Management of Service Projects in Support of Space Flight Research

Connect and Discover
Project Management Challenge 2009
Creative Collaboration Track
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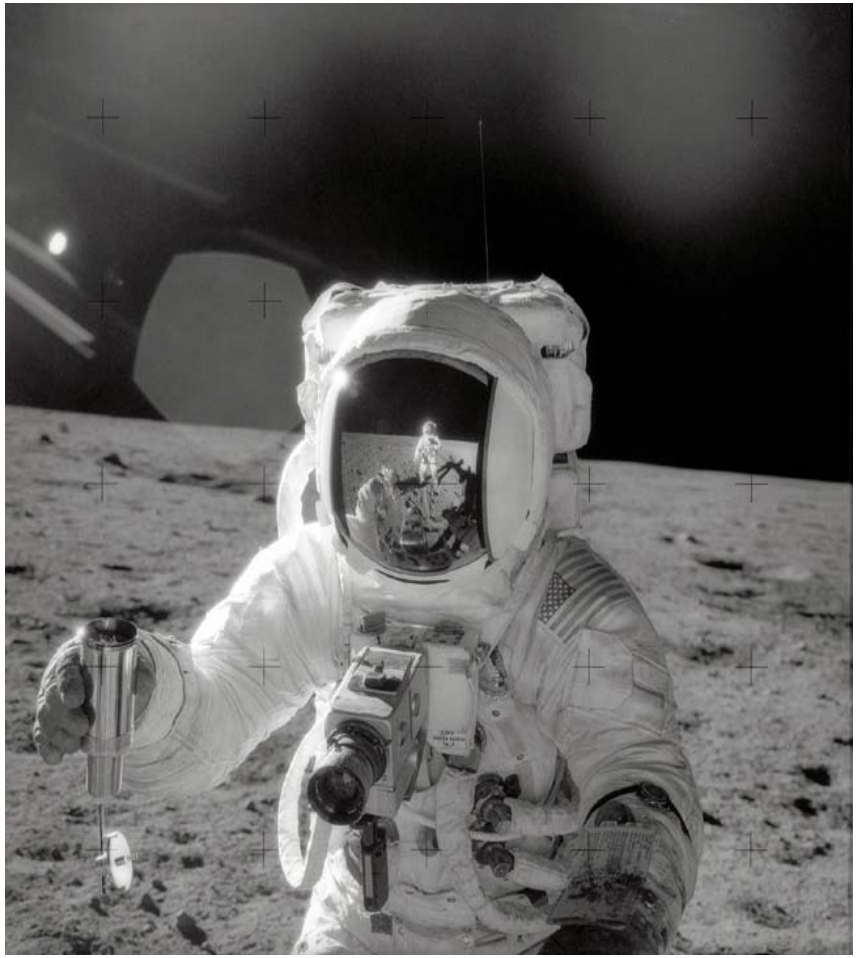


Microgravity Environment Effects on Humans

- Bone density reduction
- Cardiovascular alterations
- Muscle atrophy
- Immune system dysregulation
- Ionizing radiation exposure
- Vestibular dysfunction
- Delayed wound healing
- Gastrointestinal disturbances
- Hematologic changes
- Orthostatic intolerance
- Renal stones risk
- Psychosocial impacts

The Human Body as a Space Exploration System

- The human body is a critical system in space flight
- Requires characterization, control, optimal integration
  - Operating bands
  - Fitness for duty standards
- The human system in space exploration requires addressing
  - Biomedical risks, knowledge gaps, enabling questions, countermeasures
  - Performance and health requirements

The Human Research Program

- HRP formed at Johnson Space Center in September 2005, focusing on "investigating and mitigating the highest risks to astronaut health and performance in support of exploration missions". [HRP-47051]

- "Delivers human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration". [HRP-47065]

- "The exploration missions include both lunar missions and missions to Mars. Although both mission types involve some of the same human health and performance challenges, each also includes specific challenges…" "HRP research and technology development is phased to supply appropriate deliverables in time to meet the challenges of each mission type as it occurs." [HRP-47053 Rev C]

- "Requirements driving the HRP work and deliverables are derived from the exploration architecture, as well as Agency standards regarding the maintenance of human health and performance". [HRP-47052 Rev B]

HRP Goals & Objectives

- **Goal**: “To provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration”. [HRP-47051]

- **Specific Objectives**:
  - “Develop capabilities, necessary countermeasures, and technologies in support of human space exploration, focusing on mitigating the highest risks to human health and performance”
  - “Define and improve human spaceflight medical, environmental, and human factors standards”
  - “Develop technologies that serve to reduce medical and environmental risks, to reduce human systems resource requirements (mass, volume, power, data, etc.) and to ensure effective human-system integration across exploration systems”
  - “Ensure maintenance of Agency core competencies necessary to enable risk reduction in the following areas:
    - A. Space medicine
    - B. Physiological and behavioral effects of long duration spaceflight on the human body
    - C. Space environmental effects, including radiation, on human health and performance
    - D. Space human factors” [HRP-47051]

Organization of HRP

HRP Program Elements

- Human Health Countermeasures (HHC)
- Space Human Factors and Habitability
- Exploration Medical Capability
- Behavioral Health and Performance
- Space Radiation Project
- International Space Station Medical Project (ISSMP)

HHC Projects

- Exercise Countermeasures Project
- EVA Physiology, Systems and Performance Project
- Flight Analogs Project (FAP)
- Non-Exercise Physiological Countermeasures Project
- Digital Astronaut Project

Flight Analogs Project

- FAP provides one technique HRP will use to address many critical questions about how humans can live and work during extended missions away from Earth, “and to devise ways to ensure astronaut safety and productivity on extended missions”.

- Formed “to develop, maintain and operate a validated ground-based bed rest analog for microgravity and investigate alternative additional ground-based analogs that may be applicable to HRP research”.

[FAP Project Charter]

• “The FAP provides a service and facility for use by the HRP. This service consists of the conduct of, and participation in, controlled campaigns, data collection and analysis, facilitation of collaboration among medical operations and research communities, and facilitation of collaboration between US and international investigators.” [HRP-47062]

Bed rest subject at Flight Analog Research Center, General Clinical Research Center, UTMB

ISS Medical Project

"An important component of the HRP involves research on the International Space Station (ISS), a unique laboratory environment in space that enables the collection of critical inflight data necessary for exploration mission risk reduction. The HRP must ensure that the ISS is utilized to the maximum extent possible to perform the essential research and technology development tasks that can only be done inflight." [HRP-47053 Rev C]

- ISSMP "formed to maximize the utilization of ISS in obtaining solutions to the human health and performance problems and the associated mission risks of exploration class missions."
- Its goal is "to maximize the utilization of the ISS and other spaceflight platforms to assess the effects of long-duration spaceflight on human systems to enable Exploration mission success."

[ISSMP Project Charter]

ISSMP Objectives

- Facilitation and flight validation of NASA's health, medical, human performance, and environmental standards in time for exploration mission planning and design.
- Facilitation of flight quantification of human health and performance risks associated with human spaceflight for exploration missions.
- Facilitation of flight validation of countermeasures and technologies to prevent or mitigate adverse outcomes of human health and performance risks.
- Facilitation of flight validation of countermeasures and technologies to monitor and treat adverse outcomes of human health and performance risks.
- Provision of enabling capacity to facilitate human space exploration with respect to the human system.
- Maximization of the opportunity provided by ISS for information and investigations on long duration exposure to spaceflight.
- Sustenance and management of personnel, ground facilities, and flight systems necessary to execute HRP flight activities.
- Compliance assurance for processes and products with the NASA Policy Directives and NASA Procedural Requirements identified in HRP PRD.

[HRP-47057]

ISSMP Processes

Input: Monitoring, countermeasures, research proposals, and technology validation protocols from HRP program elements.

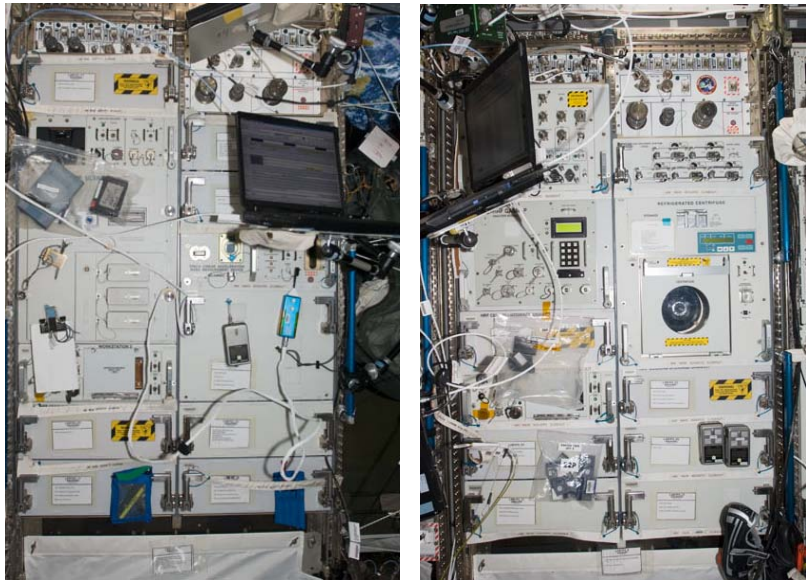
Processes:

- Program interface
- Translation of requirements into implementable functional requirements
- Design of operational scenarios
- Development and certification of hardware & software
- Program control & systems engineering rigor provision
- Development of crew procedures
- High-fidelity crew & ground cadre training
- Monitoring of real-time operations and facilitation of data transfer & remote PI interface
- Support of data and sample collection at multiple landing sites
- Flight and ground systems sustenance and evolution to meet program needs
- Optimization of flight resources

Output: High quality data products to enable: countermeasure and medical protocol validation, technology demonstration, and risk mitigation.

ISSMP Management Challenges

- Service project, dependency-rich
- Multiple customers
- Changing ecosystem
  - Programmatic
  - Research
  - Flight manifests
  - Flight schedules
  - Flight platforms
  - Budgetary
  - International Partners
- Constrained resources
  - Human subjects
  - Ascent, descent mass
  - On-orbit crew time
  - Conditioned stowage
  - Compressed timeframes
  - Postflight BDC
  - Limited utilization timeline



Human Research Facility (HRF) Racks

The challenge: Management of a service project that functions in an environment subject to changes and resource constraints.

Service Projects

- “The PMBOK Guide identifies that subset of the project management body of knowledge generally recognized as good practice . ‘Generally recognized’ means the knowledge and practices described are applicable to most projects most of the time, and there is consensus about their value and usefulness.”

[PMBOK Guide, 4th Edition, 2008]

- Project diversity demands project segregation to improve management approaches, however, there are no standard systematic categorization or classification schemes of project types.
- Service projects offer functions that are necessary, but not core competency, to others. They are “projects with a difference”, frequently exhibiting significant variances from typical projects described in the PMBOK Guide. [PMI S&O SIG]
- Service projects may differ from typical projects in project definition, relevant metrics, life cycle, financial planning and control, ending criteria, requirements, and risk.

Traditional PM Practices

- Anticipatory, plan-driven
- Process-based, formalized
- Rigorous methodology
- Stable, anchored scope
- Waterfall serial, sequential process flow
- Stage-gated phased transitions with milestones
- Subject to requirements paralysis
- Deliberate, enforced events flow, formal steps defined
- Predictable forecasts, foreseeable
- Systematic, prescriptive, deterministic processes
- High-assurance
- Compliance-focused
- Low-responding to project ecosystem
- Structured paradigm
- Conformance-to-plan culture
- Linear thinking
- Standard, unvarying practices
- High organizational maturity
- Point-of-plan value
- Rule-centric, quantitative control
- Low-change environment
- Rigid architecture
- Frozen up-front specifications
- Strong discipline
- Bureaucratic
- High “ceremony” (documentation, etc.)

Change-embracing Attributes

- Nimble, swift, agile
- Dynamic, adjustable
- Adaptive planning
- Unstable, unpredictable, turbulent, unknowable environment
- Malleable, maneuverable methodology
- Flexible
- Iterative
- Incremental
- Shortened cycles, faster delivery
- Parallel, simultaneous, concurrent
- Open-scope
- Prioritized expectations
- Minimal “ceremony” (documentation, steps, etc.)
- Embraces, plans for innovation
- Communication rich (feedback, lessons learned, etc.)
- Value-driven
- Progressively elaborated plan
- Exploratory processes
- Emergent architecture
- Evolvable
- Responsive
- Delivery-focused
- Participatory decision-making
- Situation-based revisable methodology, tailored to fit
- Uncertainty, opportunity compatible
- Collaborative, interactive
- “Chaordic”

Conceptual Sources that Address Change

- **Theory of Evolution**
  - Adaptation
  - Fitness landscapes
  - Evolutionary optimization
  - Incremental changes
  - Epigenetic
  - Ontogenesis
  - ("Biomimetic Project Management")
- **Complex Systems Theory**
  - Emergence
  - Self-organization
- **"Agile" Software Development Methodologies**
  - Extreme programming (XP)
  - Scrum
  - Dynamic Systems Development Method (DSDM)
  - Lean Software Development
  - Adaptive Software Development
  - Feature-Driven Development
  - Crystal Methods
  - Unified Process (UP)
  - Evo

Agile Processes in Software Engineering

- "An agile methodology is a framework for software engineering that embraces change." "But agile also means that the framework itself is flexible and adapts to any situation." [J. Krebs, 2009]

- **Agile Manifesto**
  - Processes and tools are preceded by individuals and interaction
  - Comprehensive documentation is preceded by working software products
  - Contract negotiation is preceded by customer collaboration
  - Following a plan is preceded by responding to change

- **Project Managers Declaration of Interdependence (PMDOI)**
  - Focus on continuous flow of value
  - Reliable results through continuous interactions and shared ownership
  - Uncertainty is expected and managed through iterations, anticipation, adaptation
  - Creativity and innovation facilitated
  - Group accountability and shared responsibility boost performance
  - Situational specific strategies, processes and practices improve effectiveness and reliability

Agile Methods of Software Development

- **Key Characteristics**
  - Iterative
  - Incremental
  - Self-organizing
  - Emergence
- **Key Practices** [J. Krebs, 2009]
  - Iterative-incremental
  - Test-driven
  - Continuous integration
  - Face-to-face communication
- **Key Objectives** [Highsmith, 2004]
  - Continuous innovation
  - Product adaptability
  - Reduced delivery schedules
  - People and process adaptability
  - Reliable results

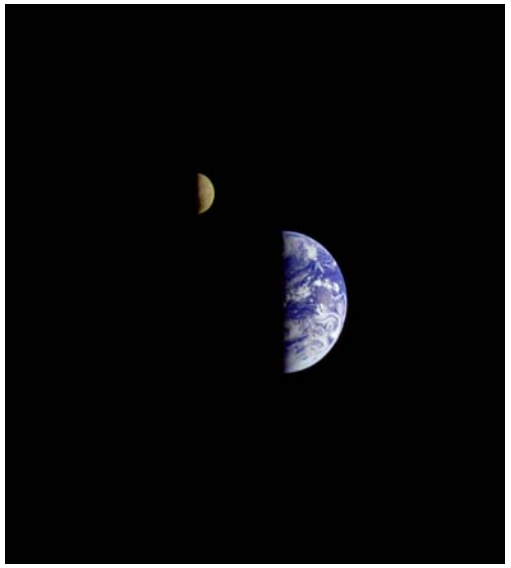
Traditional waterfall paradigm changes in agile development [Leffingwell, 2007]

- Measure of Success: from conformance to plan to response to change, working product
- Management Culture: from command and control to leadership, collaborative
- Requirements and Design: from big and up front to continuous, emergent, just-in-time
- Coding and Implementation: from code all features in parallel, test later to code and unit test, deliver serially
- Test and Quality Assurance: from big, planned, test late to continuous, concurrent, test early
- Planning and Scheduling: from PERT, detailed, fix scope, estimate time and resource to two-level plan, fix date, estimate scope

Creative Collaboration and Practices

ISSMP Challenge Mitigation Efforts

- Hybrid approach, where traditional project management methodologies are combined with agile strategies, e.g.:
  - Responsiveness to change
  - Rapid cycles
  - Active lessons-learned, frequent feedback
  - Adaptive, optimized processes
  - Evolvable, streamlined ops & logistics
  - Continuous improvement
  - Prioritized, concurrent development
  - Risk management techniques
  - Stakeholder involvement, collaboration
  - Vigilance through monitoring & adjustment
  - Interactive high performance teams
  - PM as facilitator, information manifold
  - Planning techniques
  - Face-to-face communication, co-location
- Creative collaboration (synergy)
  - With other groups
  - With International Partners
  - With other field centers
  - Between research teams
- Other practices



An Example from the Past

Challenges of CBOSS-FDI Progress Flight Opportunity

- Scientifically sound
- Short order development
- Rapid certification and integration
- Low upmass
- No downmass; all data collected remotely
- No crew training on ground
- Non-biological
- Non-toxic
- Flexible operations
- Modular configuration
- Versatile experimental design
- Resistant to a wide temperature range
- Telescience-compatible assay (design and fabrication of imaging device)

Concluding Remarks

- Service projects can form integral parts of research-based project-focused programs to provide specialized functions.
- Traditional / classic project management methodologies and agile approaches are not mutually exclusive paradigms.
- Agile strategies can be combined with traditional methods and applied in the management of service projects functioning in changing environments.
- Creative collaborations afford a mechanism for mitigation of constrained resource limitations.

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