care practitioners, and residents. The first intensivist’s efforts had secured the unit a dedicated nursing staff, many of whom learned to enjoy taking an active role in treatment decisions. Yet nurses and other staff members still complained that they lacked the expertise to make important medical decisions. The PICU’s emerging design required a high level of distributed knowledge and expertise as well as distributed authority. As both intensivists wanted to further increase the level of bedside caregiver participation in the PICU, they made attaining this level of staff medical knowledge one of the major drivers behind their design efforts.

While the first intensivist previously conducted informal lessons, training became increasingly formalized after the second intensivist’s arrival. The intensivists began teaching staff members how to identify medical problems that brought children to the PICU. They taught caregivers how to identify and treat complications that could arise because of disease or inappropriate medical care. The intensivists also gave staff members formalized decision-making aids to help them know when they could treat a patient themselves and when they should ask for help. They taught staff members to break down a patient’s symptoms into categories, assess the severity of each category, and begin treating the most acute symptoms while calling for additional help if needed.

To further facilitate decentralized decision making, the intensivists emphasized that they would respond immediately to staff questions. They gave out their personal phone numbers and encouraged staff to feel comfortable calling them if they were not present and the attending physician could not assist.

Both intensivists continued to teach informally whenever opportunities arose, but they also initiated formal in-service training sessions for all staff members on duty. As part of the training, the intensivists encouraged staff members to read medical journals and textbooks to further educate themselves. Several former nurses and respiratory care practitioners report that they became so interested in what they were learning in these training sessions that they decided to return to school for advanced degrees.

Furthermore, all staff members regardless of position and disciplinary background were encouraged to attend the physicians’ rounds on the PICU floor, and these rounds included an educational component to ensure that staff possessed the abilities necessary to function across roles. The intensivists took up the practice of wheeling a blackboard around the PICU during rounds so that they could write notes and draw diagrams to facilitate staff training.

While residents and fellows commonly take part in physicians’ rounds at hospitals, the level of participation instituted at the focal PICU was extraordinary. Morning rounds routinely included all residents, the fellow (if on service), lead respiratory therapist, charge nurse, pharmacist, social worker, and the patient’s bedside nurse and respiratory therapist. As PICU staff members became accustomed to participating in physicians’ rounds, they undertook larger roles. Nurses began presenting patients and discussing treatment options with the physicians.

One intensivist notes that it took several years before staff members were trained well enough to implement his vision of an optimally decentralized PICU design. Prior to this time, staff members did not possess the knowledge to participate in medical decisions and treatments to the extent that he desired. Thus, the establishment of the PICU’s decentralized design was a process rather than an event.
Supporting Staff Decisions
As staff members received more training, they began to feel comfortable accepting more responsibility and the two intensivists increasingly delegated authority to them. However, specialists from other hospital departments were unaccustomed to such a degree of knowledge distribution and occasionally resisted decisions made by staff when treating PICU patients. The PICU directors developed a policy to always support their staff members’ decisions in these situations. While staff members’ decisions were not always right, the two PICU intensivists believed that their decentralized design improved response times and decision quality on average because staff with direct information about critical situations made important care decisions. Distributed decision-making authority reduced the need for information to flow up through the chain of command and back to the bedside caregiver.

The PICU directors also assigned bedside caregivers the role of ensuring common and consistent patient treatment plans. As situations developed and additional people and resources responded to critical events at the PICU, arriving members were trained to inquire about and use information from bedside caregivers to assess the situation and develop a common treatment strategy. This was one of the PICU’s central design elements, and also perhaps the source of its greatest difference from other units in the hospital.

When the second intensivist arrived in the PICU, he brought the notion of postevent debriefings from his experience in emergency services, and frequent debriefings were quickly institutionalized in the unit. He routinely conducted debriefings open to all involved staff following major events. While most large healthcare organizations utilize some form of postcrisis debriefing, the intensivists believed that these meetings tended to be rare and typically restricted to physicians, residents, and hospital administrators. Debriefings at the PICU became unusual in their frequency and inclusiveness. The purpose of these debriefings was twofold: First, to encourage staff to learn from an experience while it was still fresh, and second, to act as a form of therapy for staff members. These sessions allowed staff members to talk through their emotions and prepare themselves to return to work.

Resistance and Buffering
The decentralization and elevated educational focus designed into the unit encountered opposition from some staff members. As a result of their educational focus, some of the physicians’ rounds lasted longer than normal. This was, and still is, one of busiest PICUs in the country, and some staff members considered the rounds a waste of time. Some resistance to the goal of increasing staff autonomy also arose. While most of the staff embraced or at least cooperated with the intensivists’ push to delegate decision making, the approach required a significant commitment by staff members to learn how to perform new duties.

However, internal resistance to the decentralized design in the focal PICU was not nearly as strong as resistance from other departments in the hospital. Colleagues from other departments increasingly discussed the PICU’s design and processes with the intensivists, at times to advise the intensivists of resistance from administration, and at other times to argue that staff members made poor care decisions. Hospital administrators and some physicians from other departments also saw the practice of staff members attending in-service trainings and physicians’ rounds as a waste of time and resources.

To preserve their desired organizational design in light of these concerns, the PICU directors developed formalized protocols to constrain bedside caregiver discretion within certain boundaries. For instance, they created new rules that required bedside caregivers to first open the airways of new patients before beginning to design a treatment plan. This rule ensured that patients were stable before staff members began to think about appropriate treatments and gave staff members time consult with physicians as needed. In addition, the new protocols required PICU staff to ask for assistance under specified conditions. When a patient exhibited one or more of a certain set of symptoms, they were required to get a second opinion from another staff member before proceeding with treatment; when a patient exhibited one of more of a second set of symptoms, they were required to ask a PICU physician for assistance; and when a patient had one or more of a third set of symptoms, they were required to call a specialist from another department in the hospital for a consultation.

By following these metarules for decision making, bedside caregivers maintained their ability to make decisions regarding routine patient care without consulting physicians while avoiding further conflicts with outside specialists. The metarules placated administrators and physicians outside the PICU by giving them indirect but formalized control over caregiver activities, because physicians could modify rules governing the breadth and scope of allowable discretion. While the PICU’s initial design called for broad staff decision-making authority, the two intensivists realized that the new formalization created a superior organizational design. Not only did the institution of formal metarules placate hospital administration, but it also helped some staff members feel more confident in their patient care decisions.

Despite this change, some physicians in the hospital remained uncomfortable. To minimize resistance from these physicians, the two intensivists moved to buffer the PICU from the remainder of the hospital as much as possible. Early efforts in this direction led to the assignment of dedicated nurses and respiratory care practitioners to
the unit. Later efforts were aimed at increasing the unit’s autonomy. Before the PICU’s establishment, physicians from other hospital departments (pediatricians, surgeons, cardiologists, and others) came from their home departments and managed critically ill children in the original adult ICU as needed. This practice continued to an extent after the PICU’s founding because critically ill children often required the care of medical specialists. The two intensivists came to see the porosity of the PICU’s boundaries as a potential hazard to patient safety.

As their vision of an effective organizational design evolved, the two intensivists decided to minimize the unit’s porosity by assuming primary responsibility over all ventilator patients. They became the main points of contact for specialists from outside the PICU to discuss patient matters and solicit advice regarding patient care within the unit. This simplified work for staff members but complicated the intensivists’ responsibilities because they now handled conflict with outside physicians. Discussions about appropriate care would occasionally arise between them and external specialists, diverting some of their time and attention away from responding to their own staff. The intensivists viewed the change positively, believing that staff members could operate more effectively when buffered from external conflict.

In addition to serving as gatekeepers between the PICU and the hospital, the two founding intensivists took steps to reduce PICU’s dependence on outside expertise. They each received additional training so that they could personally perform many of the functions that previously had required the services of a specialist. For example, at the beginning of the PICU’s history, external ear, nose, and throat (ENT) specialists performed difficult intubations in the unit. When some ENTs voiced disagreement with practices in the PICU, the two lead intensivists began performing difficult intubations themselves and training their fellows to do them as well. They also requested that all anesthesiology fellows be assigned to the unit to reduce their dependence on outside anesthesiologists.

The intensivists argued that the changes improved patient care in the PICU because children’s conditions often deteriorated while they were waiting for specialists to arrive. However, these moves also further buffered the PICU and its unique design from the rest of the hospital. The second intensivist took additional steps to make PICU admission through the pediatric critical care transport system independent of the outside hospital by training transport paramedics and PICU staff to perform functions originally assigned to hospital triage staff. In addition, the intensivists gradually discontinued offering care outside of the PICU. While the high workload within the PICU itself often precluded the intensivists from responding to pediatric emergencies in other departments, the intensivists also felt that they could not maintain a consistent quality of care when working with resources and staff outside of the PICU.

**Reliability and Outcomes**

Compared to the other PICUs examined in the Pollack et al. (1993) study, the focal PICU had normal mortality rates for a PICU of its size during its first two years. After this period, however, its mortality rate began to decline, even while the unit was growing rapidly. By 1993—the year the Pollack et al. study was published—the focal PICU’s mortality rate was 4.6%, compared to the average rate of 7.8 ± 0.8% for PICUs with more than 18 beds. Except for a brief increase in 1994, associated with the establishment of the intermediate ICU (which increased the average severity of the conditions of PICU patients), the mortality rate at WHTCH’s PICU remained low. In 1999, the last full year that the original intensivists remained at the unit, its mortality rate was 3.5%.

Mortality rate is a poor indicator of healthcare performance both because numbers are difficult to obtain and because it is notoriously difficult to control for the severity of a unit’s case load. We mention it here simply as an indicator that the PICU’s design appears to have helped it perform well. Aside from mortality, several other indicators of patient medical outcomes also appeared to improve as the PICU’s distinctive decentralized design was put in place. For instance, the unit’s staff introduced several innovations that improved patient care. These innovations would not have been possible without the additional medical training and patient-care discretion given to staff members in the PICU. In one case, respiratory care practitioners changed the blend of helium and oxygen when administering gas to patients with severe asthma. The innovation gave children on ventilators increased energy, allowing them to play for longer periods. In another case, resident nurses began placing the children on their stomachs during a period when the unit experienced a higher incidence of acute lung disease. They discovered that children had better lung function in this position, with oxygen entering the blood more easily. In a third case, some respiratory care practitioners began setting ventilators to higher breath rates, sometimes reaching levels higher than those generally considered safe. Further study of the practice found that higher ventilator rates made some patients more comfortable and alert and did not cause adverse health outcomes.

The design instituted by the two managing intensivists also led to higher satisfaction and lower turnover among staff members in the unit. The PICU’s founding director saw one of his primary responsibilities to be creating a supportive environment. As a consequence of this effort, the PICU had an extremely low turnover rate for nurses and therapists, much lower than is common in intensive care generally. Several former residents reported the
PICU residency to be the most difficult but most enjoyable of their residencies.

Culture Clash
In 1993 the PICU brought in an additional pediatric intensivist fellow to assist the original two intensivists. As the unit grew, others were hired and the number of doctors (including fellows) in the unit soon stabilized at five. Until 1997, the only physicians assigned to the PICU were the original two intensivists, their fellows, and intensivists who had received their fellowship training in the unit. As a result, the unit’s physicians strongly agreed that its decentralized design, although unorthodox, was effective.

Beginning in 1997, intensivists trained elsewhere were hired into the unit. The PICU’s continuing expansion and the departure of intensivists trained in the unit for leadership positions elsewhere created vacancies. The PICU’s high utilization demanded that vacancies and new positions be filled quickly, and the founding intensivists eventually turned to externally trained intensivists to expedite staffing needs.

A few of the externally trained intensivists did not see the value of the PICU’s approach and believed instead that the unit’s design might constitute malpractice because physicians in the unit did not always control patient treatments. The new intensivists introduced notions of strict physician authority and one-way, downward communication. Although the protocols allowing staff to exercise discretion remained in place, staff members learned that the new doctors interpreted them differently than the original two intensivists did. In fact, during this period, staff members began to refer to cultural differences between “PICU north” and “PICU south” because the founding intensivists’ offices were located on the south side of the unit. Concerns of malpractice liability from physicians inside the PICU resonated with negative feelings about the unit held by some physicians elsewhere in the hospital. Physicians from other departments saw the growing rift within the PICU and became more outspoken about their disagreement, often refusing to let the two founding intensivists treat their patients even within the PICU. Some hospital administrators, never completely comfortable with the level of autonomy at the PICU, used these concerns to argue against providing dedicated resources or supporting the unit’s continued expansion. In this environment, both of the original intensivists chose to leave WHTCH and accept positions elsewhere in 2000.

According to staff members who remained at the PICU, the design features of the unit changed following the departures of the two original intensivists. Physicians began to assert their authority over patient care decisions and ignore suggestions from bedside staff members. Staff turnover in the unit increased and staff members who remained learned to follow physician instructions and largely keep their opinions to themselves. Although the PICU retained some procedures allowing staff discretion and might still have been considered “participative,” its staff no longer enjoyed broad decision-making autonomy. Furthermore, procedures put in place to support staff autonomy were gradually discontinued. The new physicians did not encourage staff members to participate in rounds and no longer used rounds as a training opportunity. Similarly, the practice of holding postevent debriefings was all but discontinued and, when debriefings were held, staff members were not encouraged to participate.

Although current staff members believe that the new PICU intensivists are skilled doctors and that the PICU remains a relatively safe unit, they suggest that its health outcomes are not as good as they once were. The annual mortality rate at the unit has increased since its low in 1999. Finally, as noted previously, staff turnover has increased during the same period. WHTCH’s PICU remains a good unit but has lost its distinct design and may be less reliable than in its previous form.

Discussion
The design of WHTCH’s PICU evolved over time in response to environmental and technological demands, resulting in an extremely decentralized decision-making structure for an industry where strictly enforced hierarchical relationships are more often the norm. The PICU also became unusually self-sufficient in an area in which organizational boundaries are typically porous or unidentifiable.

The PICU’s experience provides several implications for organizational design theory and practice. The case draws a connection between organizational design and leadership. The coincidence of the founders’ departures and design changes at the PICU suggests the alternative explanation that good leadership rather than organizational design led to the PICU’s performance. It may have been that the charisma and personal leadership qualities of the two head intensivists motivated staff members to achieve high performance independent of any design interventions that were introduced. According to the PICU members with whom we spoke (including the two intensivists), this was not the case. Neither intensivist claims extraordinary leadership qualities, and other staff members do not attribute such to them. In fact, while most of the PICU staff accepted and came to agree with the intensivists’ approach, others did not—some harboring personal dislike for the intensivists themselves. Furthermore, current staff members are quick to point out that the intensivists who headed the PICU after 2000 are neither poor leaders nor poor physicians. Rather, several of them emphasized that the reason for the PICU’s success stems from the fact that its design differed from those of other ICUs.
Despite these assertions that the PICU case is a design story and not a leadership story, the case seems to suggest a closer connection between the two explanations than previously acknowledged. Organizational design is often seen in terms of impersonal structural characteristics: span of control, levels of hierarchy, formalization of rules, and so on. The PICU case instead suggests that organizational design exists at least as much in designers’ visions as in organizations’ formal structures. For example, the PICU director’s vision for the unit was continuity of high-quality care through a highly knowledgeable, motivated, and involved support staff. While this vision did not change during the PICU’s growth and evolution, many of its structural characteristics did change as the unit met new challenges. For example, when the first intensivist arrived at the unit, he did not fully appreciate the amount and formality of staff education necessary to fulfill his goals for the unit. Similarly, the two intensivists originally sought to minimize formal boundaries on staff decision-making authority, but later decided that encasing staff authority in formalized metarules actually created a more effective design in line with their original vision.

The PICU’s design was an ongoing effort, and its most stable components centered on a vision of distributed knowledge and decentralized intensive care. To the extent that this vision existed largely in the minds of the two PICU directors, the unit’s design cannot easily be separated from its leaders. The PICU’s experience resonates with Boland and Collopy’s (2004) notion of managing as ongoing design. Many (perhaps most) of the design features that eventually came to characterize the PICU were not planned from the foundation of the unit. Rather, they were instituted in response to new challenges or unanticipated consequences of the unit’s evolution. For example, neither of the two intensivists anticipated the lengths to which they would eventually go to isolate and buffer their unit from the broader hospital. Their buffering efforts were necessitated by unexpected hostility to the PICU’s design from other hospital units. The case highlights the cyclic nature of organizational design. Organizational leaders put a design in place, observe its effects on the organization, adjust the design, again observe the effects, and so on.

In another vein, the PICU experience shows that a design’s origin may be as important as its content. While much work examines the adoption of legitimized forms and increasing conformity among organizational designs in a field (DiMaggio and Powell 1983), few perspectives address the motivation to search for alternative designs when commonly accepted forms exist. The PICU story highlights the idea that organizational leaders with diverse prior experiences can introduce this form of divergent change (see Kraatz and Moore 2002). Many of the unit’s design features were based on organizational designs employed by fire department emergency medical service organizations. However, appropriate these designs may have been to pediatric intensive care, they were unfamiliar to nurses, therapists, and physicians. Unfamiliarity led many members of WHITCH and the PICU itself to distrust the new design. Much of the ongoing design effort undertaken by the two PICU intensivists was devoted to combating this distrust.

Similarly, the PICU case also illustrates some of the unique challenges of designing an organizational subunit to operate much differently than does its parent organization. Any organizational design that differs from an accepted, institutionalized model in its industry is necessarily fragile. However, the PICU’s design was even more tenuous because it was at odds with accepted designs in its parent organization. While the PICU directors succeeded in implementing such a design, the unit’s design required constant and effortful maintenance. The PICU’s director quickly discovered that his unique design was difficult for many physicians and staff members to accept. He responded by taking steps to buffer his unit from its parent organization and associated designs. He obtained dedicated nurses and respiratory care practitioners, unified the unit’s contact with other departments through himself and his associate, and limited the need for outside specialists to enter the unit. The PICU case suggests that buffering subunits with unique designs from their environments is important to their operation, but also raises specific challenges. Much prior work focuses on organizations naturally buffered from outside pressures and lacking exposure to market or competitive forces (LaPorte 1988, LaPorte and Consolini 1991, Roberts 1990, Rochlin et al. 1987). Indeed, many such organizations may be conceived of as “total institutions” (Goffman 1984), as they achieve strong cultures by largely removing their members from outside society. The present examination reveals that such isolation takes considerable effort in multiunit organizations. While such a subunit may need to distance itself as much as possible from its parent organization, the case illustrates that resistance may develop from members of other organizational subunits and organizational leaders who perceive such buffering as a threat to their power. Without continuous buffering efforts, the unit may easily be overrun by the culture of its parent organization or its industry at large.

The case also suggests that several characteristics of the PICU’s design evolved in direct response to challenges posed by the unit’s technology and environment. There are many examples of organizations facing similar hazards that have attempted but were unable to reach goals for safety and operational reliability (e.g., McCurdy 1993, Roberts et al. 2005, Vaughan 1996). There are several differences between the PICU and designs at these other organizations. Specifically, the PICU was highly decentralized, as its founders delegated authority through the organization. Organizations desiring consistent performance under hazardous
conditions indeed must be designed to give front-line employees tremendous levels of decision-making authority and flexibility (LaPorte 1988, Roberts and Bea 2001, Rochlin et al. 1987). The relationship between complex organizational environments and decentralized decision-making authority has long been acknowledged by contingency literature on organizational design (e.g., Burns and Stalker 1961). While many organizations distribute knowledge and delegate decision-making authority during periods of abnormal operations or crises, they normally display high levels of centralization and formalization during more routine periods (Roberts et al. 1994). However, the decentralization of decision making at WHTCH’s PICU was broad based and not confined to emergency situations, suggesting that decentralized decision making need not be coupled with periods of strict hierarchy.

The PICU experience also reinforces the assertion that decentralization requires distributed knowledge (Roberts 1990, Weick and Roberts 1993). The founding inten-sivists devoted a great deal of time and attention to training staff members about how to make treatment decisions. Their experience shows that front-line employees cannot be expected to effectively shoulder decision-making responsibilities without sufficient knowledge and training. Some prior studies suggest that the high levels of training required to create such knowledge distribution may be too costly for organizations in most environments (Roberts et al. 1994). However, the focal PICU functioned quite efficiently with such a structure in spite of the training requirements. Indeed, the unit’s low doctor/patient ratio was one of the conditions that necessitated decentralization.

The PICU experience also lends support to a growing recognition that even generally successful organizations make mistakes and must learn from them to maintain their consistency (Weick et al. 1999). Behavioral perspectives argue that organizations and the people in them often learn through performance shortfalls, interpreting successes as a sign that change is not needed and learning only in response to failure (Haunschild and Sullivan 2002, March and Simon 1968). Crises inevitably arise in any complex healthcare setting. Postcrisis debriefings provided opportunities and time for the staff and founders to learn from failures, and because PICU leaders did not search for “responsible” parties to blame for poor outcomes, unit members were able to learn from their experiences without fear of retaliation.

A recurring question for the founders, however, was whether an organization can be designed to operate reliably in some more benign way than waiting for lessons learned in blood, as failures are costly and often difficult to learn from (March et al. 1991). In fact, the leaders of the PICU did not wait for a serious accident before delegating authority, developing structures to distribute knowledge, and creating other conditions that they believed would lead to enhanced learning and performance. Rather, in designing the unit, they drew on the failures and successes of other organizations with which they had been associated. As a result, their design interventions sought to avoid strict hierarchy, absolute physician control over patient treatment, and strict individual accountability (or blame) for adverse patient outcomes.

Conclusion
This paper develops important and neglected aspects of the literature on organizational design and advances implications for the design of any organization facing environmental and technological challenges. Much research in organization theory has shifted away from organizational design and its provision of practical knowledge regarding the design and operation of organizations. Our examination of WHTCH’s PICU leads us to conclude that extreme flexibility, distributed knowledge, emergent organization in the face of crisis and decentralized decision-making authority can all be designed into organizational units.

We find that organizational design in the PICU was an ongoing process, not an event that occurred at the unit’s initiation. The PICU directors continually readjusted their design to meet internal and external challenges. In this sense, the PICU’s design resided perhaps more in its leaders’ vision than in its structures and processes. The vision of how the PICU should operate remained constant, while its structures were often changed in response to unexpected consequences of the design itself. We also find that it is difficult for organizational subunits to institute unique designs. Because it contrasted with the designs of other subunits in its parent organization, the PICU’s design was fragile. Only the vigilant efforts of PICU leaders to buffer it from the rest of the organization allowed it to maintain its distinctiveness. And in the end even these efforts were not enough.

Endnote
1A fictitious hospital name was used to preserve the confidentiality of the facility and its employees.

References


Improving Patient Safety in Hospitals:

Contributions of High Reliability Theory and Normal Accident Theory*

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ABSTRACT

Objective. To identify the distinctive contributions of High Reliability Theory (HRT) and Normal Accident Theory (NAT) as frameworks for examining five patient safety practices.

Data Sources/Study Setting. We reviewed and drew examples from studies of organization theory and health services research.

Study Design. After highlighting key differences between HRT and NAT, we applied the frames to five popular safety practices: Double-checking medications, Crew Resource Management (CRM), Computerized Physician Order Entry (CPOE), incident reporting, and Root Cause Analysis (RCA).

Principal Findings. HRT highlights how double checking, which is designed to prevent errors, can undermine mindfulness of risk. NAT emphasizes that social redundancy can diffuse and reduce responsibility for locating mistakes. Crew Resource Management promotes high reliability organization by fostering deference to expertise, rather than rank. However, HRT also suggests that effective CRM depends on fundamental changes in organizational culture. NAT directs attention to an under-investigated feature of Computerized Physician Order Entry: It tightens the coupling of the medication ordering process, and tight coupling increases the chances of a rapid and hard-to-contain spread of infrequent, but harmful errors.

Conclusions. Each frame can make a valuable contribution to improving patient safety. By applying the HRT and NAT frames, healthcare researchers and administrators can identify healthcare settings in which new and existing patient safety interventions are likely to be effective. Furthermore, they can learn how to improve patient safety, not only from analyzing mishaps, but also by studying the organizational consequences of implementing safety measures.

Key Words. Double-check, Crew Resources Management, Computerized Physician Order Entry, Incident Reporting, Root Cause Analysis.
The Institute of Medicine (IOM) report *To Err is Human* introduced many patient safety advocates to the idea of developing hospitals into High Reliability Organizations (HROs) (Kohn, Corrigan, and Donaldson 2000). The HRO model is appealing, in part, because it helps healthcare organizations incorporate lessons learned from high hazard industries, such as aviation and nuclear power. In contrast, Normal Accident Theory (NAT), another research perspective that examines similar industries, did not receive such widespread attention from the healthcare sector. Although High Reliability Theory (HRT) and NAT were first cast as competing perspectives, they are now considered complementary (Perrow, 1999a; Weick 2004).

The two sets of HRT and NAT assumptions, concepts, and empirical predictions are best viewed as providing distinctive frames for understanding patient safety (Weick 2004). HRT and NAT are bodies of theory, research, and recommendations for practice and policy that evolved essentially in parallel. Hence, there are instances where these approaches diverge in their assumptions and in the organizational features they treat as critical, rather than offering competing hypotheses.

Each frame poses significant questions and offers valuable insights into the pursuit of patient safety. Previous studies compared the two perspectives by applying them to disasters (e.g., Roberts 1990) or near disasters (e.g., Sagan 1993), but we apply them to five popular patient safety practices. We aim to identify distinctive contributions that HRT and NAT make to understanding the organizational conditions affecting patient safety in hospitals and the prospects for transforming hospitals into HROs. To accomplish this, like Snook (2000) we expand NAT beyond its original system-level focus to include processes and interactions among units and individuals. Moreover, we apply NAT to understanding incidents and component failure accidents in hospitals, not just to systems accidents.

### COMPARING HIGH RELIABILITY AND NORMAL ACCIDENT THEORIES

Building on Sagan (1993), Table 1 compares and contrasts the two frames and their applications to hospitals. As the first two rows indicate, HRT argues that the features of HROs can be identified and adopted by other organizations seeking to attain high reliability (Roberts 1990). In contrast, as NAT scholars uncover enduring and inherent risks in high-hazard industries, they raise doubts whether the prototypical HROs in some high-hazard industries deserve imitation by others. One way to view this debate would be to see NAT authors as critics of HRT, as they raise concerns about features such as redundancy, training, and an integrated safety culture in which HRO analysts put considerable trust (e.g., Weick, Sutcliffe, and Obstfeld 1999). Another view would credit HRT for drawing attention to the realm of shared cognition and culture (e.g., Weick 1987; Roberts 1993), whereas NAT adds awareness of the effects on safety of system features including coupling, interactive complexity, and politics (Sagan 1994). Coupling refers to the degree of dependence among system components (e.g., procedures, equipment, and the people who operate them). Interactive complexity is the extent to which interactions among such components are unexpected, unplanned, or not visible.

As noted in the third column of Table 1, hospital organization and practice diverge substantially from the elements of HROs (Gaba 2000). Hospital managers typically pursue multiple and conflicting goals. Clinicians’ objectives and practices may diverge from
management’s espoused goals for safety and quality. Many technical and social features of hospitals exhibit redundancy, but not all of these contribute to safety and reliability (e.g., Lingard et al. 2004). Much of the gap between hospital realities and the HRO model reflects the fact that hospitals are professional bureaucracies (Mintzberg 1979), where norms and routines are learned through professional socialization and authority flows through professional hierarchies. In addition, whereas clinicians readily shift decision making responsibility in response to changing conditions (e.g., emergency codes), hospitals usually do not (e.g., Meyer 1982).

Hospitals tend to be loosely coupled. Loose coupling of routine activities enables providers to notice problems and intervene before they cause harm. Similarly, changes in one unit do not necessarily affect others. Except for emergencies, hospitals tolerate time delays (e.g., in a patient being sent for imaging tests), and the sequencing of procedures is often flexible (e.g., scheduling imaging tests and medication administration).

Hospitals do not ordinarily provide fertile grounds for the development of well-integrated and cohesive cultures of reliability. Hospitals and health care as a whole are very complex (Gaba, et al. 1987; Gaba 2000) and may be growing more so (Lake et. al. 2003). Hospitals often encompass a myriad of sub-cultures that mirror the structural complexity of the hospital system and its occupational differentiation (Degeling, Kennedy, and Hill 2001; Edmondson 1996; Ferlie et al. 2005; Sexton et al. 2001; Singer et al. 2003). Furthermore, some professional beliefs and norms clash with HRO norms (Leape and Berwick 2005; Thomas and Helmreich 2002).

**APPLYING HRT AND NAT PERSPECTIVES TO PATIENT SAFETY PRACTICES**

How can the HRT and NAT frames contribute to a fresh look at five popular and promising patient safety practices? We will examine each of these practices in turn.

**Double-Checking Medications**

Conducting double-checks, in which one provider reviews and signs off on another’s task, is a form of social redundancy that is pervasive in nursing (e.g., Cohen and Kilo 1999; Griffin 2003) and pharmacy (e.g., Cohen et al. 1996) and is required in particular situations by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). Despite the widespread practice of nurses double-checking medications, it has not been widely studied in hospitals (ISMP 2004). Double-checking requires that one fallible person monitor the work of another imperfect person. Because people tend to hear what they expect to hear and see what they expect to see, effectiveness is reduced (e.g., Reason 1990, ISMP 2003). Applying the HRT and NAT frames calls attention to the social and organizational implications of double-checking.

From a HRT perspective, when two professionals double-check a hazardous medication, they embody three key attributes of a HRO: 1) redundancy, 2) adherence to patient safety norms embedded in cultures of reliability, and 3) use of formal procedures that reinforce culturally expected behavior. Despite the Institute for Safe Medication Practices (ISMP) norms for double-checking high-hazard medications, one survey reports that such norms were routinely followed in only 45% of the hospitals (Smetzer, et al. 2003). Furthermore, HRO proponents are aware of the limits of relying solely on prevention as a means of averting harm (Weick and Sutcliffe 2001). Over-reliance on double-checking can actually reduce mindfulness of safety risks. For example, if a hospital is not selective in its medication double-checking requirements (ISMP...
2004), providers may consider the pervasive requirement to be a “superficial routine task” and not check independently (ISMP 2003).

The NAT frame also underscores the limits of redundancy, as embodied in double-checking medications. Even if nurses double-check medications independently, as instructed by ISMP alerts, they both can make the same mistake; both providers may be stymied by equipment or other environmental design flaws, such as a confusing drug label (ISMP 2004). Furthermore, double-checking, like other backup procedures, can compensate for underlying problems, and thus, delay their discovery and correction (Reason 1997). For example, if a mistake is detected and corrected during a routine double-check procedure in the hospital pharmacy, it is not classified as an error, and thus, the underlying cause may go unnoticed by pharmacy management (Tamuz, Thomas, and Franchois 2004).

NAT researchers argue that social redundancy, such as double-checking, may inadvertently undermine safety protections because of the inherent difficulties of expecting people to act as backups. When people are aware that others are duplicating their efforts, redundancy can diffuse responsibility and lead individuals to overlook safety checks (Snook 2000; Sagan 2004b). Instead of conducting an independent double-check, pharmacy “staff learn to rely upon the checker to catch problems” (ISMP 2004). Alternatively, a pharmacist who trusts the quality of a colleague’s work may fail to conduct a thorough, independent double-check due to overconfidence (Smetzer 2005). Effective duplication can also be subverted by differences in status and responsibility, such as when the nurse who double-checks, defers to the nurse with the primary drug administration responsibility.

Crew Resource Management (CRM)

Crew Resource Management (CRM) is a form of interpersonal communication training developed for and by commercial airline pilots (e.g., Weiner, Kanki, and Helmreich 1993; Hamman 2004), based on group dynamics research (Hackman 1990, 1993), and adapted as teamwork training in simulated operating room settings (Helmreich and Schaefer 1994: Gaba 1989; and Gaba, Maxwell, and DeAnda 1987). CRM practices include briefings -- in which the person in charge reviews the tasks facing the team and highlights potential threats -- and interpersonal communication methods. CRM instructs subordinates on how to raise safety concerns and question the actions of authority figures without challenging their authority. CRM is one of the “proven methods” of teamwork training for healthcare providers (Kohn, Corrigan, Donaldson 2000: 149). Hospitals have implemented both briefings and instruction in interpersonal communication (Leonard, Graham, and Bonacum 2004; McFerran et al. 2005), although these vary in thoroughness and depth.

Although teamwork is not considered a key element of HRT, CRM training fits well with the HRO model (e.g., Weick and Sutcliffe 2001). CRM techniques support “migrating decision making,” in which decision makers defer to the person with the relevant expertise, rather than the one with the highest ranking authority. Furthermore, CRM can make it easier to identify anomalies and, thus, respond flexibly to an unexpected situation. For instance, a team member is expected to speak up when confronted with a potential threat to patient safety (Sutcliffe, Lewton, and Rosenthal 2004).

HRT highlights how reward systems and organizational culture influence the effectiveness of CRM implementation (Musson and Helmreich 2004). Successful CRM implementation depends on removing disincentives for speaking up. If CRM training consists of
“one-shot, day-long classroom lectures” (Musson and Helmreich 2004: p. 29), it is unlikely to be sufficient to produce cultural change and overcome prevailing norms against speaking up to authority. Effective CRM would have to grow out of or be customized to fit a hospital’s cultures.

Perrow (1999a), the originator of NAT, underscores the broad, societal implications of supporting CRM and other methods designed to improve safety through modifying work group culture. He raises concerns that methods for improving teamwork “ask how we can make risky systems with catastrophic potential more safe” (Perrow 1999a: p. 379), but fail to raise more fundamental questions about the implications of pursuing efficiency goals in industries with catastrophic potential. Perrow’s concerns may be less relevant to hospitals than to other high-hazard organizations because loose coupling among hospital equipment, procedures, and units reduces the potential for catastrophic system accidents.

NAT’s emphasis on coupling and interactive complexity draws attention to important structural conditions that may affect CRM effectiveness in hospitals. CRM techniques are likely to prove more effective when systems and procedures are loosely coupled, because team members have time to identify hazards and to intervene before negative consequences occur. In contrast, tightly coupled, time-dependent technologies (e.g., chemical plants, heart-lung machines) provide fewer opportunities for intervention (Perrow 1984, 1999b). Therefore, we hypothesize that CRM methods will vary in their effectiveness depending on the degree of coupling that characterizes specific medical, surgical, and emergency response procedures.

Furthermore, under conditions of interactive complexity even if CRM enhanced communication among authority figures and their subordinates, they might still fail to recognize an unsafe situation or identify emerging threats. When practitioners cannot predict all the conditions under which potentially hazardous interactions might occur, they lack access to information that could be critical to collective decision making. Practitioner assessments of a situation may also be obscured by multiple layers of redundant safety measures. For example, in one hospital, the pharmacy computer system frequently generated a flurry of redundant but irrelevant warnings, making it difficult for the pharmacists to notice critical warning messages (Tamuz and Thomas 2006). Thus, in loosely-coupled systems, NAT would view efforts to improve interpersonal communication through CRM as necessary, but not sufficient conditions for improving patient safety.

Computerized Order Entry (CPOE)

Researchers and health policy analysts recommend CPOE implementation as a means of reducing medication errors that lead to adverse drug events (e.g., Aspden et al. 2004). CPOE eliminates handoffs between physicians, nurses, clerks, and pharmacists and reduces errors due to illegible handwriting, similar sounding drugs, and predictable drug interactions. CPOE can also accurately and efficiently collect data on particular error frequencies and disseminate such drug-related information. (See Kaushal, Shojania, and Bates 2003 for a review).

HRT and NAT do not directly address CPOE. However, both frames suggest constructive insights. The HRT perspective would highlight CPOE’s impact on information flow among decision makers. CPOE can contribute to HRO development by providing clinicians and higher-level managers with accurate data on error frequencies and adverse drug events. A disadvantage of CPOE is that current software and commercial products may not solve and can even complicate data entry, retrieval, and exchange as well as communication among providers (Miller and Sim 2004, Health Data Management 2005, Ash, Berg, and Coiera 2003). Thus,
implementing CPOE may enhance data access for top managers while hindering communication among clinicians with expertise and first-hand experience.

NAT draws attention to the implications of CPOE for system design. CPOE has the potential to produce fundamental design changes in the medication process; these changes would reduce interactive complexity and tighten coupling between medication ordering and dispensing. CPOE would reduce the potential for unexpected interactions in the medication process by eliminating involvement of some personnel (e.g., clerks who copy and fax the doctors’ orders) and equipment (e.g., fax machines). Coupling would tighten because an order change would more directly and rapidly affect drug dispensing; proceeding from the physician’s keyboard to the pharmacy computer, with fewer possibilities for people to alter or stop the order.

In practice, however, CPOE systems do not yet conform to designers’ expectations. The difficulties that have emerged can be readily understood within the context of NAT. First, according to NAT, system breakdowns can result from an array of different conditions, ranging from simple, recognized component failures to a multiplicity of unanticipated and unpredictable interactions. Second, redundancy in technologies like CPOE not only can enhance safety precautions, but also may undermine them.

To illustrate these two issues, we draw examples from research on an early CPOE system (Koppel et al. 2005). The researchers found that CPOE eliminated some medication error risks but gave rise to an array of other unanticipated risks. In NAT, some of these errors would be classified as simple component failures, such as the failure of the computer program to cancel a test-related drug order after the physician cancelled the order for the test. Other risks documented in this CPOE system illustrate how instances of interactive complexity can occur even in a relatively linear CPOE system (Perrow 1984). For example, residents diligently followed the dosing guidelines on the computer screen, but the minimal doses appearing on the screen reflected purchasing procedures for the pharmacy (e.g., purchase as 10 mg tablets) rather than clinical standards (e.g., for effective minimum dosage). Thus, a process designed for use by one component (i.e., pharmacy) interacted in an unexpected way with another (i.e., house staff). From a NAT viewpoint, simple component failures are less troublesome; once identified, they can be corrected. But unanticipated interactions among system components cannot be completely predicted, averted, or designed away.

This CPOE study also illustrates the difficulties of adding redundancy onto an existing organizational system, a recurrent theme in NAT research (e.g., Sagan 2004b). Some of the problems reported by Koppel and colleagues emerged from the design of the new CPOE technology and its unanticipated interactions with components (e.g., equipment, operators) in the existing medication ordering process (see also Han et al. 2005). CPOE was added to an existing system in which nurses continued to use handwritten reminders (e.g., to renew antibiotic orders) and attached them to patients’ charts. However, because the physicians were entering orders in electronic patient records, they did not notice the nurses’ written reminders. This illustrates how adding CPOE to an existing system resulted in unexpected interactions among system components.

One of the advantages of CPOE is that it replaces social redundancy (e.g., nurses checking doctors’ orders) with technical redundancy (e.g., computerized error detection). However, for allergy monitoring, “House staff claimed post hoc [allergy] alerts unintentionally encourage house staff to rely on pharmacists for drug-allergy checks, implicitly shifting responsibility to pharmacists” (Koppel et al. 2005:1200). This illustrates how technical redundancy can generate social redundancy and thereby increase the potential for error.
NAT points to a third potential problem with CPOE that has not been widely discussed: The safety trade-offs associated with making technologies more tightly coupled. To reduce routine errors, CPOE tightens the coupling of the medication ordering process. An unanticipated consequence of tighter coupling may be greater risk of infrequent, but potentially widespread and harmful errors. For example, a mistake in a decision rule programmed into the computer has the potential to harm many patients simultaneously.

We support implementation of CPOE but emphasize that NAT sounds an important cautionary note about the trade-offs in implementing tightly coupled systems. We need to better understand the conditions under which hospitals should tighten the coupling between departments and procedures, for example, as a means of reducing multiple, error-prone hand-offs. We also need to specify conditions under which hospitals can allow loose coupling and thereby provide more time to diagnose, respond to, and reverse potentially hazardous situations. Slowing down and decoupling operations can provide time for safe recovery, but at the cost of efficiency.

In hospitals, tight coupling is likely to occur in four types of procedures, which are shown in Table 3. Emergency procedures tend to be tightly coupled because they are time dependent. In technology-driven procedures, such as anesthesiology (Gaba 1989), tasks are time-dependent and the sequence of tasks cannot be easily changed. Chemical procedures are tightly coupled because they are time-dependent, invariant in their sequences, and follow a standard path. Furthermore, tight coupling of these procedures reduces the feasibility of using slack-- buffers or redundancies that may mitigate negative outcomes. Finally, automation often further tightens the coupling in technology-based and chemical processes, reducing the availability of alternative paths to implementation and the slack resources necessary for recovery. The risk in automation is that a low-probability error, such as introduction of an incorrect component in a chemical process, can rapidly spread a wave of high consequence errors.

**Incident Reporting**

The 2000 IOM report (Kohn et al. 2000) identified underreporting as a patient safety issue and recommended that hospitals develop non-punitive environments to promote incident reporting. Patient safety advocates (e.g., Kaplan and Barach 2002) called for intensifying the reporting and analysis of near-miss data, and some hospitals implemented a variety of near-miss reporting systems modeled, in part, on the aviation experience (Etchegary et al. 2005, Battles et al. 1998; see Wald and Shojania 2001 for an overview of incident reporting systems).

Both HRT and NAT stress the importance of learning from errors and near misses. However, the proponents of the two perspectives differ in their assessment of the feasibility of gathering information about these safety-related events and learning from them.

Although HRT does not explicitly promote incident reporting systems as a safety measure, incident reporting systems are consistent with elements of HRT. Incident reporting provides a method for clinicians to relay first-hand data about potential patient safety threats to key decision makers, provided that the clinicians can engage in valid “sensemaking” (i.e., accurately interpret what they observed.) In addition, top-level HRO managers could gather and analyze incident data to assess emerging patient safety problems and evaluate existing ones; they
could use the incident data to maintain a “big picture” of potential threats to patient safety. HRT advocates (e.g., La Porte and Consolini 1991) are optimistic that organizations can create reward systems that support meaningful incident reporting and promote the capacity to learn from errors. HRT researchers also recognize that when organizations do not fully enact these HRO precepts, they can hinder the gathering and use of incident reporting data. Making sense of errors can be problematic in HROs (Weick and Sutcliffe 2001); this might be reflected in healthcare providers’ expressions of confusion over what constitutes a medical error (e.g., Taylor et al. 2004; Wakefield et al. 2000). Moreover, there are also concerns about the reliability of incident report data, because of the tendency toward underreporting (e.g., Aspden et al. 2004). Furthermore, hospitals undermine the incentives for incident reporting when they “blame and shame” those who make mistakes (Roberts et al. 2004).

NAT researchers recognize that incident reporting systems can provide the feedback organizations need to learn from their experience, but they tend to be pessimistic that organizations will succeed in modifying their internal reward systems to promote blame-free incident reporting and learning (Sagan 1994, 2004a; Perrow 1999b). “The social costs of accidents make learning very important; the politics of blame, however, make learning very difficult” (Sagan 1994:238). High-hazard organizations usually do not create incentives for individuals to report their errors or for departments to share incident data with one another. Despite these difficulties, airlines have developed innovative methods of reducing incentives for incident reporting. Pilots who self-report incidents are sheltered from company disciplinary measures and full regulatory prosecution (Tamuz 2000).

Whereas HRT focuses on the “culture of blame” and NAT on “the politics of blame,” both sets of researchers concur that misguided reward systems discourage incident reporting. Surveys of healthcare providers suggest that fear, particularly of implicating others (e.g., Taylor et al. 2004) or of litigation (e.g., Vincent et al. 1999) contributes to underreporting. Similarly, nurses are less likely to disclose their errors if they perceive their unit leader is not open to discussing mistakes (Edmondson 1996).

Given the formidable barriers to gathering data within the organization, NAT directs attention beyond the organization’s boundaries. The organizational environment provides alternative methods for incident reporting as well as a source of pressure for internal change. Perrow recommends “constant feedback about errors and a system-wide sharing of near misses” (Perrow 1999b:152). He focuses on gathering data and disseminating information among organizations, not within them. Such industry-level, non-regulatory, inter-organizational reporting systems are exemplified by the Aviation Safety Reporting System (ASRS) (Tamuz, 2001) and an ASRS-based transfusion medicine reporting system (Battles et al 1998).

NAT researchers also suggest that agencies in the external environment can exert influence on intractable internal organizational interests. These agencies can create pressures and incentives to adopt safety practices (Perrow 1999b). For example, JCAHO has created incentives for hospitals to promote incident reporting and adopt patient safety practices (Devers, Pham and Liu 2004). Unfortunately, external forces, such as the tort system and professional licensing boards, can also block organizational learning in high-hazard industries when external agents assume that incompetent individuals cause most errors and adverse events (Tasca 1990). Therefore, NAT highlights the roles of agencies in the external environment in shaping internal incident reporting and patient safety practices.
Root Cause Analysis (RCA)

A Root Cause Analysis (RCA) is a formal investigation of an adverse event or a potential adverse event (i.e., one in which the patient was not injured but could have suffered harm). RCA programs rely on rational decision making processes to provide impartial, analytical tools for adverse event analysis. The nuclear power industry developed methods for investigating the root causes of hazardous events (e.g., Perin 2004). Similar RCA techniques have been adapted to the Veterans Administration Hospitals (Bagian et al. 2002) and disseminated as a model for U.S. hospitals. Specific RCA methods have been devised for UK healthcare settings (Donaldson, 2000) and tailored to analyzing transfusion medicine mishaps (Kaplan et al. 1998).

The HRT perspective highlights the potential contributions of RCAs. RCAs can be seen as a forum for “migrating decision making” by providing an opportunity for people with first-hand knowledge of an event to share their expertise with upper-level managers. Developing a culture of reliability and mindfulness would be a necessary condition for holding effective RCAs and also would be consistent with expanding the RCA focus to include potential adverse events, not just patient injuries.

HRT also focuses on communication with top management and within management teams. HRT would lead us to ask what top managers know about the RCA events and about any plans to avert their recurrence. Ideally, in an HRO, information resulting from an RCA would contribute to development of management’s “big picture” of the hospital operations.

NAT highlights how applications of rational problem solving techniques, such as RCA, are affected by decision making under conditions of ambiguity and politics. Political considerations can affect critical choices about:1) the events to be considered in a RCA, 2) investigation and interpretation of what went wrong, and 3) corrective actions. When decision makers choose events for RCAs, they often do so under conditions of ambiguity (Marcus and Nichols 1999). In hospitals, it is often unclear whether an adverse event could have been prevented, whether it is a rare aberration or likely to recur, or in the case of a near miss, whether it could have resulted in harm (March, Sproull, and Tamuz 1991).

Ambiguity gives managers room for interpretation. They may choose to investigate events that advance their personal or professional interests, whether to engineer a certain success or distract attention from a failure. Alternatively, they may decide not to analyze a particularly threatening event. Furthermore, decision makers may choose to analyze a near miss because they can devise a solution for it (Carroll 1998) or because it matches a solution they want to implement (Kingdon 1995). Interpreting the causes of and solutions for an accident can be a highly political process (Tasca 1990). When alternative solutions conflict, NAT would predict that the choice will migrate to the most influential participants, not necessarily to those with the most expertise. In addition, when a patient is harmed, the stakes are high, and clinicians seek to protect “their own.” In one hospital we studied (Franchois 2003), provider groups protected their own professional interests by choosing solutions in response to a patient injury, and in some cases, implementing their preferred solutions, before the first RCA meeting was held. RCA participants may also join in producing a “success” that identifies a proximate, simple, and visible cause and thereby avoids in-depth treatment of the issues, like other forms of limited learning in hospitals (Tucker and Edmonson, 2003). Despite its name, a RCA can allow the participants to choose simple fixes rather than searching for more complicated underlying causes. Thus, the HRT frame highlights potential contributions of a RCA, while the NAT frame illuminates the limitations of implementing a RCA in practice.
CONCLUSION

High Reliability Theory and Normal Accident Theory raise fundamental issues surrounding the introduction of safety practices in hospitals, particularly those adopted from other industries. Each distinctive frame focuses attention on some organizational conditions affecting safety while overlooking others. Each frame has strengths and can make a valuable contribution to improving patient safety. We sought to highlight the most productive applications of the frames, underscore their pitfalls, and call attention to their blind spots. Our approach may help policy makers, managers, and clinicians avoid putting confidence in solutions that might not produce the expected results and could actually divert attention from safety risks and needed changes.

Healthcare researchers and administrators might find it useful to apply HRT and NAT frames to help assess the trade-offs associated with patient safety practices and to identify contexts in which certain patient safety interventions are more likely to be effective. In particular, administrators might find it useful to apply these frames when deciding whether to adopt safety practices from other industries. For example, NAT directs attention to the organizational conditions under which the practice originated, as well as those conditions in the hospital to which it will be adapted. Applying these frames can assist administrators and practitioners learn, not only from medical mishaps, but also from the hospital’s choice and implementation of safety measures. By examining how organizations adopt and adapt new patient safety practices, administrators, as well as researchers, can also gain insight into organizational conditions affecting patient safety.

Despite the value of NAT and HRT, practitioners and researchers should treat both as frames and not as blueprints; they are sensitizing devices and not roadmaps (see Schon 1983). In the final analysis the theories, practices, and hypotheses that flow from HRT and NAT need to be tested empirically – both through research and through action – by formulating ideas, trying them out in practice, gathering data on the effects of these practices, and reformulating the ideas in keeping with the findings.

NOTES

1 On framing see (Bolman and Deal 2003; Harrison and Shirom, 1999; Morgan 1996).

2 We constructed the four sets of concepts by regrouping concepts presented by Roberts and her colleagues (Roberts, Yu, and van Stralen, 2004; Roberts et al. 2005). We focus mainly on the systematic HRT framework presented by Roberts and her colleagues in the Patient Safety Handbook (Roberts, Yu, and van Stralen 2004), because it is widely disseminated in the healthcare community. See Schulman (2005) for a discussion of variations on HRT, Weick and Sutcliffe (2001) for their application of HRT to business organizations. For NAT, we draw primarily on Perrow (1984, 1999a) and Sagan (1993, 1994). For comparisons of HRT and NAT and their applicability to healthcare see Gaba (2000); Gaba, Maxwell, and DeAnda (1987); and Hoff, Pohl, and Bartfield (2004).
REFERENCES


Table 1: Comparing HRT and NAT Theories to Hospital Organizations

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>HRT</th>
<th>NAT</th>
<th>Hospital Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Concern</td>
<td>Improve reliability in high-hazard settings (e.g., airlines, nuclear power)</td>
<td>Raise awareness of unavoidable risk of major system failures in industries using tightly coupled, interactively complex technologies (e.g., nuclear power)</td>
<td></td>
</tr>
<tr>
<td>Orientation</td>
<td>Optimistic and melioristic; focus on internal organizational practices and culture</td>
<td>Pessimistic; focus on industries: encourages political elites to abandon or radically restructure systems based on high-risk technologies</td>
<td></td>
</tr>
<tr>
<td>Applications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objectives</td>
<td>Reliability is first priority</td>
<td>Safety competes with other objectives</td>
<td>Administrators confront competing objectives</td>
</tr>
<tr>
<td>Redundancy</td>
<td>Technical and social redundancies enhance reliability</td>
<td>Redundancy can contribute to accidents when it: • lacks independence • increases complexity • obscures operating processes • diffuses personal responsibility</td>
<td>There are many social redundancies and some technical ones Some redundancies enhance reliability; others reduce it</td>
</tr>
<tr>
<td>Structure and Processes</td>
<td>Reliability enhanced by: • Rules and SOPs • Training in rule applications</td>
<td>Limited impact of rule enforcement and training</td>
<td>Professional controls are applied more frequently than rule enforcement; clinicians train through apprenticeship</td>
</tr>
<tr>
<td></td>
<td>Decision making migrates towards expertise</td>
<td>Decision making migrates towards powerful</td>
<td>Decisions sometimes migrate towards powerful</td>
</tr>
<tr>
<td></td>
<td>Flexible structure enables rapid response</td>
<td>Key structural concepts include: • Interactive complexity • Tight and loose coupling</td>
<td>Decision making tends to be decentralized</td>
</tr>
<tr>
<td></td>
<td>HRO lacks discussion of complexity and</td>
<td>Interactive complexity and tight coupling create potential for</td>
<td>Hospitals tend to be: • complex</td>
</tr>
</tbody>
</table>
| Culture                  | Cultural norms enhance reliability and safety | Safety culture is necessary, but not sufficient for safety | Hospital cultures characterized by:
  - multiple sub-cultures
  - conflicting beliefs and norms |

| Assumptions About Risk   | Managers assume that risk exists and that they can devise strategies to cope with risk | Politics and personal interests influence risk interpretation | Sources of risk are ambiguous
Developing risky new procedures and applications enhances hospital's and providers' reputations |

| Rewards                  | Rewards should be consistent with desired behavior | Reward system influences and is influenced by politics | External organizations influence internal allocation of rewards |

| Cognition                | Emphasizes cognition and developing a culture of mindfulness | Limited treatment of cognition | Organizational conditions can distort or undermine mindfulness
Few empirical studies of cognition |

|                        | Top managers see the big picture | Barriers to top managers gathering information from front lines |
|                        | Individuals engage in valid and reliable sensemaking | Successful history undermines current vigilance |
Table 2: HRT and NAT Analyses of Patient Safety Practices

<table>
<thead>
<tr>
<th>Patient Safety Practice</th>
<th>Analysis within HRT Frame</th>
<th>Analysis within NAT Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Double-Checking Medications</strong></td>
<td>Incorporates redundancy</td>
<td>Constrained by limits of social redundancy</td>
</tr>
<tr>
<td></td>
<td>Exemplifies a cultural norm</td>
<td>Can hinder and delay problem detection</td>
</tr>
<tr>
<td></td>
<td>Creates formal procedures to assure reliability</td>
<td>Can lower vigilance</td>
</tr>
<tr>
<td><strong>Crew Resource Management (CRM)</strong></td>
<td>Enables people with critical expertise and information to make decisions</td>
<td>Seeks to make risky technologies safer, not reduce their catastrophic potential</td>
</tr>
<tr>
<td></td>
<td>Facilitates flexible responses to unexpected situations</td>
<td>Better suited for loosely coupled technologies</td>
</tr>
<tr>
<td></td>
<td>Incorporates reward systems and cultural norms that support speaking up to authority</td>
<td>Relies on interpersonal communication skills; these are necessary but not sufficient to identify safety threats</td>
</tr>
<tr>
<td><strong>Computerized Physician Order Entry (CPOE)</strong></td>
<td>Provides a method for gathering error data for top managers</td>
<td>May reduce interactive complexity, but will increase tight coupling</td>
</tr>
<tr>
<td></td>
<td>May hinder open communication among different professionals</td>
<td>Reduces errors from simple component failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adds to risk of infrequent, high consequence errors affecting many patients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Illustrates limitations of redundancy “added on” to original design</td>
</tr>
<tr>
<td><strong>Incident Reporting</strong></td>
<td>Requires end to “culture of blame”</td>
<td>“Politics of blame” hinders reporting</td>
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<tr>
<td></td>
<td>Relies on individual capacity to engage in valid sense-making</td>
<td>Incentives lacking for reporting incidents</td>
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<tr>
<td></td>
<td>Provides a method to integrate individual heedfulness with organizational level assessment</td>
<td>Promotes inter-organizational exchange of safety-related reports</td>
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<tr>
<td></td>
<td>Enables top management to assess the big picture</td>
<td>Pressures from the external environment may influence internal reward system and enhance (or inhibit) reporting</td>
</tr>
<tr>
<td><strong>Root Cause Analysis (RCA)</strong></td>
<td>Fits HRO emphasis on learning from adverse events</td>
<td>Constrained by difficulties of learning from adverse events</td>
</tr>
<tr>
<td></td>
<td>Supports sharing expertise from front lines</td>
<td>Interpreting adverse events, their causes and solutions, can be shaped by political and personal interests</td>
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<tr>
<td></td>
<td>Works better in organizations with a culture of</td>
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<tr>
<td>reliability</td>
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<tr>
<td>Requires a reward system that does not blame or punish those involved in adverse events</td>
<td>Fosters overlooking problems that lack available solutions or ones preferred by management</td>
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<tr>
<td>Provides big picture to top management</td>
<td>Identifying problems can be hindered by complexity and multiple layers of redundancy</td>
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<td></td>
<td>May lead participants to choose solutions based on ease of implementation</td>
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Table 3: Tight Coupling in Hospitals

*Conditions Conducive to Tight Coupling*

<table>
<thead>
<tr>
<th></th>
<th>Emergency Procedures</th>
<th>Technology-based Procedures</th>
<th>Chemical Processes</th>
<th>Automation</th>
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</thead>
<tbody>
<tr>
<td><strong>Examples</strong></td>
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<td></td>
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<tr>
<td>• Responding to life-threatening “code”</td>
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<tr>
<td>• Treating heart attack patient</td>
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<tr>
<td>• Dispensing urgent “stat” medications</td>
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<tr>
<td>• Anesthesia in surgery</td>
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<tr>
<td>• Heart-lung machine in open-heart surgery</td>
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<tr>
<td>• Dialysis</td>
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<tr>
<td>• Batch lab tests</td>
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<tr>
<td>• Drugs in which the effects cannot be mitigated or reversed after administration</td>
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<tr>
<td>• CPOE</td>
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<tr>
<td>• Robotic drug dispensing</td>
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<tr>
<td>• Batch blood tests</td>
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**Tight coupling Elements**

<table>
<thead>
<tr>
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<th>Emergency Procedures</th>
<th>Technology-based Procedures</th>
<th>Chemical Processes</th>
<th>Automation</th>
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<tbody>
<tr>
<td>Delays are detrimental</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Invariant sequences</td>
<td>X</td>
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<td></td>
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<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>One path to goal</td>
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<tr>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Little slack allowed</td>
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<td>X</td>
<td>X</td>
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</table>

1 See Perrow, 1984.
Creation of a Pediatric Intensive Care Unit (PICU)

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A long habit of not thinking a thing wrong gives it the superficial appearance of being right. Thomas Paine

Growth in the PICU

In 1988 the PICU consisted of 8 patient beds without a full-time medical director. General pediatricians and subspecialists (such as neurologists, nephrologists, and allergists) provided critical care. One pediatric surgeon with little experience in pediatric critical care provided surgical support. Senior pediatric resident physicians in their last year of training acted in a subordinate role to surgical interns (physicians in their first year of training).

Five years later, the PICU grew in size to one of the 6% largest in the country. It had 25 beds with a full-time Pediatric Intensivist as medical director and several Pediatric Intensivists as sole attending physicians for medical patients and several pediatric surgeons for the surgical patients. Attending physicians took call from home, returning to the PICU about one-third of their nights on call.

Knowledge and techniques we shared with staff had to have immediate use. Frequently the staff did not appreciate live or die situations. The unit grew in size faster than its experience and we needed to save lives. Also, the information had to be sufficiently compelling that they would immediately put it to use with a clear benefit to the staff member rather than the patient. Benefit to the patient became arguable because of the uncertainty of outcomes.

We focused on problem-solving techniques, psychological influences, and social interactions. We could identify success when the staff member changed behavior, particularly if we began to see this behavior in others as through a contagion. Clear identification of roles and goals, both on a small scale and as a global approach (hospital and community), gave context for this change in culture.

But it was not without impediments or opposition.
Ron Perkin, a Navy A-4 Aviator from the Viet Nam War, arrived in December 1988 to develop a pediatric intensive care unit. He recruited me to begin in August 1989 partly because my background in fire department EMS resulted in a similar point of view for leadership and organizing for emergencies. He told me he wanted a program that did not repeat the mistakes of the US Navy; I wanted a program that used the best from ambulance men and the fire department.

Dr. Perkin said the basis of the program would be support of the bedside caregiver. My background from the fire department led me to agree with his approach. To do this, I at times, had to work with staff that made decisions I would not have. This would put me in the predicament of accepting some less than satisfactory solutions. But by not correcting them and showing how their answer to the problem could work I found they would listen to me, trust me, and, soon, identify errors and mistakes they made. They began to listen and learn more effective approaches.

As nurses felt more supported, they became more open in presenting patient situations to residents and attending physicians. They also trusted themselves more which increased their acceptance of the unpredictable and to novel approaches to problems. We began to identify patients earlier in the course of disease. Residents became a more integrated part of the team.

Trust began to develop between staff but trust in one’s self during an emergency did not develop without the presence of either one of us. The initial event occurred when Dr. Perkin resuscitated a child in respiratory failure. The team’s conventional approach was to hurriedly give medications and place a breathing tube into the trachea. This would occur as rapidly as possible, often with the body moving faster than the mind could work. He stopped the process in mid-action several times to allow the team to manually breath for the child. Once staff had all calmed, and they realized they could keep the child alive, the feeling of emergency passed and smooth operations began. Speed, they had learned, came from smooth operations, not from hurried activity.

We also began teaching the principles of physiologic deterioration rather than diagnoses. Identification of early heralds of physiologic deterioration, occurring in the early ambiguous period of disease processes, would allow safer and more effective interventions. While this might lead to second-guessing and criticism for over-reaction, we pointed out that all emergency services respond strongly to initial calls. We developed this same thought process: respond strongly then back off later.

With use of physiologic dysfunction as our model, rather than disease diagnosis, the staff would engage the disease process earlier in the course of deterioration. Working toward a diagnosis or attempting to use protocols and published evidence of best practices would delay intervention. It would also lead to confusion whether the patient related to a specific group studied, and if the patient would respond as the majority of patients studied or the minority of patients and exceptions.
Early identification accomplished little without immediate engagement of the issue. Our staff faced uncertain problems with time dependence and grave threat. Medicine teaches “First, do no harm” yet, in such emergencies, doing nothing is harmful. With the use of emergency decision making techniques, identification of psychological interference in teamwork, development of team by shared objective, and maintaining inclusiveness of all participants in our system, we found an organic system that would capture emergencies and errors early when they were most reversible and had the least complications in treatment. We taught that, while one cannot predict the future, one could prepare for it.

This directly led to a decrease in cardiac arrests and resuscitations in the hospital wards. Nurses, respiratory care practitioners and physicians would identify early, subtle findings and initiate treatment based on correcting physiology, not on diagnosis. If any doubt occurred about response to therapy or acceleration of the disease process they would transfer the patient to the PICU. Indication for PICU admission consisted simply of a request by anyone. Once in the PICU we would make decisions on keeping the child in the unit based on the trajectory of deterioration and response to therapy.

How to function in an emergency is important. I had observed that doctors evaluate and paramedics decide. This led to more work in decision making that involved combat models such as John Boyd’s OODA loop (Observe, Orient, Decide, and Act) over protocols and policies. The loop functioned in clear, deterministic systems where the situation determines intervention and intervention determines outcome. It functions in areas with fuzzy borders when a child’s condition has not deteriorated into an emergency when an emergency protocol would come into play. It also functions in ambiguous states when the situation is unknown. In such conditions, the OODA loop helps one learn what works through action and identifies the structure of the problem.

You do in an emergency what you do every day (Joe Martin, Battalion Chief ret, Los Angeles FD). We developed our daily routine such that it easily evolved into an emergency resuscitation. This allowed staff to use emergency techniques in the nascent period of an emergency before it can be clearly identified or declared.

One particular area of difficulty was abstract thought. Staff shifted from abstract thought to concrete thinking during an emergency with uncertainty or the unexpected. Teaching them to use concrete thought in low-tempo times helped them move smoothly into high-tempo situations without loss of communication.

This began a focus on articulate, objective, and succinct communication. Slang and jargon interfered with communication as we did not have standard definitions for their use.

We removed all policies to allow staff to solve the individual issue based on the situation and resources at the time of the issue. We began use of basic problem structure situation-intervention-objective as guidance of the program over policies. We placed emphasis on objectives and goals rather than situation identification.
I believed that self-efficacy would produce confidence, teamwork, and leadership. To help individuals learn problem solving we would discuss while I let the individual(s) develop a solution. With use of further information, now made salient by their decisions, I could guide them to better solutions and recognition of confounding situations and variables. I always left the individual with a final choice that I respected and would then follow.

Decisions migrated to the most qualified individual, defined as the one with the most information of the situation at hand regardless of rank, status, or role. Residents felt more supported and comfortable with their decisions. They became more integrated into decision making with the team.

Team formation would follow status and role during low-tempo times such as on patient care rounds. During high-tempo times (uncertainty with time dependence and grave threat) team formation occurred by shared objective. We had previously identified global objectives by lectures (formal or bedside) and individual objectives during patient care rounds. This reduced ambiguity during times of uncertainty. Further effects of ambiguity and uncertainty were ameliorated by decision processes and supportive environment (“You can do no wrong,” “There is no bad decision,” “Every bad result tells about the structure of the problem”).

As team formation improved leaders from various levels (ranks and status) emerged. Team leaders would occasionally step back and view the entire setting. When a fire captain picks up a fire hose, he is no longer a fire captain; he is a firefighter (Randy Ammons, Capt, Rialto FD). We identified them as those who could bring various points of view together toward a common goal.

Stress develops in high-tension programs working in the presence of death. Civilian organizations do little to address these effects on staff. We borrowed from military and public safety services. I gave routine lectures on the structure of stress as demands exceeding personal attributes and resources. We then discussed methods to increase attributes and resources as well as re-evaluating the demands. We encouraged the view that expectations were pre-planned failures, worry was living in the future when the problem was in the present.

When four or five children died in a short time period (usually 10-14 days) the emotional tone of the unit became palpable. I would review the number of children we admitted who received critical care techniques medications and technology only provided in the ICU and who survived in a normal state. (I did not include those who survived with any disability.) Typically we saved four-to-five children for every child who died. Staff found they routinely focused on failures rather than successes.

Focus on failure over success does play a significant role in high-risk, live-or-die situations. We constantly worked with staff who would remember their successes. We had to remember our failures. While we managed a patient we had to evaluate if we were
wrong. While confirmation bias is the norm in civilian population, we had to adopt nullification bias (searching for information that disproves your hypothesis or action) found in the military and public safety.

Much of their learning occurred in real time with our presence and interaction on scene. We returned to the PICU whenever an emergency resuscitation occurred. We would walk through the unit several times each week even if not on service caring for the patients. Despite that, in the first two years we would become successful only to fall apart from over-confidence. As Dr. Perkin put it, “Sometimes you have to fall apart to fall together.”

As confidence grew and resuscitations became more organic we began to have families present during resuscitations, even failed resuscitations. This made perfect sense to me because I had always had families, friends, and strangers present during resuscitations in my ambulance and paramedic experience. We found it no different in the PICU. This also became an natural extension of our policy of open visitation, where parents and grandparents could visit for unlimited time all day with only a few exceptions.

**Development of a culture**

By design we wanted a program built from the bottom up to improve safety. I wanted to develop a culture (values, beliefs, behaviors) similar to the best of the fire service. Internalized, culture brings passion, purpose, and fulfillment. It produces normative members that share ideals. When imposed, culture alienates members, leads to internal shut down and, at best, produces quid-pro-quo members, at worst, it produces alienated members for whom only punishment drives behaviors.

Values change from low-tempo to high-tempo times. Civilian observers and participants in emergencies (uncertainty, time dependence, and grave threat) miss this. We expected obedience for low-tempo times in that higher status positions would respond to requests for support and lower status positions would carry out orders. In high-tempo times we desired immediate engagement of the problem which requires initiative and creativity. Criticism, punishment, and consequences quickly destroy initiative resulting, in our view, in a dangerous environment. This emphasizes transformational leadership over transactional leadership.

The primary belief we sought is belief in one’s self. Primary to developing this is self-efficacy and a supportive environment.

Unrecognized fear response was the greatest behavior issue we addressed. This involves recognition of anger as the fight response, plausible avoidance (“What are the most recent lab values?” “I need to check another patient”) as flight response, and confusion, inactivity, and inability to recall as cortisol-mediated freeze response.
Fear as fight response manifested as anger. Any anger during an emergency resulted only from fear, typically at the inability to reach a preplanned objective (expectation). Without this perspective, staff felt that anger in a higher ranking individual was justified because it came from incompetence on the staff member’s part.

Fear as flight response manifested as avoidance, which can be quite subtle as in requests for more information or leaving to perform work elsewhere.

Fear as freeze response was most enlightening to staff. They felt the freeze response develop and knew it was a neurochemical response, not inadequacy on their part. They learned to return to a previously reached objective and the freeze response dissipated.

Development of mindfulness (Weick and Sutcliffe)

Preoccupation with failure helped us prevent failure, identify it early in its course, and to mitigate the effects of failure. This involved gaining trust in staff to discuss error, mistakes and failures, generally by repeated demonstration that failure arises from the situation. Can there be failure in the unknown or with uncertainty?

Failure, error, and mistakes in other operations (early ambulance and fire service) were viewed differently. Some things did not work; there was a better way; could we have done it differently; it did not go as expected. These phrases allowed discussions of error, mistakes, and failure without the moral connotation those words give.

We maintained a reluctance to simplify situations and issues. This appears somewhat paradoxical but we found that situations and simple solutions do not really exist. When resident physicians would initially present a critically ill patient they would simplify the patient into systems or problems they could make sense out of. For a dying patient they would first discuss lab values and fluids with mechanical ventilator settings given last. I would have them list ALL problems, and then we would connect the problems into groups. They could then identify one or two initiating events that developed into related physiologic manifestations with numerous observable, but expected and explicable, observations. Then we would identify interventions for the day. We closed with the course of the disease, and possible complications from pathophysiology and from our treatments.

We taught sensitivity to operations with discussions that error had antecedent events within our system. There would be no shame, name, or blame. I advised supervisory staff to stand back occasionally, not involved with any emergency activity, to observe the action in total. The amount of staff and level of activity always impressed them and gave them greater feelings of support.
A commitment to resilience allows us to adapt to changing situations and conditions, including the evolution of error. This kept error small and manageable, particularly with use of decision migration and engagement of the problem from early heralds of error.

Deferece to expertise, and authority and decision migration are covered elsewhere in this paper.

Use of reliability (Roberts)

**Structure elaborating**

One does in an emergency what one does everyday. There is no change in behavior for emergency operations. Our system, designed to operate in the routine day-to-day care of critical care, would easily accelerate to match the patient’s demands. The bedside nurse remained engaged with patient assessment and care. As demands increased, another nurse (RN) would see the activity and arrive to assist, identifying a role such as obtaining medications, administering medications, evaluation of vital signs, ensuring vascular access, or recording activity. The respiratory care practitioner (RCP) would arrive and evaluate the respiratory system, ensure oxygenation, evaluate equipment function, and obtain necessary labs.

The staff would constantly match immediate resources with demands of the situation. At some point, generally dependent on the patient’s physiological demands, they may call a “Code Blue” (resuscitation) response which would bring physicians, more staff, and the unit charge nurse and lead RCP. As staff arrive they identify a need based on their past experience and begin work. They may ask if there is a specific need based on the patient’s disease or condition.

Though the transition from routine care to unexpected problem and on to resuscitation moves smoothly, the change to Code Blue status has some significance. It releases resources in the unit to focus on the one patient, such as RNs leaving their assigned area to assist. It also moves medical requests to the front of the line. X-Ray requests, medications, and laboratory work become a priority for the whole hospital.

**Role switching**

Routine critical care can generally be managed by only a few individuals. The RN monitors the patient at bedside, records vital signs, obtains body fluids for laboratory analysis, administers medications, and administers feedings by vein or tube into the stomach. The RN will communicate to the family and other hospital services. The RCP will periodically evaluate the airway, oxygen administration, and mechanical ventilator function.

A resuscitation, at the other extreme, involves individuals to monitor the patient, obtain body fluids for laboratory analysis, record vital signs and resuscitation activity, mix
medications at bedside, administer medications, evaluate the respiratory function, operate
the mechanical ventilator, hand ventilate and provide heart massage as necessary.

Though routine care and resuscitations have much in common, they differ in that many
tasks become interdependent yet must occur simultaneously during the resuscitation.
Obtaining blood for laboratory analysis may have to wait until vascular access is
obtained. However, medication may have to be administered before the blood is drawn,
unless certain other needs have priority.

As the resuscitation expands, RNs and RCPs may arrive from elsewhere on the unit.
Their positions are backfilled by bedside staff at each nursing station. This ensures an
area does not become devoid of staff. As the resuscitation resolves, staff return to their
respective worksites. Tasks in the unit continue to be met. Tasks in the resuscitation are
also met.

**Migrating authority**

Caring for children in critical care routinely involves uncertainty. Early in the process,
the disease has not declared itself. During this period many diseases share common
findings. For example, the lung has only a few consequences from disease, they include
inability to absorb oxygen or release carbon dioxide or impeded air flow. It has only a
few responses, including increased or decreased respiratory rate and large or small chest
expansion. The lung can be a target organ as in pneumonia, a secondary target as in acute
respiratory distress syndrome, or a compensating organ as in diabetic ketoacidosis. Thus,
pulmonary findings can be initially uncertain as to the cause of the disease.

Information necessary to provide care to the child may come from advanced knowledge
of disease processes or from discussions with other experts. It may also come from
intimate knowledge gained by remaining at the child’s bedside for hours, or in-depth
evaluation of one organ system as the RCP does.

The individual who has the information to make a decision for treatment could be the
attending physician, distant consultant, or bedside caregiver. Maintaining central
authority as medicine does by culture may lead the person with the least real-time or
intimate knowledge to make a particular treatment decision. While physicians see
laboratory values, radiographic findings, and colleagues as resources to make effective
decisions, they rarely see bedside staff as resources to make the decision.

**System resetting**

Nasty surprises occur in critical care. Diseases evolve and develop complications.
“Complication” is defined by the World Health Organization as a second disease that
interferes with care of the first. This second disease may already exist, as a child with
cancer who develops an infection. Or one disease may create other diseases. As the
disease evolves, a more serious illness than expected may present itself. A child with
pneumonia may develop a blood stream infection which evolves into septic shock.
Sometimes, therapies do not work, resulting in use of more high-risk treatments. Severe asthma may not respond to medications. The team then may have to place a breathing tube in the child’s airway and use mechanical ventilation. At some point the physician must identify when a less dangerous therapy has not worked and move on to more dangerous therapies. There is no clear line when a less-dangerous therapy has become dangerous because the disease has progressed.

Therapies may also have adverse effects. One cannot predict when a patient will develop and adverse effect. When one does develop, the team must treat two diseases (a complication as defined above).

System resetting must occur rapidly and not depend on the presence of the physician, another reason for the importance of authority migration.

**Support for constrained improvisation**

Physicians in training encounter the concept of freelancing early in their training. As medical students or resident physicians they come to understand that they cannot treat patients without the consent of the attending physician. Working outside that consent is called freelancing. Early on, physicians learn not to step outside the bounds of accepted medical care nor accept such behavior in others.

This can interfere with care in a complex, dynamic system with inherent uncertainty. Staff may learn to improvise in a manner to prevent detection. One consequence is to lower trust between physician and staff.

In the ICU disease processes do not always play out in a predictable way. The physician and/or the staff may not have experience with a given situation. Staff lack of trust in the physician will interfere with the physician’s ability to innovate. Physician lack of trust in staff interferes with their ability to identify what works through action.

van Stralen and Perkin inculcated **trust** by preventing the “shame, name, blame” culture frequently found in civilian high stress work. Support for the staff included support for decisions that might not have been the best. By discussing the decision and showing how it could be plausible, they taught how problems could be solved by various interventions. They also introduced better problem-solving strategies. These included the basic problem of situation-intervention-objective. Medicine focuses on situation (diagnosis) whereas the ICU focused on reaching the objective. By evaluating the interventions necessary to reach the objective, one could better make the diagnosis. Also, Boyd’s OODA loop became a staple of decision making.

Improvising with **tools** is possible as physicians have authority to use medical devices for off-label purposes (uses other than approved by the Food and Drug Administration). However, the governance of the hospital limits the ability of physicians to improvise. Bedside staff can improvise. When the ICU first used helium for treatment of severe asthma, the RCPs improvised the equipment to blend helium with oxygen when administering the gas to our patients.
Van Stralen and Perkin reduced as much as possible rules, policies and protocols in an effort to maintain adaptability. One Pediatric Emergency Medicine Fellow had performed a fluid resuscitation in the Emergency Department (ED). (She had previously trained in the ICU.) The rule in the ED was to start a drug infusion to help the heart beat harder once fluids equivalent to half the blood volume had been administered (about 40mL/kg), then transfer to the ICU. She pointed out that, while there were no signs of excessive fluid administration, there were still signs of low fluid status. She continued giving intravenous fluid boluses and corrected the child’s state. The child was admitted to the hospital ward and did well.

Another occasion, one of the ICU Attendings gave fluid in a resuscitation to a child who then developed fluid in the lungs, backing up from the heart. He berated himself until it was pointed out the response to fluids had made the diagnosis of left-sided heart failure. This is a difficult diagnosis to make in an infant. He had remained too true to the rule of limiting fluids to heart patients (even if undiagnosed!).

**Routines** may be modified as necessary. During a period when the ICU experienced a higher incidence of acute lung disease, RNs began placing the children on their stomach. We discovered that we had better lung function with oxygen entering the blood more easily.

**Cognition Management Methods**
We routinely stated our “support for the bedside caregiver”. This brought focus and support to the importance of those working most closely with the patient.

Patient descriptions were made based on physiology, not on disease states. For example, a patient was not in shock nor developed hypovolemic shock. Rather, the patient had hypovolemia or was periherally vasoconstricted with low central venous pressure. This brought focus to the physiological derangement that could be corrected rather than a disease entity to be treated. The latter could more likely result in disagreements and arguments.

Standard decision theory based more on fire service and military models replaced algorithms and protocols common to medicine. These became a part of routine conversation.
Unit Statistics

<table>
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<tr>
<th>Year</th>
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<th>5700 Deaths (%)</th>
<th>5800 Admissions</th>
<th>5800 Deaths %</th>
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<td>59 (6.7)</td>
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<tr>
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<td>1151</td>
<td>93 (8.1)</td>
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<tr>
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Unit 5700 has 25 beds; Unit 5800 has 33 beds split between Intermediate ICU and Cardiothoracic ICU

Unplanned Extubation of Endotracheal Tube

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<td>1.3</td>
<td>0</td>
</tr>
<tr>
<td>1996</td>
<td>1.2</td>
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Interfacility Critical Care Transport Experience (1993)*

<table>
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<th>PICU</th>
<th>Physiologic Deterioration</th>
<th>Equipment Failure</th>
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<tbody>
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<td>0.8% (5/650)</td>
</tr>
<tr>
<td></td>
<td>2-11%</td>
<td>2%</td>
</tr>
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</table>

- We use trained RNs and RCPs but inexperienced pediatric resident physicians
Organization
AT THE LIMIT
Lessons from the Columbia Disaster

EDITED BY
WILLIAM H. STARBUCK
AND
MOSHE FARJOUN

Blackwell Publishing
MAKING NASA MORE EFFECTIVE

William H. Starbuck and Johnny Stephenson

Will NASA succeed in its endeavor to remain relevant, to correct organizational deficiencies, to gain set foot on the moon, and ultimately to explore the outer reaches of the cosmos? This chapter suggests actions that NASA can take to raise its effectiveness toward achieving those goals. The chapter reviews key properties of NASA and its environment and the organizational-change initiatives currently in progress within NASA, and then attempts to make realistic assessments of NASA’s potential for future achievement. Some environmental constraints make it difficult, if not impossible, for NASA to overcome some challenges it faces, but there do appear to be areas that current change efforts do not address and areas where some current efforts appear to need reinforcement.

Since the chapter focuses on NASA, it does not attempt to generalize about other organizations. However, many large government agencies and many large corporations share some of NASA’s properties, and they can possibly gain insight from this example. For example, other government agencies derive their budgets and structures from political processes and negotiations with Congress and the President, they operate facilities in several states. Similarly, many large corporations embrace highly diverse and decentralized divisions. Many corporations, large and small, have to reconcile the differing perspectives of managers, engineers, and scientists.

NASA also resembles other large and complex organizations in having flexible, ambiguous, and complex definitions of what it is trying to achieve over the long run (Starbuck and Nystrom, 1983). The Apollo project during the 1960s brought together a very effective combination of resources that had the potential to accomplish more than land on the Moon. However, the actual landing put a punctuation mark after NASA’s principal goal, and the war in Vietnam and the challenges of “the Great Society” raised question marks about NASA’s future. What should NASA be trying to achieve? How could the US benefit best from NASA’s capabilities? The ensuing four decades have brought an evolving array of capabilities, goals, and programs, some of which had sounder rationales than others. For NASA to make itself more effective is not merely a matter of achieving predefined goals but of discovering goals that will utilize the agency’s capabilities for the benefit of its nation and humanity.
LIMITED DEGREES OF FREEDOM

NASA's distinctive properties and environment limit what it can do to become more effective... or even different in some respects. To be practical, recommendations have to consider these properties. The distinctive properties include the diversity and autonomy of NASA's centers, a structure that has been set by the politics of earlier eras rather than by the logic of current activities, funding that has not depended upon its accomplishments and indeed has correlated negatively with them, shifting and impossible goals, an assigned role as the coordinator of an industrial network, and extreme scrutiny as a symbol of American technological achievement. Each of these properties offers NASA some advantages that would be difficult or impossible to forgo, even as each also restricts NASA's degrees of freedom.

Diversity and autonomy within NASA

NASA is both one agency and several. Its 10 centers are extremely autonomous. Although most large corporations have divisions with substantial autonomy, corporate divisions rarely or never have enough independent power to challenge their corporate headquarters. However, NASA centers have independent political support and some employ their own Congressional liaison personnel. Murphy (1972) attributed NASA's congressional liaison activities to the tenure of Administrator James Webb during the 1960s. Furthermore, relevant Congressional committees hold meetings at the larger centers, with the result that key members of Congress become personally familiar with the centers, their activities, and their leaders. Johnson Space Center and Marshall Space Flight Center, which jointly control almost half of NASA's budget, have sufficient autonomy that they have been known to proceed contrary to direct instructions from NASA's headquarters (Klerkx, 2004).

NASA's centers have very distinctive personnel, cultures, and procedures. For example, the Jet Propulsion Laboratory (JPL) operates as a Federally Funded Research and Development Center (FFRDC) that works under contract with NASA and has greater personnel flexibility than other NASA centers. JPL employs scientists who work on unmanned exploration of the solar system and outer space and who have openly criticized manned space flight as wasteful, dangerous, and unnecessary. By contrast, Langley Research Center employs mainly engineers and scientists who support the design and testing of aircraft components used in commercial and private transportation. Behavioral Science Technologies (BST, 2004) surveyed employees' opinions at the NASA centers. Personnel at Kennedy Space Center and Marshall Space Flight Center scored above average on all 11 scales, and personnel at JPL scored above average on 10 scales. At the other extreme, personnel at Glenn Research Center scored below average on 10 scales, and personnel at Stennis Space Center and at NASA's headquarters scored below average on 7 scales. BST also received complaints from personnel at the centers and at NASA headquarters about inadequate communication between the centers and NASA headquarters and about competition between centers. Centers have distinct rules for such mundane activities as travel to ever corpor persisted fo

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as travel to conferences and expense reimbursement; such differences occur whenever corporations merge or make acquisitions, but in NASA, these differences have persisted for nearly half a century.

The autonomy of its centers gives NASA as a whole resilience, fosters innovation, and strengthens survivability. It is an agency with multiple agendas, multiple constituents, and multiple protagonists. A failure or setback in one part may not affect other parts, or insofar as it does, these effects may arouse reactions from constituents who are protecting their interests. There is, for instance, little reason to link problems with space flight to the missions of aeronautics centers that perform services such as testing radios intended for use in commercial aircraft. However, the NASA organizational umbrella allows more mundane activities to draw some grandeur from more adventurous and visible projects, and allows riskier projects of speculative value to gain support from their links with essential and beneficial activities. Decentralized contacts with numerous members of Congress help to broaden understanding of NASA’s goals and activities. As well, centers’ different cultures foster different ways of thinking and the development of distinct ideas, and debate within NASA helps to reduce “groupthink.” However, as would be the case in any organization, NASA insiders do not exhibit in public the full range of opinion that occurs among outsiders, and NASA insiders have sometimes been disciplined for speaking too critically.

Structured by history and politics rather than current tasks

Like other government agencies, NASA’s structure reflects history and politics more than logical analysis of tasks it is currently pursuing. The Langley laboratory was founded in 1917 in response to a perception that private industry was doing too little aeronautical research. Ames and Glenn were created in 1939 and 1941, respectively, to support aeronautical research in the face of an impending war (Burgos, 2000; Muenger, 1985). Langley, Ames, and Glenn had reputations as exciting workplaces for aeronautical engineers who wanted to pioneer. Military agendas, politics, and regional economics influenced the selection of sites for Ames and Glenn, as they have for other NASA facilities (Burgos, 2000). Langley and Ames had sites on military airfields. Lobbying by the California aircraft industry, which produced half of the US output, led to Ames’ placement there. Nineteen cities competed for Glenn, but Cleveland won the competition by offering to supply electricity at low cost for wind tunnels.

The history of Cape Canaveral illustrates how then current perceptions and immediate events affected decisions about NASA’s facilities (Spaceline, 2000). In 1938, the Navy set out to add two air stations on the east coast of Florida, and it chose Cape Canaveral for one of these. The Banana River Naval Air Station operated from 1940 until 1947 and then fell vacant. Meanwhile, missile testing began in White Sands, New Mexico, but only short-range missiles could be tested there. In 1946, the Joint Chiefs of Staff established a “Committee on the Long Range Proving Ground” to analyze possible locations for a new missile range to be shared by all military branches. The committee identified three sites: one on the northern coast of Washington, one at El Centro, California, and the Banana River Naval Air Station. In May
1947, an errant V-2 rocket went south instead of north over the White Sands range, flew directly over El Paso, Texas, and crashed into a cemetery in Juarez, Mexico. Four months later, the Committee on the Long Range Proving Ground announced its decision to recommend placing the missile proving ground at El Centro, which was very close to existing missile manufacturers, with Cape Canaveral offered as a second choice. However, the California site would launch missiles over Baja California, and with the Juarez cemetery fresh in mind, Mexican President Aleman refused to agree to allow missiles to fly over Mexican territory. Thus, in 1949, President Truman designated Cape Canaveral to be the Joint Long Range Proving Ground. The Army’s Redstone Arsenal began to use Cape Canaveral to test missiles in 1953, and the Navy began using it in 1955.

Of course, as time passed, the reasons for creating facilities or placing them in specific locations became obsolete, and the presence of NASA facilities has altered the areas where they are located. Cleveland’s location away from coasts no longer renders it safe from attack, which had been an asset in the late 1930s, and northern Ohio now has relatively high electric rates (McGuire, 1995), but several thousand Ohio residents depend on Glenn economically. The initially isolated Cape Canaveral has attracted nearly 10,000 permanent residents and a substantial tourist industry.

The major political contingencies have included general US economic conditions and the policies of various presidential administrations. Figure 16.1 shows the history of NASA’s employment and budget, with the budget adjusted for inflation. Peak levels occurred in 1966 and 1967 during the Apollo program. NASA’s budget and employment then shrank rapidly, with budget cuts leading employment cuts. Congressional debate about the size of NASA’s budget began in 1966, three years before the first flight to the Moon. The decline in NASA’s budget during the late 1960s and early 1970s received impetus from growing skepticism among voters about the benefits of space exploration, as well as if (Murphy, 1993), the C the ensuing 1993, the C the ensuing while NAS/ dropped bel

Its politic and how to decisions w space shuttl 1970s, the the shuttle's cers at Mar opted for s create an ir other shuttl 1995). Four: $655 million Lockheed t contract to contract to decision, at General Ac had not bee should mak no reason NASA recor.ion. Utah’s Fletcher ha links to Ut: connection: Morton Th about the d the advisor

![Figure 16.1](image_url)  
**Figure 16.1** NASA’s budget and workforce.
as well as from financial demands of the Vietnam War and "Great Society" programs (Murphy, 1972). NASA's budget and employment stabilized in the mid-1970s and remained fairly level until the Challenger disaster. Challenger stimulated substantial budget increases, with employment increases a couple of years later. However, in 1993, the Clinton administration set out to reduce the federal workforce, and over the ensuing six years the government as a whole reduced employment by 20 percent while NASA shed 30 percent of its workforce. By 1998, NASA's employment had dropped below 18,000, but its budget continued to decline until 2000.

Its political environment has second-guessed NASA's decisions about what to do and how to do it and restricted NASA's discretion. Perhaps the most visible of these decisions was the selection of Morton Thiokol to supply solid rocket boosters for the space shuttle. Facing congressional resistance to the shuttle program during the early 1970s, the Nixon administration cut its budget by 20 percent, and NASA modified the shuttle's design to elicit support from the Department of Defense (DOD). Engineers at Marshall Space Flight Center wanted to use liquid-fuel boosters, but NASA opted for solid-fuel boosters because the US Air Force wanted bigger payloads. To create an impression of lower costs, NASA decided to recycle the boosters and most other shuttle components after use (Dunar and Waring, 1999; Hoover and Fowler, 1995). Four companies submitted bids to build these boosters. Aerojet Solid bid $655 million, Morton Thiokol and United Technologies both bid $710 million, and Lockheed bid $714 million. The NASA advisory panel recommended giving the contract to Aerojet Solid, but the NASA Administrator, James Fletcher, awarded the contract to Morton Thiokol in Brigham City, Utah. Aerojet Solid appealed Fletcher's decision, and after many allegations and counter-allegations, Congress asked the General Accounting Office (GAO) to investigate. GAO said that the award procedure had not been improper in that NASA's regulations clearly stated that the Administrator should make the decision, not the advisory panel. However, GAO said it could find no reason for selecting Morton Thiokol over Aerojet Solid and recommended that NASA reconsider the decision. Morton Thiokol's location was a topic of much discussion. Utah's senators Jake Garn and Frank Moss had actively supported NASA; James Fletcher had been President of the University of Utah until 1971 and he had many links to Utah and its industries. Fletcher himself denied that his business and social connections had influenced his decision, but his reasons for awarding the contract to Morton Thiokol were unclear and unconvincing. Further, NASA fueled suspicion about the decision process by refusing to answer questions about the membership of the advisory committee that had recommended the selection of Aerojet Solid.

Political pressures give birth to inconsistent and impossible goals

Competing goals or goal conflicts exist within all organizations and within most projects – one subgoal contradicts another, different stakeholders attempt to claim shares, multiple goals compete for attention and resources. Likewise, all organizations struggle to balance short-run goals, which might undercut future options, against long-run goals, which might never become realistic (Starbuck, 2005a). Political environments
seem to invite multiple goals and to shift attention toward the short run. Members of Congress earmark projects for funding that may or may not be consistent with agencies’ ongoing missions. Some of these goals, or the priorities among them, change over brief time horizons, as new Houses of Congress and new presidential administrations add their agendas on top of previous ones.

NASA’s high-profile goals in space travel and exploration require persistent efforts over long time horizons, whereas politicians who must face re-election campaigns in two to four years tend to show little interest in goals that will require two or three decades to achieve. Thus, NASA’s goals have become increasingly diverse over the course of its 45-year history. According to the audit report of NASA’s Inspector General in March 2001, NASA was attempting to achieve no less than 211 “performance targets.” In addition to exploring the universe and developing ways for humans to travel in space, NASA says it is supporting such diverse subgoals as better transportation of farm livestock, communication to and employment of people having limited English proficiency, environmental protection, design and construction of conventional commercial aircraft, dissemination of technological knowledge, medical diagnosis, military defense, and research by minority universities.

One central goal conflict involves the tradeoffs between technological innovation, cost, and safety. In principle, NASA is supposed to pioneer new technologies, and new technologies inevitably entail risk. Indeed, NASA’s technologies tend to be very complex ones in which many components can fail, so the risks are rather high. The risk that a shuttle flight will cause death has been around 2 percent (Whoriskey, 2003) even though NASA goes to great lengths to protect life. Fatal accidents threaten NASA’s long-term goals by eliciting negative publicity and very unfavorable attention, which lead NASA’s constituents to wonder if the rewards of exploration are worth the risks. Therefore, NASA must continually seek to minimize such risks at the expense of cost, innovation, and discovery. Of course, safety conflicts with cost efficiency (Heimann, 1993; Landau, 1969). Very safe systems are very expensive because they undergo much testing and they incorporate much redundancy, and very safe systems require slow technological change in order that the reliability of components can be verified. The shuttle and space station have thousands and thousands of components, many of which can cause trouble, and so NASA is reluctant to modify them unless reasons are compelling. One result is that NASA’s space programs incorporate technology that is many years out of date.

Another goal conflict involves tradeoffs between technological innovation and international cooperation. When NASA uses innovative new technologies in projects that involve international cooperation, it is disclosing these technologies to its international partners. Although the diplomatic façade maintains that international partners are trustworthy friends, there are variations among these friends, and some technologies might have military applications. As well, members of Congress have sometimes challenged NASA’s support of the space programs of other countries on the ground that these activities create competitors for American industry (e.g., a letter from GAO to Senator Phil Gramm on February 6, 1996).

The complexity of NASA’s goals is partly a result of endless political maneuvering around its goals and its budget. Some of NASA’s activities have very strong political support because of the economic effect the testing of these fractions has on the national defense. They are vital to the economy of the nation. The most obvious example is the space program, which not only provides employment and economic stimulus but also serves as a source of technological advancement. The space program has received over $150 billion since its inception in 1958, and it is expected to continue to grow in the future. The space program is considered by many to be the cornerstone of American industrial and technological leadership, and it is seen as essential to maintaining a strong national defense. The space program is also seen as a source of pride for the nation, and it is a symbol of American ingenuity and technological prowess.
Excerpts of the text:

"...NASA's budget increased to support more and delivered less. The television commentators who spoke with members have tended to disappoint. By comparison, NASA's contractors have promised more and delivered less. ..."
admiration of a space transportation system that could launch monthly later spoke sarcastically of a system that fell far behind its announced launch schedule. Such over-promising and the ensuing disappointments seem to be inevitable in the US political system.

NASA coordinates an interorganizational network

Among NASA's diverse goals is maintenance of and support for an interorganizational network. Aerospace companies have been deeply involved with NASA since the earliest days of space exploration, and NASA has subsequently been the coordinating node of an interorganizational network. Major companies such as Lockheed Martin and Boeing participate in planning what NASA is going to do and how it is going to do it, and NASA personnel know that these companies are going to receive significant contracts to carry out the work. Its participants take this network's stability for granted. Starbuck served on a committee that made recommendations concerning the design of the space station, and another member of this committee, Harry L. Wolbers, headed the space activities for McDonnell-Douglas. Starbuck speculated to Wolbers that he must be nervous about the selection of contractors for the space station because it would probably make a big difference financially if NASA selected McDonnell-Douglas to become the primary contractor for the space station. Wolbers replied, "No, it does not matter who is the primary contractor. We are major subcontractors on every bid."

In 2004, NASA employed about 19,600 people directly but also around 38,900 people through contracts. That is, in 2004, only a third of the people working on NASA projects were actually NASA employees. The NASA component is lowest at Johnson, Kennedy, and Stennis, where contractors account for about 81 percent of the workforce. These ratios are typical for recent years. By contrast, back in 1965 when NASA's employment was nearing an all-time high, the ratio of NASA employees to contractors' employees reached an all-time low; NASA's own employees comprised only 8 percent of the people working on NASA projects, and contractors were employing 92 percent.

NASA's creation was a reaction to Russia's Sputnik, and one aspect of this reaction was concern about potential military threats. Thus, the US has always seen activities in space as having military implications, and the DOD manages large space programs. The Air Force's Space Command, which accounts for most of DOD's spending for space-related activities, currently has a budget that is about three-fourths of NASA's budget.

There are very fuzzy boundaries between NASA's activities and those of the DOD. Some of NASA's most senior leaders are of DOD descent, boundaries between the two organizations are not always clear, and the mission objectives of DOD occasionally influence mission objectives within NASA. For instance, according to the 1994 "US Space Transportation Policy," DOD is responsible for "expendable launch vehicles" and NASA for reusable ones. However, before 1994, DOD was working on a reusable vehicle, and the next space policy statement may shift the boundary again. The 1997

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The 1997

Annual Defense Report remarked, "Although the National Aeronautics and Space Administration (NASA) is the lead agency for the development of reusable launch vehicles (RLVs), DOD will work closely with NASA as it defines requirements and pursues technologies. The expertise at DOD labs on reusable technology will be a valuable asset to NASA as it develops the RLV." The aerospace firms that work for NASA also work for DOD, and some NASA personnel are military personnel. The International Space Station is a descendant of the Air Force's Manned Orbital Laboratory; it was passed to NASA because the Air Force could not get funding for it. Several NASA facilities are adjacent to military ones. For example, Edwards Air Force Base shares various operations with NASA's Dryden Flight Research Center. Because of these colocated facilities, some DOD contracts include services to NASA as well as to DOD. DOD and NASA have jointly awarded a contract—currently estimated at around $9 billion—to TRW Space and Electronics to build the National Polar-Orbiting Operational-Environmental Satellite System. NASA collaborated with DOD personnel in the development of requirements for the Orbital Space Plane that was cancelled after the President's January 2004 announcement of his long-term goals for space exploration. According to Sean O'Keefe, the NASA Administrator, "you really can't differentiate...between that which is purely military in application and those capabilities which are civil and commercial in nature" (Zabarenko, 2002). O'Keefe then proposed that the government take another look at the restrictions that DOD should build only "expendable launch vehicles" and NASA only reusable ones.

NASA began the space shuttle program largely because of the economic benefits it would provide for the firms in its network. In the late 1960s, President Richard Nixon did not want to fund another large NASA project but he wanted to support the aerospace industry, which was depressed (Klerkx, 2004). The industry and the White House sought to identify on-Earth projects that would exploit the expertise of aerospace companies, and a few such ventures began (e.g., the building of mass-transit systems). However, no compelling ideas emerged that would be sufficient to rescue the entire industry. Meanwhile, the DOD had become a strong proponent of the shuttle, so Nixon eventually authorized the shuttle project.

The number of participants in this network has decreased considerably over the years. According to Klerkx (2004), 75 companies were focusing on space technologies around 1980, and by 2000 this group had consolidated to just five companies—Boeing, General Dynamics, Northrop Grumman, Lockheed Martin, and Raytheon. This consolidation may have slowed innovation by increasing the influence of vested interests and by giving NASA fewer ideas and options. Indeed, Boeing and Lockheed Martin have a partnership, the United Space Alliance, that dominates all other participants in influence and contract amounts. The large aerospace companies have also been active politically. In the defense sector, the four companies making the largest political contributions during the 2004 election cycle were Lockheed Martin, General Dynamics, Northrop Grumman, and Raytheon; and Boeing ranked tenth (www.opensecrets.org/industries/).

As NASA's coalition partners have merged and consolidated, they have grown more powerful vis-à-vis NASA and more interested in operating independently of NASA. In the early 1990s, Boeing, General Dynamics, Lockheed, Martin Marietta,
McDonnell Douglas, and Rockwell collaborated to investigate the feasibility of developing communication satellites and space transportation as commercial enterprises by private industry. In its 1997 version, the "Commercial Space Transportation Study" argued that space transportation was operating under conditions "considerably different from nontime commercial markets." At present, said the report, "Launch infrastructure, principal launch assets, and manufacturing facilities are under the control of various branches of the U.S. government. The market is predominately determined by governmental budgets. This places a large element of market risk due to the uncertainties of annual appropriations. Transitioning to a market that is predominately commercial requires the development of new markets and a major cultural change in the ways of doing business in space." However, the aerospace companies were not prepared to assert that they could develop space transportation on their own. "To attract commercial investment it appears that some level of government participation will be necessary." By 2001, the aerospace companies were giving up on commercial space activities and refocusing on military space activities. According to Morring (2001), "Civil space is chugging along in Earth orbit for the most part, without a grand mission of exploration to loosen the public purse strings. That leaves military activities as the sector where the men who guide space business for Boeing and Lockheed Martin see their best chance for near-term growth." Of course, the successful launch of Spaceship One may have made space tourism a new market force, one that the major aerospace companies have been ignoring.

One result of NASA's interorganizational network is debate about what to do inside NASA itself versus outside via contractors...Contractors have weaker constraints and more flexibility but they are less subject to influence by Presidents or Congress and they have tended to focus on short-term results at the expense of long-term objectives. The facilities at Langley originated because private industry was not making adequate investments in research to develop new aircraft technologies, and the facilities at Ames and Glenn were created because research by private industry had not created the advanced technology that an impending war would require.

A second result of NASA's interorganizational network is "distributed learning" as NASA shares learning opportunities with its contractors. Some architects advocate the value of "learning by building," the idea being that designers gain deeper insights into the pros and cons of their designs through participation in actually constructing them. Because NASA does little actual construction, its engineers have very restricted opportunities to learn by building. Such opportunities go to NASA's contractors.

The division of labor between NASA and its contractors received new visibility in June 2004 when a Presidential Commission recommended that NASA allocate much more of its activities to the private sector (Aldrich Commission, 2004). NASA may make changes in this direction, but the arguments have strong ideological elements and weak bases in rational assessments of technological needs and capabilities. The Columbia Accident Investigation Board (CAIB) seemed to say that NASA had lost too much of its internal capability through cutbacks in the civil service workforce. NASA currently deems the CAIB report to be prescriptive and the Presidential Commission's report to be advisory, but policies may change with a different presidential administration or a different Congress or a new assessment of national needs.
In summary, NASA has diverse relationships with its contractors, ranging from arm's-length customer-supplier relationships in which NASA defines the requirements for delivery to trust-based partnering relationships in which contractors participate in planning. Trust-based partnering relationships are essential where there is great technological uncertainty. Contractors' personnel sometimes have expertise that NASA lacks internally. NASA cannot always specify what designs are the most feasible or what quality standards are essential at the outset of a project. NASA cannot lobby Congress for funding commitments nearly as effectively as can its numerous and widely dispersed contractor partners. Such conditions are especially relevant for NASA's pursuit of space exploration. Since NASA cannot determine in advance all the technologies needed to accomplish space exploration and it certainly does not have sufficient budget to realize the complete long-term goals, NASA is collaborating closely with a range of partners to define intermediate steps that make up strategic and technological roadmaps. Furthermore, since the goals extend over decades, NASA must build a network of support that incorporates many aerospace companies. The companies realize that they will be formulating requirements, often in parallel with companies they view as competitors, yet the collaboration can generate significant gains in technology and ultimately revenues. Many companies will see gains, not only from their work with NASA, but also from work with DOD and commercial customers. They therefore serve as valuable advocates by deploying their lobbyists to encourage long-term commitments and funding. These partnering relationships are essential, yet extremely complex, and result in NASA's devoting significant energy and attention to coordinating this vast and powerful network.

Symbolic importance but not practical importance

A NASA insider describes NASA as "the nation's team." His point is that the American public sees NASA as a symbol of national technological achievement, but this status also means that the American public thinks their team must not fail. NASA is a focus of scrutiny, partly because it undertakes adventurous tasks and partly because it stirs national pride.

Gallup polls have found wide support for NASA. Polls between 1993 and 1999 reported that 43 percent to 76 percent of the people polled judged NASA to be doing an excellent or good job. In a 2003 poll conducted just one week after the Columbia accident, only 17 percent of the respondents said that they would like to reduce NASA's budget and 25 percent said that they would like to increase NASA's budget. However, six months later, in August 2003, respondents said they would rather spend money on defense or healthcare than on the space program. A general methodological point is that assessments of public support should compare NASA with alternative uses of funds.

Seeking detail about the bases of public support for NASA, Starbuck passed out a free-response questionnaire to 179 graduate students between 22 and 35 years of age. The graduate students knew more about NASA's activities than the general public. The questionnaire did not exactly parallel the Gallup polls but graduate students
seemed to be less supportive of NASA than Gallup's respondents were. Approximately 30 percent of the students were not US citizens, although they may have been taxpayers. Somewhat surprisingly, both citizens and non-citizens gave very similar answers, although citizens and non-citizens frequently offered different rationales for their responses. To see how people perceive what NASA has been doing recently, the questionnaire asked the students to focus on its activities during the most recent decade, not the previous four decades. Table 16.1 shows their responses. This informal study offers moderate support for the idea that people perceive NASA as "the nation's team" in that 31 percent of the respondents said that NASA symbolizes American technological superiority. There is also general appreciation for NASA's contributions to scientific research and technological development, but many more of the respondents see these contributions as benefiting humanity in general rather than benefiting the US or themselves personally. Roughly a fifth of the respondents expressed doubt that NASA has contributed anything to humanity or to the US during the last 10 years, and roughly half of the respondents expressed doubt that NASA had done anything that had benefited them personally during the last 10 years. Overall, many respondents perceived NASA as having importance as a symbol of

Table 16.1 Public perceptions of NASA's contributions from 1995 to 2004 (% of those sampled; N = 179)

<table>
<thead>
<tr>
<th>Contributions to</th>
<th>Humanity</th>
<th>US</th>
<th>Me personally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific research, biological research, technological development, understanding of space, astronomy, man's place in the universe</td>
<td>63</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>None, nothing, &quot;I don't know of any&quot;</td>
<td>18</td>
<td>21</td>
<td>47</td>
</tr>
<tr>
<td>Respect for American scientific and technological capability, national pride</td>
<td>1</td>
<td>31</td>
<td>1</td>
</tr>
<tr>
<td>Demonstrated management errors, raised doubts</td>
<td>2</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Pride in human achievement, hope for the future</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Entertainment through exhibits, credibility of science fiction, imagination</td>
<td>1</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Wasted money</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Interesting pictures, pretty pictures</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>US Defense, US control of space</td>
<td>0</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Better international relations, international collaboration</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Satellites for television transmission, surveillance, and GPS</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Science education, thirst for knowledge</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Space ice cream, Tang, Velcro, useful products</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Higher status for women and minorities</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Earnings as a contractor</td>
<td>0</td>
<td>0</td>
<td>2</td>
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<tr>
<td>Useless discoveries</td>
<td>1</td>
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American to travel in NASA's acting these etc. Starting making air (e.g., McTfi in 2000, 17 average, an five years.

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American technological achievement, of scientific research, and of human aspirations to travel in space, but few respondents could point to immediate consequences of NASA's activities for themselves. It would appear that NASA has not been convincing these educated people of its value to them.

Starting in 1999, the Mercatus Center at George Mason University has been making annual evaluations of how well the 24 federal agencies report to the public (e.g., McTigue et al., 2004). NASA’s reporting ranked 14th out of 24 in 1999, 23rd in 2000, 17th in 2001, 12th in 2002, and 20th in 2003. NASA has never been above average, and 70 percent of the federal agencies have done better reporting over these five years.

**OPPORTUNITIES FOR IMPROVEMENT**

NASA clearly faces issues that are broader in scope than the organization itself. Even so, this chapter considers four clusters of areas in which NASA can bolster its future: NASA’s influence upon its environments, its structure, processes guiding its development, and its culture. Although separating issues into distinct subsets helps to keep the discussion simple, it understates the complexity of relationships and the flexibility of options. Organizational structures have very malleable properties. Many structures can produce similar results depending on the people who manage them and the cultures in which they operate. People can bridge organizational gaps or they can turn them into crevasses; they can treat rules as general guidelines or wear them like straitjackets. A person who manages very effectively in one culture may flounder badly in another. A leader who appears visionary and charismatic when backed by a President and Congress may seem inept and blundering without such support. That said, a primary determinant of NASA’s ability to address organization-design issues effectively is its leadership.

Over the last 45 years, NASA has experienced a series of leaders and leadership philosophies at varying levels, i.e. Administrators responsible for the entire agency, Associate Administrators serving under the Administrators but responsible for large segments of the budget, Center Directors responsible for large segments of the agency’s infrastructure and people. Some of these leaders influenced their domains more strongly than others. NASA has experienced turnover at its headquarters and among the senior leaders at its field centers, especially after failures, after changes of President, and after changes of NASA Administrators. Leadership choices are significant and many of NASA’s personnel attribute some of the agency’s acknowledged deficiencies to programs and values espoused by former Administrators or other senior leaders, as each espoused certain philosophies and initiated programs to implement those philosophies. An obvious uncertainty, then, is how long those organizational initiatives persist as leaders change. This is true for NASA’s current leaders, who have espoused various initiatives during their tenure. Although the initiatives occurring during 2004 have had stimulus and support from NASA’s current leaders, the next generation of leaders is likely to halt the current initiatives, replace them, or launch others with different goals.
NASA’s influence upon its environments

NASA can and should do a better job of convincing the American people that it is delivering useful results... here and now. Why do NASA’s activities warrant spending billions of dollars and risking human lives?

Of course, the President and Congress have direct control of NASA’s budget, so NASA has devoted effort to persuading them of its value. However, the President and Congress have other priorities that are contending for resources and they have rather short time horizons. History demonstrates that support by the President and Congress has been fickle, and that such support has sometimes induced NASA to take on projects of questionable technological merit and to lower its quality standards. When disasters ensued, it was NASA that took the blame rather than the President and Congress.

Because NASA’s technological horizons extend several decades, it needs to pursue long-term goals with stable programs, which implies that it needs support from voters and taxpayers who are convinced that its activities are highly valuable to them and their families within the imminent future. Many voters and taxpayers say they believe NASA is contributing to humanity by raising human aspirations, exploring the universe, and developing space travel. However, idealism and altruism have limits, so NASA needs voters and taxpayers to perceive more direct benefits to them as well. Visits to NASA facilities and space ice cream are soft foundations for $16 billion budgets. NASA’s ability to pursue long-term goals is threatened by the existence of large numbers of voters and taxpayers who say that NASA contributes nothing to them, to the US, or to humanity. NASA should not be relying on the public to figure out the significance of its space exploration and technological development; it should be making such translations and communicating them.

It seems relevant that, despite the multiple initiatives to improve NASA that have been occurring both within the agency and in its political environment since the Columbia disaster, there has been no discussion of the need to improve its image with the American public. Awareness of the desirability of public support, in itself, could be one of NASA’s greatest needs.

NASA’s structure

NASA should maintain its focus on technical excellence as it pursues grand goals of exploration and technological development. To foster technical excellence, NASA should make its organizational structure less mechanistic, more adaptable to changing environments, and less risk-averse. NASA should become a better model of a learning organization that operates in a near-boundaryless fashion and that places greater value on innovation than on protecting the status quo.

One external driver toward change is the June 2004 report of the President’s Commission on Implementation of United States Space Exploration Policy, which recommended that NASA’s centers should explore the possibility of becoming Federally Funded Research and Development Centers (Aldrich Commission, 2004). FFRDCs are not-for-profit organizations that operate under contracts with government agencies, and since these restrictions, it may be found that the issue of competition into FFRDCs could be addressed, leading to solutions that benefit science, research, and industry.
Making NASA More Effective

and since they are not formally units of the government, they are free from some restrictions, including civil service employment regulations. GAO has reported that NASA is finding it difficult to recruit and retain staff, and more flexible pay scales might ease such problems (GAO, 2003). The Jet Propulsion Laboratory is already an FFRDC. If other NASA centers become FFRDCs, they would each have contracts with a government agency, presumably NASA's headquarters.

A central issue may be what combinations of facilities would have FFRDC status. If each of the current facilities were to be set up separately, their current autonomy would become more difficult to break down and their current isolation from each other might increase. However, during 2004, NASA's internal assessments were that seven "enterprises" were too many and so NASA reorganized budgets and administration into four "mission directorates"—aeronautics research, exploration systems, science, and space operations—only three of which manage facilities. Aeronautics research includes Dryden Flight Research Center, Glenn Research Center, and Langley Research Center. Science includes Ames Research Center, Goddard Space Flight Center, and JPL. Space operations include Johnson Space Center, Kennedy Space Center, Marshall Space Flight Center, and Stennis Space Center. Therefore, NASA might have just three FFRDCs, in which case there would be an opportunity to increase integration and cooperation across the linked facilities. The tradeoffs are between synergy and survivability. Whereas autonomous centers have tended to compete with each other and to withhold information from each other, they have also developed independent political support and resilience, and they have nourished innovation.

Consolidation of seven enterprises into four mission directorates is an indirect result of the President's January 2004 announcement of his long-term goals for space exploration. In response, NASA formed the Roles, Responsibilities, and Structure Team (also known as the Clarity Team) to address conflicts in management responsibilities, ambiguities in reporting lines, and control issues. The Clarity Team attempted a "clean sheet" approach to organizing NASA headquarters, and as one result NASA created the mission directorates. Recommendations of the Clarity Team also led to reducing the number of functional offices from 14 to seven; creating a Strategic Planning Council, chaired by the Administrator, focusing on long-term plans; and creating a NASA Operations Council, chaired by the Deputy Administrator, focusing on tactical implementation issues. It is too soon to assess the effects of these changes.

Another external driver for change has been the CAIB report. NASA formed the so-called Diaz Team to look at issues stemming from the CAIB report that were applicable to broad spectra of activities (Diaz Team, 2004), and this team made numerous recommendations. As well, CAIB called for creation of an independent technical authority (CAIB, 2003) to raise the importance of safety. NASA had already created the NASA Engineering and Safety Center (NESC) in response to the Columbia disaster. However, NESC does not have as much independence as CAIB urged, so NASA is creating another administrative subsystem to fulfill this need, with the result that NESC appears to add redundant complexity. NESC has achieved some successes that may warrant its preservation, but NASA needs to clarify the distinctive responsibilities of NESC, the office of the Chief Safety and Mission Assurance Officer, the engineering organizations, and the independent technical authority advocated by CAIB.
Internal drivers for change come from recognition of problems by NASA personnel. NASA personnel are very aware that issues have appeared repeatedly over the last three decades about the balance of power among engineers, managers, and scientists. The organizational hierarchy gives dominance to managers, whereas the people with the most direct information are engineers or scientists. One result has been that each time there has been a serious accident, retrospective analyses have inferred that engineers were trying to communicate concerns while managers were ignoring or overruling these concerns. Johnson (2004) argued that NASA's communication problems are rooted in the complexity of space systems and engineers' lack of training in communication skills. However, he cited no evidence that NASA's engineers do in fact lack communication skills, and NASA's managers might have ignored messages from highly skilled communicators.

Differences between occupational groups are not distinctive to NASA, as conflicts between the values of engineers and managers occur in many organizations, and so do conflicts between the values of scientists and managers (Schriesheim et al., 1977). Schools teach engineers that they should place very high priority on quality and safety. Engineers who are not sure whether a bridge is safe enough should make the bridge safer; engineers who suspect that a component might fail should replace it or change its function. Other schools teach scientists that knowledge is invaluable, or at least that the future value of knowledge is impossible to predict. Scientists are always coming up with new questions and new experiments to try. Still other schools teach managers that they should place very high priority on efficiency and economy. Managers are supposed to pursue cost reduction and capacity utilization, and they are constantly looking for opportunities to shave budgets or to squeeze out more output. Thus, the differing values of engineers, managers, and scientists make conflicts endemic. These conflicts are useful in that all three groups are pursuing valuable goals that are somewhat inconsistent, and the only way to resolve the inconsistencies is to argue the merits of concrete alternatives in specific instances.

However, the arguments do tend to stale and to breed cynicism. Hans Mark once recalled: "When I was working as Deputy Administrator, I don't think there was a single launch where there was some group of subsystem engineers that didn't get up and say 'Don't fly'. You always have arguments" (Bell and Esch, 1987: 49). Each group, anticipating how the others are likely to react, tends to exaggerate its own position and to discount the positions of others. In the aftermath of the Columbia disaster, a sore point within NASA was the perception that managers had demanded that engineers adhere to bureaucratic procedures that stifled information flow upward while the managers themselves violated procedures (CAIB, 2003; Diaz Team, 2004). Both Linda Ham, head of the Columbia Mission Management Team, and Sean O'Keefe, the NASA Administrator, said they did not know that engineers were worried about the condition of Columbia. According to the survey conducted by BST (2004), nonmanagerial personnel have low opinions of "management credibility" in areas and the agency received low scores for upward communication efforts and for managers' perceived support of employees.

As a result of the Columbia disaster, NASA is currently trying to mediate the relations between engineers, managers, and scientists through ombudsmen. It was the Diaz Team headquarters when commi
the Diaz Team that recommended the creation of ombudsmen at each center and at headquarters so that both civil service and contractor employees could raise issues when communications were not producing actions to correct deficiencies (Diaz Team, 2004). Ombudsmen meet regularly to compare, discuss, and resolve issues. Thus far, the number of issues raised has been modest and most have not related to safety. Some early examples, however, indicate that the program may prove successful. For example, a safety issue at Kennedy Space Center involved the addition of an antenna to a 300-foot radio tower without the associated structural strengthening to handle new wind loads from such an addition. Strengthening had been planned but was not being done, an employee grew increasingly concerned, and management seemed nonresponsive to the employee’s messages. Once the employee raised the issue with the ombudsmen, the center director ordered strengthening to be completed immediately.

Other recurrent issues raise questions about NASA’s tendency to be mechanistic. A mechanistic organization is well suited to running routine operations that utilize reliable technologies but poorly suited to developing innovative new technologies (Burns and Stalker, 1961). Mechanistic tendencies lower the effectiveness of an agency that conducts aeronautical or scientific research, explores new worlds, or sends experimental systems into space. Some evidence suggests that NASA has tended to behave like a traditional, rule-bound government bureaucracy. For example, the investigations of both the Challenger and Columbia disasters pointed out that managers had relied on rules and rituals where these made no sense. Speaking of the Columbia disaster, the Diaz Team (2004) remarked, “Management was not able to recognize that in unprecedented conditions, when lives are on the line, flexibility and democratic process should take priority over bureaucratic response.” At least in the cases of Challenger and Columbia, the use of rules linked to specialization and a compartmentalization of responsibilities continued even after people raised questions or pointed out problems. In these cases, senior managers discounted questions or statements on the ground that it was not the responsibility of these people to be asking such questions or noticing such problems. Furthermore, many NASA employees speak as those in a bureaucratic agency. BST (2004) reported, “People do not feel respected or appreciated by the organization. As a result, the strong commitment people feel to their technical work does not transfer to a strong commitment to the organization.”

To lead technologically, NASA should alleviate its mechanistic tendencies by undertaking programs to create the culture of a “learning organization” or the practices of a “boundaryless organization.” Senge (1990) defined a learning organization as a group of people continually enhancing their capabilities to achieve shared goals. “People talk about being part of something larger than themselves, of being connected, of being generative.” He argued that people in a learning organization have a shared vision of their organization’s future, they think in terms of system-wide effects, and they learn together as teams. Ashkenas et al. (2002) examined internal, external, and geographic boundaries that divide organizations. Of course, every organization has some boundaries, and some boundaries are quite useful, so the term “boundaryless” is an exaggeration. However, Ashkenas et al. argued that organizations can benefit by reducing boundaries, and they proposed ways to assess boundaries and steps to diminish or eliminate some of them.
The “One NASA” initiative, which started prior to the Columbia disaster, has focused on breaking down organizational boundaries within NASA by promoting more effective information-sharing and collaboration within the agency. Some aspects of the One NASA initiative are consistent with making NASA less mechanistic (One NASA Team, 2003; www.onenasa.nasa.gov). The team’s approach has been bottom-up by giving every employee (both civil service and contractor) an opportunity to present their ideas for making NASA more collaborative. The team received approximately 14,000 suggestions, reviewed and categorized them, and generated 38 broad action steps, which NASA’s current leadership has embraced. By the end of 2004, nine of these action steps had been completed and 23 were in progress. According to a status report on October 21, 2004, the initiative has highlighted the importance of the agency’s varied capabilities to its future success, improved interaction and commitment to collaboration among senior managers, expanded awareness of resources and capabilities, and improved communications. Leader-led workshops have broadened employees’ knowledge of the agency’s long-term goals and future direction, and transformation dialogues have increased communication between senior leaders and the broader workforce.

In addition to the “One NASA” project, current programs to influence NASA’s culture and to improve the communication skills of some senior personnel are also consistent with making NASA less mechanistic. However, short-term programs will inevitably have short-term effects. If NASA is to become an atypical government agency, it will have to institutionalize programs and practices that provide widespread training in communication and social skills and rewards for behaviors that promote learning and crossing boundaries. The Diaz Team (2004) has given reason to wonder whether NASA can actually become a learning organization. After acknowledging that the CAIB had said NASA “has not demonstrated the characteristics of a learning organization,” the Diaz Team proceeded to assert that NASA should create a knowledge-management system, should provide training in emergency response, and should develop and obey more rules. These proposals did not speak to the central elements of a learning organization, which involve cultural properties such as sharing, cooperation across boundaries, and a restless drive for improvement that overturns or modifies rules. Furthermore, the Aldrich Commission’s report seems to visualize a NASA that is even more mechanistic, more bureaucratic, and less directly involved with research or technological innovation. The report states that “NASA’s role must be limited to only those areas where there is irrefutable demonstration that only government can perform the proposed activity,” and NASA should have “a structure that affixes clear authority and responsibility.” A learning organization, an organization engaged in innovation, needs flexible authority and shared responsibilities.

Processes that guide NASA’s adaptation

NASA could benefit from clean-sheet reviews of its policies, procedures, and operating practices. Proposals for change should always become opportunities to simplify,
to cut down on red tape, and to integrate related functions, rather than simply matters of adding more rules, structure, and bureaucracy.

Over the years, NASA has tended to respond to changed priorities, new administrations, and disasters by making structural changes — new units, new procedures, or reorganization. These changes, however, have mainly been ephemeral and superficial while yielding some unintended results. NASA has tended to add new policies or procedures to existing ones instead of replacing the existing ones. This approach has the advantage that it does not arouse as much opposition from the proponents of existing policies or procedures as would substitution; those responsible for current policies or procedures see less threat from the new ones. However, the disadvantage of this approach is that NASA has built up layer after layer of policies and procedures that are partially inconsistent, and has created new organizational units that have unclear relations to the rest of NASA. One result has been that the new units and procedures have had weak impacts, and another result has been that NASA’s structure has become more and more complex over time, thus obscuring organizational interconnections and relationships from its own employees (CAIB, 2003; Diaz, 2004). Furthermore, changes in NASA’s administration have limited the periods during which proponents of change have been able to exert influence, and so NASA’s basic structure of autonomous centers has outlasted the people who would change it.

Consider the evolution of NASA’s safety-reporting structure and the varied systems that have roles in maintaining the value of safety. In 1967 after the tragic Apollo 1 fire, Congress chartered the Aerospace Safety Advisory Panel to act as an independent body advising NASA on the safety of operations, facilities, and personnel. This panel reports to the NASA Administrator and to Congress; NASA’s Chief Safety and Mission Assurance Officer provides its staff and support; and it publishes yearly reports on safety within NASA. In 1987, after the Challenger disaster, the NASA Administrator established the NASA Safety Reporting System to be used after normal reporting chains had been exhausted. It promises a prompt response should an employee choose to report a safety issue through it. As noted above, in July 2003, after the Columbia disaster, NASA announced the formation of the independent Engineering and Safety Center (NESC) to provide a central location for coordinating and conducting engineering and safety assessments across the entire agency. The announcement stated, “The new NASA Engineering and Safety Center will have the capacity and authority to have direct operational influence on any agency mission.” NASA’s Chief Safety and Mission Assurance Officer has policy responsibility for NESC, but its personnel report to the Center Director at Langley. The Columbia disaster also induced the agency to create ombudsmen at NASA headquarters and at all 10 field centers as additional channels employees can use if they feel those above them are not listening. In addition to the entities above, NASA’s safety and hazard reporting hierarchy provides alternatives through the NASA grievance procedures, through the NASA Alternative Dispute Resolution program, through procedures specified in agreements with labor organizations, and through NASA’s Office of Inspector General. Yet another safety-related authority is being created in response to the CAIB report: currently labeled the Independent Technical Authority, it is supposed to
separate the holders of technical requirements from the project organizations charged with implementing those requirements. Thus, each disaster has added at least one new safety-reporting channel, with the unintended consequence of adding complexity and confusion about appropriate handling of safety issues. NASA's overall objective of emphasizing safety is being obscured.

The shifting priorities and mandates of NASA's political environment as well as the different interests within NASA itself have added complexity to NASA's organization. Changing political mandates and Administrators with new agendas have added noise to lessons that NASA might have learned from either its successes or its failures. Furthermore, because of NASA's dependence on government funding and its status as a government agency, significant change inside NASA depends on support from Congress and the Executive Branch, including DOD. Adding complexity to these conflicting agendas, the aerospace companies also influence the goals NASA is charged with implementing as they lobby their Congressional delegations by pointing out the virtues of particular programs, projects, or technological methods. On the one hand, NASA must bend to the demands of its political environment if it wants to retain support; on the other hand, the short tenure of most politicians mean that the President and most members of Congress have short memories. It is quite difficult to sustain something that is forever changing.

Hans Mark (1987: 174–5) has said: "There has been criticism of NASA because many people believe that no long-range goal has been formulated that guides the US space program. The truth is that NASA has had a long-range goal, but it is one that has not had the unanimous support of NASA's friends and constituents and has long been the target of NASA's critics." For NASA to operate more efficiently and effectively in the future, its leaders would have to find ways to insulate the agency from influence by those who would promote other goals. However, Mark's formulation oversimplifies NASA's goal structure and it suggests that NASA's leaders may have been focusing on fairly short-term goals during the period in question. According to Mark, "The long-range goal that has been pursued consistently and with success [from 1970 through 1987] is the development of the space shuttle and the space station to achieve the permanent presence of human beings in space." Although these are clearly two of NASA's goals, NASA also encompasses units that seek to conduct scientific research about the solar system and outer space, units that seek to improve the quality and safety of commercial air travel, and units that seek to develop new technologies. Indeed, it has not been clear to everyone that the space shuttle and the space station constituted the best ways "to achieve the permanent presence of human beings in space" (Klerkx, 2004).

As NASA currently states its long-term goals, it is seeking: (1) to improve life here (on Earth); (2) to extend life there (outside Earth); and (3) to find life beyond. The sequencing of these goals seems to give high priority to improving life on Earth. However, when Starbuck asked the 179 graduate students what they perceived to be NASA's goals, they gave the responses in table 16.2. According to the graduate students, NASA has been acting as if "to improve life here (on Earth)" has low priority, and NASA has been pursuing other goals in addition to the three it formally identifies.
To maintain the degree of alertness needed for safe flights, NASA needs to set sharply defined short-term goals as well as very long-term ones. Masses of research have demonstrated that these short-term goals ought to be difficult but clearly attainable (Locke and Latham, 1990), and, to sustain their alertness, people must see definite times when they will be able to relax and decrease their alertness. Vague long-term goals such as “to improve life here” and “to extend life there” have no endpoint, so it is important that NASA also define achievable short-term goals. It is doubtful that the endpoints following each shuttle flight actually enable workers to rearm themselves for the next flight, as over time the cycles of activity come to look more and more routine. In this respect, the very assertion that the space shuttle was “operational” and would operate on a regular schedule was, in itself, a contributor to disaster. It implied that the shuttle could be managed like a train or bus service, whereas the level of alertness needed to operate shuttles reliably is many times that need to operate a bus system reliably.

The processes involved in creating an organization can be more important than the actual properties created. What works, and how well it works, depends on what preceded it. One reason is that participation enhances understanding and acceptance. People who understand the reasons for policies or procedures are better able to apply them intelligently rather than mechanically. A second reason is that proposals receive better acceptance if they come from people whom listeners perceive as knowing what they are talking about and as having the organization’s best interests at heart. A third reason is that proposals, and their proponents, meet a cold reception if they conflict with powerful interests. As one NASA person put it, “you can get dismissed from the room for disagreeing with the wrong person.” A fourth reason is that it is very difficult to terminate activities that already possess resources, staff, liaisons, and legitimacy.

Dramatic disasters have significantly altered NASA’s developmental path. Many organizations do not learn from their failures. Husted and Michailova (2002) observed that members of organizations avoid discussing failures because people
participating in failed ventures fear being blamed and because some managerial hierarchies react to failures by seeking persons to blame and then punishing the culprits. In a study of several failures by units of a large corporation, Baumard and Starbuck (2005) found that managers generally explained away large failures as having idiosyncratic and largely exogenous causes. The larger the failure, the more idiosyncratic or exogenous causes they saw. As well, managers saw no relation between new large failures and previous ones, even when the same people had managed more than one failed venture. Obviously, such avoidance and denial behaviors did not happen following the Challenger and Columbia disasters, perhaps because Presidential Commissions and press coverage did not allow normal organizational processes to occur. Indeed, the initial reaction of NASA’s management to the Challenger disaster was to assert that previously planned activities would go ahead as planned.

Many significant changes – in personnel and procedures and hardware – took place following the Challenger disaster, and many changes have been occurring since the Columbia disaster. These changes, however, probably interrupted the learning from experience that would normally have occurred, in that new personnel replaced experienced ones and new procedures were laid on top of existing ones. There is no way to know whether these interruptions were beneficial or harmful. Since learning from experience is an uncertain process, the effects of interrupting it are also uncertain. What does seem to be the case, however, is that the lessons drawn from Challenger and Columbia were and are being applied quite pervasively across NASA. By contrast, it appears that NASA has not had procedures for identifying successful practices and disseminating these across its units (Diaz Team, 2004; GAO, 2002).

Communication, culture, and performance measurement

For the agency to achieve its objectives and maintain its relevance, NASA must build support from its senior leaders through its middle managers for the idea that cultural change is not only desirable but imperative.

According to surveys by the US Office of Personnel Management during 2002, its employees rated NASA the best agency in which to work in the federal government (Partnership, 2003). Indeed, NASA ranked above all other agencies in nine of the 10 rating categories, and Marshall, Johnson, Goddard, and Kennedy ranked as the four best subagencies in which to work, with Langley ranking as the ninth best subagency. However, there are many reasons to question comparisons among the perceptions of employees who have different values and who face very different work situations (Starbuck, 2005b). The employees who rated NASA had little or no experience in, say, the Department of State, the employees who rated the Department of State had little or no experience in NASA, and the State employees might not appreciate some of the features that please NASA’s employees greatly.

Employees’ satisfaction is only one aspect of organizational effectiveness, and it can be an unimportant aspect. There are signs that NASA’s culture has biases that interfere with the agency’s effectiveness.
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One theme seems to be a tendency to overemphasize technological concerns and to underestimate social concerns. BST (2004) said: "Excellence is a treasured value when it comes to technical work, but is not seen by many NASA personnel as an imperative for other aspects of the organization's functioning" such as management, administration, or communication. Some NASA personnel reacted sarcastically to BST's culture-change program, and Johnson (2004) asserted that NASA's engineers have been "blind" to "social factors." One NASA manager remarked, "We mistake tools for solutions."

A second theme has been communication problems. Two of the most important properties of a healthy organizational culture are the ability to communicate openly and the ability to surface and manage disagreements. Obviously, these properties have not always been present in NASA. BST (2004) observed, "There appear to be pockets where the management chain (possibly unintentionally) sent signals that the raising of issues is not welcome." After reviewing communications during the Columbia disaster, Bosk surmised, "Engineers were forced to pass an answer, not confusion and uncertainty, up to the next level" (Sawyer and Smith, 2003). Bosk remarked of NASA's "can-do" culture, "That's really chilling – the notion that failure, gentlemen, is not an option." However, the published analyses of both Challenger and Columbia indicate that engineers were trying to report their concerns upward but those above them were not listening. This type of behavior is normal in hierarchical organizations, although its normality does not moderate its harmful effects. Studies of organizational communication have found that people talk upward and listen upward; superiors generally pay less attention to messages from their subordinates than the subordinates think the messages deserve, and subordinates communicate to their superiors more often than the superiors perceive (Porter and Roberts, 1976).

Before NASA can make effective strides toward a healthier culture, it must build support among its middle managers for the idea that cultural change is desirable. The effects of short-term programs decay rapidly, and new priorities could displace culture-building programs.

The key components of culture-building are training, personnel selection, rewards, and performance measurement. NASA has begun some training in communication skills, but this training seems to be focused solely on senior leaders. Training should extend throughout NASA, both in communication skills and in the value of non-technological activities, and personnel turnover implies that such training needs to be institutionalized. However, research generally supports the idea that personnel selection has stronger effects than training. That is, NASA could likely obtain more improvement by screening potential hires for their communication skills and for their appreciation for non-technological activities. It is also the case that to get effective communication, rewards must encourage effective communication. But NASA does not reward speaking up or, perhaps more importantly, listening down; and there have been instances when speaking up brought punishment. Of course, civil service rules may limit what NASA can do with monetary rewards, but non-monetary rewards can be quite effective. Furthermore, performance measurements are reinforcers. People tend to do what their organizations measure. If NASA would develop and publicize explicit measures of key cultural dimensions, personnel would make efforts to score well.
CONCLUSION

Will NASA succeed in its endeavor to remain relevant, to correct organizational deficiencies, to again set foot on the Moon, and ultimately to explore the outer reaches of the cosmos? Four priorities can raise its odds of success:

1. NASA has focused more on where it is going than what it will take to get there. For too long, NASA has marginalized the importance of the American taxpayer. Taxpayer support will be critical to NASA’s future efforts and NASA should begin now to explain better how the billions of dollars given NASA each year ultimately benefit ordinary Americans.

2. NASA has leaned toward mechanistic procedures. It should become more adaptable to changing environments and less risk-averse, a learning organization without sharp internal boundaries that places greater value on innovation than on protecting the status quo.

3. NASA has responded to problems by adding layers rather than by clarifying. It could benefit from more frequent clean-sheet reviews of its policies, procedures, and operating practices. Each proposal for change should become an opportunity to simplify, to cut down on red tape, and to integrate related functions.

4. NASA has tended to overemphasize the technical and to underemphasize the social. It must build support from its senior ranks through its middle managers for the idea that cultural change is imperative.

To attempt to manage NASA must be extremely frustrating. The agency has many highly skilled personnel who believe in their jobs, plentiful resources, and high aspirations, so great achievements should be possible. However, its political environment also makes irreconcilable demands that change unceasingly and the agency’s aspirations are literally out of this world, so disappointments, dissatisfied constituents, and failures are inevitable.

The issue that is potentially most problematic is the conflict between NASA’s personnel and facilities, which have capabilities to design and test aeronautical and space systems, and the demand that NASA turn over nearly all of its projects to contractors in private industry. This demand, which seems to have originated as a self-serving proposal by the aerospace industry during the early 1990s, was repeated most recently by the President’s Commission on Implementation of United States Space Exploration Policy (Aldrich Commission, 2004). Were this proposal to be implemented in a serious way, NASA would shut down many of its facilities and dismiss many of its scientific and engineering personnel, who might then be hired by NASA’s contractors. However, GAO has criticized NASA’s poor performance as a contract Administrator (GAO, 2003), private industry already does 80 percent of the work in the domain of space systems, and the same commission that proposed turning more of NASA’s work over to private industry also proposed converting NASA’s centers into FFRDCs, so it is very unclear what may develop. Because the political advocates for privatization face limited tenure in office and have more
burning items on their agendas, and because NASA's centers are well entrenched, the odds are against further privatization.

Because NASA's leaders are almost certain to fail or disappoint, to criticize them is unreasonable. However, NASA has generally paid too much attention to outer space and not enough attention to Earth. NASA's managers have focused on relations with the President and Congress, which are the nearest and most active of their constituents and the constituents with the most direct influence on NASA's budgets, and they have neglected to build support among the public. Although people respect NASA's ambitions, and some find them inspiring, many people feel poorly informed about NASA's value to humanity or to the US, and very few can point to concrete benefits that they have received personally from NASA's activities. Thus, NASA is entrusting its future to altruism and scientific curiosity, which are idealistic but insubstantial. A wide base of public support would help NASA to maintain more stable goals and programs with longer time horizons. To accomplish remarkable feats, NASA must operate with very long time horizons, and to pursue long-term goals with consistency, it must insulate itself from short-term political expediency. NASA could do this better if it had stronger support from a public that saw the value of its work.

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REFERENCES


HRO Principles at Work in a Multi-System Hospital Organization

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Objectives of Presentation
- Kaiser Permanente (KP) overview
- Patient safety movement begins
- Medical errors
- Human factors
- Reliability theory
- Two of KP’s patient safety projects:
  - Perinatal Patient Safety Project (PPSP)
  - Rapid Response Teams (RRT)

Kaiser Permanente Overview
Medical Care Program Relationships
Kaiser Permanente’s eight Regions are comprised of separate, but closely cooperating, organizations:
- Kaiser Foundation Health Plan, Inc.
- Kaiser Foundation Hospital, Inc.
- The Permanente Medical Group, Inc.

Kaiser Permanente Program
Founded: 1945
- Largest non-profit HMO
- 8.3 million members
- 8 Regions
- 9 states and District of Columbia
- Headquarters Oakland, CA
- 30 hospitals
- 431 medical offices
- 141,909 employees, 12,012 physicians

Northern California Region
Medical Service Areas
- 19 acute hospitals
- 1 physical rehab center
- 11 ambulatory surgery centers
- 9 home health agencies
- 7 hospice agencies
- 2 skilled nursing facilities
- 43 medical offices
- More than 60,000 employees
- 5,654 TPMG physicians
Patient Safety Movement Begins

The Institute of Medicine (IOM) Report - 11/99

- 44,000-98,000 patients die each year in hospitals from medical error
- Up to 270 patients per day due to error in U.S.
- More people die each year from error than from breast cancer, motor vehicle accidents and AIDS

“No one comes to work to commit a medical error”

Hospital Medical Errors

- IOM - 2 to 4% of all hospitalized patients experience an adverse event while in hospital (1999)
- AHRQ / Hopkins - Adverse event led to 5.5 excess patient days (2003)
- Gawande - 12% of discharged patients experienced preventable events related to hospitalization (2003)
- Bates - 6% of hospitalized patients experienced ADE (1995)
- Classen - ADE events cause increase in LOS average 1.73

Common Errors: Systems Produce the Results they are Designed to Achieve

Source: LL Leape. JAMA 1994; 272:1851

Reason’s* Model of Error

* Based on James Reason, “Managing the Risks of Organizational Accidents,” 1997

10^2 Concepts

- Designing failure prevention, identification and mitigation:
  - Decision aids & reminders built into the system
  - Desired action the default (based on evidence)
  - Redundant processes
  - Use fixed current scheduling in design
  - Take advantage of habits and patterns
  - Standardization of processes based on clear specifications and articulation

Source: Roger Resar MD
Key Principles of Human Factors

- Acknowledges that errors are part of being human and inevitable
- Emphasis on understanding work flow and task management
- Designing systems that compensate for inherent human weaknesses/vulnerabilities

Human Limitations

**Memory, mental processing capability**
- Multi-tasking, confusing machine displays, interruptions, slips & lapses, complex judgment errors

**Stressors**
- Task fixation, overload, boredom, personal/family issues

**Physiological factors**
- Fatigue, health status, substance impairment

**Organizational Cultural issues**
- Hierarchy: male/female, job status, family of origin, lack of assertion and/or escalation
- Normalization of deviance, individual violation of known procedure
- Team cohesiveness, over reliance on team members, conflict management
- No plan or rehearsals for emergencies

High Reliability Organizations (HRO)

- Exhibit continuous, nearly error-free operation, even in multifaceted, turbulent, and dangerous task environments (Karlene Roberts, 1990)
- Examples:
  - Aircraft carriers, nuclear submarines, nuclear power plants, air traffic control systems

HRO Principles for Healthcare

**Humans inherently fallible**
- Errors occur despite best intentions

**Carefully re-design systems essential**
- Become “error tolerant”
- Optimize skills of professionals
- “Error proofing” and “trapping”

**Information dispersed**
- Caregivers’ expertise respected
- Communication valued
- MD as integrator/facilitator of choices

High Reliability Organizations Characterized by Mindfulness

- Preoccupation with failure
- Reluctance to simplify interpretations
- Sensibility to operations
- Commitment to resilience
- Deference to expertise

Two Patient Safety Initiatives

- Perinatal Patient Safety Project
- Medical-Surgical Patient Safety Project with Rapid Response Teams
The Burning Platform: Total Cost of Birth Related Claims

San Francisco Chronicle
"$15 million award in birth malpractice case Hayward baby had brain damage." 5/03

San Jose Mercury News
Jose Medical Group, finding that delayed care in the delivery room led to serious brain damage for a local baby."6/03

Root Causes of Sentinel Events
(All categories; 1995-2004) Source: JCAHO

PPSP: What We Knew in 2002
The KP data said:
- The old way wasn’t working

Perinatal Patient Safety Project
Mission: This project is dedicated to empowering the staff of our perinatal units and moving toward behaviors (culture) and processes designed to create safety and prevent birth injury.

Project Design
Human (Culture)
Business (Processes)

Source: Kaset
Objectives of PPSP

- Utilize systems improvements and human factors concepts to create high reliability units
- Multidisciplinary team to implement 2-3 changes
- Evaluate effectiveness
- Transfer successful practices to all perinatal units

High Reliability Perinatal Units *

- Safety first is the hallmark of culture
  - L&D is viewed as "potentially dangerous" to guard against complacency
  - Team contribution is valued
  - Communication is structured and rewarded
  - Fetal and maternal wellness are defined
  - MD comes when called by RN
  - Emergencies are rehearsed
  - Evidence-based protocols are utilized

* Source: Simpson, Knox, JHRM, Spring 99

Regional Support

- Regional leadership and support
- Regional Steering Committee
- Quality protection
- Competitive site selection
- Contract

Medical Center Multidisciplinary Team

- Co Chairs: Obstetrician & Nurse Mg
- Providers: OB, Perinatologist, Neonatologist or Pediatrician, Certified Nurse Anesthetists, Certified Nurse Midwives
- RNs: from L&D, post-partum and NICU
- Others: Medical Social Workers, Laboratory, Unit Assistants, Environmental Services
- Union members involved

Human Factors Education

- Human Factors techniques
- "Just Culture" statement
- Structured communication: SBAR
- Human error & accident causation
- Error reduction and trapping

Human Factors Techniques

- Briefings
  - Pre- and post-procedure plus post-event
- Assertion (a communication skill)
- Escalation policy and “Stop the Line” policy
- Hierarchy flattened to communicate for patient safety
- Situational Awareness and Red Flags
  - Teamwork and communication

4-hr class before first team meeting
Structured Communication

**SBAR:**
- When clear communication is important
- Structured communication template:
  - **Situation**
  - **Background**
  - **Assessment**
  - **Recommendation**

“Just Culture” Statement

- Discussion of errors and events will occur if employees feel safe from punitive discipline
- **Exceptions:**
  - Under influence of drugs or alcohol
  - Intent to cause harm
  - Engaged in egregious negligence

Error Reduction and Trapping

- Ask for help when overloaded
- Get a second opinion when in doubt
- Honor others who call for help
- Wisdom, not weakness
- It is more important for my patient to do well than for me to look slick

HRO Self-Assessment

- Clearly stated purpose: Safety First
- Clear language: Fetal Well-Being
- Clear operating style
- Clear & concise clinical protocols and policies

* Based on: Simpson, Knox, JHRM, Spring 99

Fetal Well-being By The Fetal Heart Rate

**Ante partum (before labor):**
- **Reassuring FHR Tracing:**
  - Baseline FHR of 110-160 beats per minute (bpm), AND
  - No FHR decelerations
  - Two FHR accelerations (each of 15 beats per minute (bpm), AND
  - FHR variability (6 – 25 bpm)
  - Within 20 seconds of baseline

**Interpartum (during labor):**
- **Reassuring FHR Tracing:**
  - Baseline FHR of 110-160 beats per minute (bpm), AND
  - No FHR decelerations AND
  - Two FHR accelerations in 20 seconds
  - OR
  - Baseline fetal heart rate is 10 beats per minute lower than baseline

MD or CNM notifies Patient/Family of continuous FHR monitoring without a reassuring FHR tracing.

**MD or CNM:**
- Communicates to RN, and documents patient’s plan of care
- MD or CNM, or nurse, informs patient/family if fetus is well in the absence of fulfillment of strict criteria.
Why Rehearse Emergencies
- Teamwork & communication may reduce the frequency of emergencies in L&D but:
  NEVER TO ZERO!
- Disciplines are trained separately
- Critical skills erode when events are rare

Critical Events Team Training
- Human factors and team skills
- Scenarios based on actual occurrences
  - Situation diagnosed and managed exactly as in real life
  - Normal roles, noise and confusion
- Blame free, educational & confidential
- Drills are videotaped
  - Used for debrief and then erased
  - NOT used as evaluation tool!
Measures of Success

**Short-term measures**
- Safety Attitudes Questionnaire

**Long-term measures**
- Birthing events
- Medical-legal claims
- Patient satisfaction data

**IHI’s OB Trigger tools**
- Participated in pilot study of tools

Safety Attitudes Questionnaire

- Reliable & valid tool
- All 12 perinatal units
- All disciplines and shifts involved in the continuum of care of Labor and Delivery

PPSP Safety Attitudes Before and After

- Pre PPSP Pilot
- Post PPSP Pilot

Teamwork Climate

Success of PPSP

- Initiated in **2002**
- Continuing evolution within KP NCAL
- 2004 Lawrence Award in NCAL for innovation in patient safety
- 2005 Lawrence Award in SCAL for replication of a patient safety initiative
- Spread throughout Kaiser Permanente nationally
Spreading Success in KP

SBAR: KP-wide initiative
PPSP in all KP Regions (2003)
- So Calif., Pacific North West, Mid-Atlantic States, Hawaii, Colorado
Critical Events Team Training (2003)

NC Project Aims
- Improve identification, assessment and intervention for hospitalized patients (outside ED&ICU) at the first signs of clinical deterioration.
- NCRM will oversee implementation in 18 hospitals
- Focus on education of HROs, human factors and communication, and
- Implement Rapid Response Teams

Evidence of Problems
- 76% arrests ongoing instability > 1 hr prior to arrest. Average = 6.5 hrs, Victorian study, (Buist, Med J Aust 1999)
- 70% (45/64) arrests with evidence of respiratory deterioration within 8 hrs. (Schein, Chest 1990)
- 66% (99/150) abnormal signs and symptoms within 6 hrs of arrest and MD notified in 25% of cases (25/99) (Franklin, Crit Care Med; 1994)

Four Fundamental Problems
- Failure to plan
- Failure to recognize
- Failure to communicate
- Failure to rescue

KP and IHI’s 100K Lives Campaign

Medical-Surgical Patient Safety Project with Rapid Response Teams

Rapid Response Team

Definition
A group of clinical personnel with critical care skills trained to evaluate and potentially manage a patient that may be rapidly deteriorating.

RRT Membership
- ICU RN & Respiratory Therapist
- ICU RN, RT, Intensivist &/or Resident
- ICU RN, RT, Physician Assistant
### Australian Medical Center
**Medical Response Team**

**Before** | **After**
---|---
Cardiac Arrests | 63 | 22
Deaths/cardiac arrest | 37 | 16
Days in ICE post arrest | 163 | 33
Days in hospital post arrest | 1363 | 159
Inpatient deaths | 302 | 222

Source: Bellomo R, Golsmith D, Uchino S, et al., MJA 2003

### RRT Implementation
**PLAN:**
- Form medical-surgical patient safety team to implement RRT

**DO:**
- Implement RRT
  - Pilot small scale changes
  - Implement best methods
  - Spread RRT to all medical-surgical units

**STUDY:**
- Review data: Teams and Regional Steering Comm.

**ACT:**
- Continual improvement and hold the gains

### NCal RRT Call Criteria
- Staff member concerned / worried
- Acute HR change (<40 or >130)
- Acute SBO change (<90 or >220)
- Acute RR change (<8 or >28)
- Acute SaO2 change (<90% w/ O2)
- Acute change in LOC/response
- Acute change in urine output (<50 ml in 4 hrs)
- Persistent/changing pattern of chest pain
- Seizure (new onset)
- Severe / uncontrolled pain

### Goals
- Reduce Code Blues by 50%
- Decrease adjusted mortality rates by 40%
- Increase perception of communication and teamwork by 10%

### Predictions
- **CODE BLUE CALLS**
- **RRT CALLS**
- **HOSPITAL MORTALITY**

### RRT Implementation
**2005:** Pilots in 18 medical centers
**2006:** Full implementation in NCAL

**Information and data sharing:**
- Collaborative monthly meetings
  - Share findings and best practices.
- Monthly graphs:
  - RRT calls
  - Code Blues
  - Mortality per 1,000 discharges by medical center
Summary

- Patient safety is no accident
- High reliability is a journey. We are on the first leg.
- High reliability and safety are perishable and need to be reviewed and renewed daily!
Comparison of the Culture/Climate Surveys

Sexton and Helmreich’s Surveys

from:

Sexton et. al., developed four questionnaires. The cockpit management attitudes questionnaire has been widely used in aviation and was developed to measure attitudes toward stress, status hierarchies, leadership, and interpersonal interaction issues. The questionnaire is reliable, sensitive to change, and the elicited attitudes have been shown to predict performance. A subsequent version, the flight management attitudes questionnaire, was developed to broaden the perspective of the instrument to include the effect of organizational climate and national culture on safety. The survey, however, addresses team interactions.

Two medical surveys were developed as part of an extension of human factors research into medical environments: the operating room management attitudes questionnaire and the intensive care unit management attitudes questionnaire. All the questionnaires contained a core set of items from the cockpit management attitudes questionnaire with minor modification of wording to match the work environment—for example, “Junior cockpit crew members should not question the decisions made by senior cockpit crew members” was changed to “Junior operating room team members should not question the decisions made by senior team members.” These core items allow comparisons to be made over time, across different organizations, across positions within an organization (such as nurses and doctors), and across disciplines.

All surveys were administered through hospital or airline internal mail (with parallel covering letters). Respondents were given the option of returning their questionnaires in an anonymous drop box or a stamped envelope addressed to the author’s laboratory in Austin, Texas. In each administration, the survey content was essentially the same.

The core items have been administered to cockpit crew members (captains and first and second officers) from 40 different airlines in 25 countries over 15 years (with the flight management attitudes questionnaire used in the seven years preceding this article). The operating room questionnaire was completed by theatre staff (surgical and anesthetic consultants, nurses, and residents) from urban teaching and non-teaching hospitals in Italy, Germany, Switzerland, Israel, and the United States in the three years prior to the publication of this article. The intensive care data are from staff in one large urban teaching hospital in the United States. The respondents were intensive care physicians (adult and child pulmonary physicians, cardiologists, and neo natologists) and nurses (registered nurses, licensed vocational nurses).
Data from each of the surveys were merged into a combined database of operating theatre, intensive care, and flight crews. Data from each of the staff positions were collapsed across all hospitals with representative samples. The authors excluded two hospitals from the analyses because they did not provide representative samples. **Descriptive data are presented as the sample size was insufficient for multilevel modeling.**

**Command Safety Effectiveness Survey**

*From:*  

The Command Safety Effectiveness Survey is a derivative of the Command Safety Climate Assessment (CSCA) developed for the U.S. Navy. The CSCA survey process is based on the notion of high reliability organizations (HRO) and their ability to reduce risk during hazardous operations. **The high reliability research base for the survey calls on the results of over fifteen years of organizational research conducted at the University of California, Berkeley.** Using HRO principles, CSCA surveys assess an organization's ability to conduct flight operations and maintenance in terms of leadership, culture, standards, policies, procedures, and practices. **The survey addresses organizational issues.** Attributes of the CSCA survey process include: ease of use, 24/7 Internet accessibility in a non-intrusive environment, participant anonymity, unit confidentiality, and the ability to compare the unit results with other aggregate organizational data.

The CSCA survey is a web-based tool for commanding officers (CO) to survey aircrew and maintainers on their perceptions regarding safety issues within their unit. **This tool allows a CO implement intervention strategies prior to an adverse occurrence.** Three on-line surveys are available: (1) Command Safety Assessment (CSA) survey which assesses an organization’s operational practices from an aircrew’s perspective, (2) Maintenance Climate Assessment Survey (MCAS) which assesses an organization’s maintenance practices from a maintainer’s perspective, and (3) NADEP Maintenance Climate Assessment Survey (MCAS) which assesses maintenance practices from a depot-level perspective. This sixty two item Likert scale survey takes approximately 15 minutes per participant to complete. Respondent anonymity is protected. Feedback is immediately available to the CO upon completion of the survey process. Comparisons can be made across aircraft types, squadrons in training and at sea, squadrons at time one and time two, etc. Higher-headquarters commanders can also access aggregate survey data for comparing aircraft types and communities while still maintaining unit confidentiality. **To date, over 80,000 Naval Aviation personnel have participated in norming the survey.** In March, 2002 *Approach Magazine* published the article “Taking the ‘Safety Pulse’ of Your Squadron.” which describes the surveys.

The Organizational Safety Effectiveness Survey (OSES) developed for NASA is based on this prior CSAS. Validation activities for this assessment were undertaken at
Lockheed Martin Space Systems Company. The Lockheed Martin OSES was developed with NASA in mind, and considers issues related to Columbia and several other space systems accidents and incidents. Much of the information discussed for use in construction of the aerospace version of the OSES for Lockheed Martin was directly applied to building a comparable OSES for NASA, as there are many overlapping projects and products in joint aerospace efforts between NASA and Lockheed Martin. Other versions of this instrument were developed for the airline and medical industries.

**Behavioral Science Technologies**

Behavioral Science Technologies (BST), located in Ojai, California, began its business efforts in the behavior modification area. In recent years it has added to its technologies a “culture” assessment. The research foundations for the assessment activity come from industrial psychological theory and are directed to understanding individual perceptions of leadership, etc. That is the BST measure is an individual difference assessment. It is also proprietary. To our knowledge the instrument has not been normed.

**Organizational Culture Inventory (OCI)**

The OCI is the most widely used and thoroughly researched tool for measuring organizational culture. It provides an assessment of an organization’s operating culture in terms of behaviors that members believe are required to “fit in and meet expectations” in their organizations. The OCI measures twelve types of behavioral norms that may characterize the operating culture of an organization. Four of these behavioral norms are constructive and facilitate high quality problem solving and decision making, teamwork, productivity and long term effectiveness. Eight of the behavioral norms are defensive and detract from effective performance. Thus, the OCI enables organizations to analyze their cultures and identify practical strategies for enhancing their productivity and long term effectiveness. The OCI addresses individual differences.

OCI profiles can be created at the unit level (such as region, branch, department or group). Unit profiles reveal whether subcultures exist. The OCI can be administered along with the Organizational Effectiveness Inventory (OEI). The OEI measures structures, systems, technologies, and skills/qualities that shape the organization’s current operating culture, as well as the outcomes that are effected by the current operating culture. The OCI takes approximately 20 minutes to complete. The OCI was copyrighted by Human Synergistics/Center for Applied Research, Inc.

**Potential Journals for Publication**

**Journals Treating Safety in Health Care**

- *Quality and Safety in Health Care*
- *International Journal for Quality in Healthcare*
- *Joint Commission Journal for Quality and Patient Safety*
Quality & Safety in Health Care (formerly Quality in Health Care) is a leading international peer review journal in the growing area of quality and safety improvement. It provides essential information for those wanting to reduce harm and improve patient safety and the quality of care. The journal reports and reflects research, improvement initiatives and viewpoints and other discursive papers relevant to these crucial aims with contributions from researchers, clinical professionals and managers and experts in organizational development and behavior.

The journal covers the development and integration of quality and safety initiatives into routine practice experience of improving practice in all sectors of health care services the influence of management and organizational learning on the quality and safety of clinical care the views of consumers and their role as promoters of improved quality and safety in health care research relevant to health care quality and safety from a wide range of relevant sources including non-medical domains. QSHC aims to contribute actively to the debate about the quality and safety of health care by exploring subjects and ideas (from both routine clinical and managerial practice and research) which concern and inform this debate and which focus on real benefits to patients. We’ve published in this journal so we know something about it.

International Journal for Quality in Health Care
http://www3.oup.co.uk/jnls/list/intqhc/scope/

The International Journal for Quality in Health Care makes activities and research related to quality and safety in health care available to a worldwide readership. The Journal publishes papers in all disciplines related to the quality and safety of health care, including health services research, health care evaluation, technology assessment, health economics, utilization review, cost containment and nursing care research, as well as clinical research related to quality of care.

This peer-reviewed journal is truly interdisciplinary and includes contributions from representatives of all health professions such as doctors, nurses, quality assurance professionals, managers, politicians, social workers and therapists, as well as researchers from health-related backgrounds.

Joint Commission Journal of Quality and Patient Safety
http://www.jcrinc.com/subscribers/journal.asp?durki=460

Joint Commission Journal on Quality and Patient Safety is a peer-reviewed journal that serves as a forum for practical approaches to improving quality and safety in health care. Specific interest areas include:
Published monthly, *Joint Commission Journal on Quality and Patient Safety* is dedicated to providing health care providers and quality and safety professionals with the information they need to promote the quality and safety of health care. *Joint Commission Journal on Quality and Patient Safety* invites original manuscripts on the development, adaptation, and/or implementation of innovative thinking, strategies, and practices in improving quality and safety in health care. The descriptive ("this is what we did") and prescriptive ("this is how to do it") information is intended to help readers adapt activities to improve quality and safety to their own organizations. Case studies, program or project reports, reports of new methodologies or new applications of methodologies, research studies, and commentaries on issues and practices are all considered.

*Journal of Patient Safety*

http://www.pohly.com/mags/journalpatientsafety.html

*Journal of Patient Safety* is a new publication dedicated to presenting research advances and field applications in every area of patient safety. While *Journal of Patient Safety* has a research emphasis, it publishes articles such as near-miss opportunities, system modifications that are barriers to error, and the impact of regulatory changes on healthcare delivery. The *Journal of Patient Safety* is a peer-reviewed, scholarly publication focuses on all aspects of patient safety, including, but not limited to original late-phase translational research (from research findings to patient settings); original articles that focus on clinical applications of research; reports on best practices at the level of institutional process and policy; detailed, objective technology reports and reviews. This mix of research and real-world findings makes *Journal of Patient Safety* a valuable resource across the breadth of health professions and from bench to bedside.
The BMJ aims to publish rigorous, accessible and entertaining material that will help doctors and medical students in their daily practice, lifelong learning and career development. In addition, it seeks to be at the forefront of the international debate on health. To achieve these aims we publish original scientific studies, review and educational articles, and papers commenting on the clinical, scientific, social, political, and economic factors affecting health. We are delighted to receive articles for publication in all of these categories - from doctors and others. We can publish only about 9% of more than 6000 articles that we receive each year, but we aim to give quick decisions (see Advice to contributors).

The BMJ is published weekly and has a circulation of about 108,500, of which 13,500 copies are distributed outside Britain. In addition, local editions reach another 173,000 readers. Material published in the weekly journal may be reproduced in these editions, in the student BMJ, and on this web site.

General Medical Journals That Publish Articles on Safety Issues

Health Care
Health Care Management Review
Critical Care Medicine
Medical Care
Pediatrics
Annals of Family Medicine
Jama-Journal of the American Medical Association
Advances in Health Care Management
New England Journal of Medicine
Annals of Emergency Medicine
Health Affairs

Health Care Management Review
http://www.hcmrjournal.com/pt/re/hcmr

Health Care Management Review (HCMR) is a peer-reviewed quarterly journal that addresses the full range of challenges and concerns that busy health care academics and executives face every day, and provides the latest developments in the health care field. Written by high-profile authors and guided by a prestigious Editorial Board, HCMR presents in-depth analysis and solutions in a reader-friendly format. The journal features multidisciplinary content that applies theoretical frameworks and principles to health services management and practice. Topics include new developments, practical solutions, and insightful analyses in finance, marketing, labor relations, cost containment, quality assurance, planning, computers and technology, staff recruitment, pay and benefits, and much more.
Regular Feature Samples:

Turnover in Health Care
Recruitment and Retention Strategies
Ethics Orientation
Clinical Information Systems
Improving Outcomes
Financial Planning for Growth

Critical Care Medicine

Critical Care Medicine is the premier peer-reviewed, scientific publication in critical care medicine. Directed to those specialists who treat patients in the ICU and CCU, including chest physicians, surgeons, pediatricians, pharmacists/pharmacologists, anesthesiologists, critical care nurses, and other healthcare professionals, Critical Care Medicine covers all aspects of acute and emergency care for the critically ill or injured patient. Each issue presents critical care practitioners with clinical breakthroughs that lead to better patient care, the latest news on promising research; and advances in equipment and techniques.

The purpose of this journal is to publish original articles on significant work in critical care medicine, as well as meaningful abstracts of the more important papers on the subject appearing in world medical literature. It also provides a forum for exchange of ideas on what's right and what's wrong in the management of the critically ill; a truly in-depth coverage of this new science. All articles are original submissions and are peer-reviewed.

Published 12 times per year
Ranked 3rd among 17 titles in the Critical Care Medicine category of the

Medical Care
http://www.lww-medicalcare.com/pt/re/medcare/journalinfo.htm

Rated as one of the top ten journals in healthcare administration, Medical Care is devoted to all aspects of the administration and delivery of healthcare. This scholarly journal publishes original, peer-reviewed papers documenting the most current developments in the rapidly changing field of healthcare. This timely journal reports on the findings of original investigations into issues related to the research, planning, organization, financing, provision, and evaluation of health services.

Pediatrics
http://pediatrics.aappublications.org/misc/about.shtml

Pediatrics is the official journal of the American Academy of Pediatrics.
Pediatrics publishes papers on original research or observations and special feature articles in the field of pediatrics as broadly defined. Papers on matters pertinent to pediatrics will also be included from related fields such as nutrition, surgery, dentistry, public health, child health services, human genetics, animal studies, psychology, psychiatry, education, sociology, and nursing.

Pediatrics serves as a medium for expression to the general medical profession as well as pediatricians. The Executive Board and Officers of the American Academy of Pediatrics have delegated to the Editor and Associate Editor the selection of articles appearing in Pediatrics. Statements and opinions expressed in such articles are those of the authors and not necessarily those of the American Academy of Pediatrics, its Committees, or the Editor or Editorial Board of Pediatrics.

Annals of Family Medicine
http://www.annfammed.org/misc/about.shtml

The Annals of Family Medicine is a new peer-reviewed research journal to meet the needs of scientists, practitioners, policymakers, and the patients and communities they serve. The Annals of Family Medicine is dedicated to advancing knowledge essential to understanding and improving health and primary care. The Annals supports a learning community of those who generate and use information about health and generalist health care.

The Annals seeks to identify and address important questions in health and the provision of patient-centered, prioritized, high-quality health care. We welcome clinical, biomedical, social and health services research. The Annals publishes original research, methodology, and theory, as well as essays from reflective clinicians, patients, families, communities, and policymakers. We publish selected systematic reviews that build on current knowledge to advance new theory, methods, or research directions. The Annals seeks manuscripts that use and develop rigorous quantitative and/or qualitative methods, and manuscripts with application to practice, theory development, and policy. We encourage practice-based research and research that bridges disciplinary boundaries.

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The Annals publishes special reports of value to the communities it serves, including:

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Policy statements from sponsoring and other organizations
Special Reports undergo the editorial and peer review process before acceptance for publication.

*JAMA-Journal of the American Medical Association*

http://jama.ama-assn.org/about_current.dtl

**Key Objective**
To promote the science and art of medicine and the betterment of the public health

**Critical Objectives**
To maintain the highest standards of editorial integrity independent of any special interests. To publish original, important, well-documented, peer-reviewed articles on a diverse range of medical topics. To provide physicians with continuing education in basic and clinical science to support informed clinical decisions. To enable physicians to remain informed in multiple areas of medicine, including developments in fields other than their own. To improve health and health care internationally by elevating the quality of medical care, disease prevention, and research. To foster responsible and balanced debate on issues that affect medicine and health care. To anticipate important issues and trends in medicine and health care. To inform readers about non clinical aspects of medicine and public health, including the political, philosophic, ethical, legal, environmental, economic, historical, and cultural.

To recognize that, in addition to these specific objectives, *The Journal* has a social responsibility to improve the total human condition and to promote the integrity of science

*Advances in Health Care Management*

http://chcs.ba.ttu.edu/ahcm/

The *Advances in Health Care Management Research* series is designed to fill the gap between the reviewing and synthesizing of current management research in health care and the addressing and producing of top-quality papers concerning emerging, real-world problems. Therefore, this series, edited by John D. Blair, Myron D. Fottler, and Grant T. Savage, has the overarching goal of publishing the highest quality research in the health care management field including analytical, state of the art reviews and empirical papers on cutting edge issues. Karlene’s going to be on a panel put together by Grant Savage in August. To accomplish this goal, three types of papers are included in each annual series:

1. Competitive Papers "open-calls" focused on a cutting edge health care management issues (e.g., the future of integrated delivery systems, the changes in health care governance, etc.);
2. Invited Review Papers on organizational environment as well as organizational process and structure variables (e.g., human resources management, strategic management, etc.); and

3. Award-Winning/Best Papers from the Health Care Management Division of the Academy of Management.

With the ever-increasing demand for sophisticated management and accountability in the health care industry requires professionals whose education is strongly based in business principles. These business principles are based on strong research and academic theory building. This series is intended to be the premier outlet for these types of founding principles in the health care management field.

_New England Journal of Medicine_

_www.nejm.org_

Frequently Asked Questions
General Information about the Journal
http://authors.nejm.org/Misc/AuthorFAQ.asp

_Medical Journals Interested in HRO_

_Annals of Emergency Medicine_
http://www.mosby.com/annemergmed
https://www.editorialmanager.com/annemergmed/

Annals of Emergency Medicine, the official journal of the American College of Emergency Physicians, is an international, peer-reviewed journal dedicated to a mission of improving the quality of care by serving as an excellent educational and communication vehicle for emergency medicine and related medical specialties. Annals publishes original research, clinical reports, opinion, and educational information related to the practice, teaching, and environment of emergency medicine.

_Health Affairs_
http://www.healthaffairs.org/1500_about_journal.php

Health Affairs is the leading journal of health policy thought and research. All papers are peer-reviewed, and the acceptance rate is 10-15 percent. Published since 1981, Health Affairs is nonpartisan and presents a wide range of timely research and commentary on health issues of current concern in both domestic and international spheres.

_Non-Medical Journals Interested in HRO_

_Safety Science_
_Human Factors_
_Organization Science_

_Safety Science_
Safety Science serves as an international medium for research in the science and technology of human safety. It extends from safety of people at work to other spheres, such as transport, leisure and home, as well as every other field of man's hazardous activities.

Safety Science is multidisciplinary. Its contributors and its audience range from psychologists to chemical engineers. The journal covers the physics and engineering of safety; its social, policy and organizational aspects; the management of risks; the effectiveness of control techniques for safety; standardization, legislation, inspection, insurance, costing aspects, human behavior and safety and the like.

Safety Science enables academic researchers, engineers and decision makers in companies, government agencies and international bodies, to augment their information level on the latest trends in the field, from policy makers and management scientists to transport engineers. The journal focuses primarily on original research papers across its whole scope, but also welcomes state-of-the-art review papers and first hand case histories on accidents and disasters of special significance. The emphasis is on safety risks, as distinct from health risks, but may include both.

Human Factors
http://www.hfes.org/publications/HFJournal.html

The premier publication of the Society, Human Factors is a peer-reviewed journal presenting original papers of scientific merit that contribute to the understanding and advancement of the systematic consideration of people in relation to machines, systems, and environments. Articles encompassing basic and applied research, quantitative and qualitative approaches to theory, evaluative reviews of the literature, and state-of-the-art reviews cover all aspects of the human-system interface.

Human Factors also features special sections highlighting important areas. In recent years, topics have included fatigue, elderly drivers, training, measurement, visual displays, assisting people with functional impairments, human information processing, expert systems, and vigilance. These special issues can be used as supplementary materials in the classroom. The Berkeley group knows what this journal likes.

Organization Science
http://web.gsa.cmu.edu/orgsci/index.htm

Organization Science publishes fundamental research about organizations, including their processes, structures, technologies, identities, capabilities, forms, and performance. Research from different disciplines, such as organizational behavior and theory, strategic management, psychology, sociology, economics, political science, information systems, technology management, communication, and cognitive science, is represented in the journal. We welcome research at different levels of analysis, including the organization, the groups or units that constitute organizations, and the networks in which organizations are embedded. Diverse methods and approaches are also welcome. Creative insight often occurs at the boundaries between traditional research approaches and topic areas. The editors are especially interested in manuscripts that break new ground rather than ones that make incremental contributions. In addition to the original research reports that are the core of the journal, we occasionally publish
essays in our “Perspectives” section that direct attention to an important new organizational phenomenon or redirect a line of research. We also publish essays in our “Crossroads” section that capture a current debate about organizations. More specifically, *Organization Science* seeks to publish papers that:

- start up or redirect a line of inquiry;
- draw upon multiple disciplines;
- employ diverse methods, including qualitative, field, survey, archival, laboratory and computational methods;
- focus on different kinds of organizations, including firms, not-for-profit organizations and voluntary organizations;
- make a theoretical contribution;
- provide new empirical findings;
- achieve genuine integration of theory and data;
- provide a theoretically-driven review and integration of an important research area;
- discuss findings in terms of improving organizational performance.

In addition to publishing, *Organization Science* seeks to recognize and develop scholars and scholarship by providing high quality and timely feedback and engaging exemplary scholars in the process of identifying and developing innovative and excellent research. Roberts has published in this journal it is one of the two pre eminent journals in the organizational field.
FURTHER READING


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Department of Pediatrics, School of Medicine, Loma Linda University

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