

Cost and Schedule Overruns in NASA Programs

Analysis and Recommendations

May 2004

MIT Sloan System Dynamics 15.875

Alex Denissov, Tina Laforteza, Jay Wynn

AGENDA

- **Prologue: Insights from the class**
- **Project Background: Congressional Frustrations**
- **Problem: Cost and Schedule Overruns**
- **Insights: Layers of Influence and Control**
- **Recommendations**



15.875 Project

Prologue

Background

Problem

Insights

Rec's

Insights from the Class

- **Standard Method**
 - correct definitions help
 - “less is more”
 - genius is simple
- **Process Consultation**
 - permanent feedback is key
 - 10 “mini-clients” vs. 1 “mega-client”
 - rule of diminishing returns
- **Systems Dynamics and Modeling**
 - process vs. result
 - start with simple and add complexity
 - one loop at time



15.875 Project

Donald Peterson

Colonel, USAF, Ret. & NASA astronaut, STS-6

*“...contrary to publicly released findings, it's becoming clear that the **Challenger and Columbia accidents were not caused by careless preflight processing or poor real time decisions in Mission Control, but rather by intrinsic, serious design flaws built in from the beginning**, that made the Shuttle vulnerable and are proving extremely hard to fix...*

Prologue

*...I am getting the feeling that NASA is like a high strung, poorly conditioned, racehorse; strong out of the gate but not a good finisher. **You seem to be very interested in starting out the gate to create new, exciting programs and build impressive high performance vehicles, but lacking in stamina and often stopping before you reach a satisfactory finish line.** Your philosophy seems to be "...let's build something exciting and figure out what to do with it later..." There is no continuity in your programs; they have all been "giant leaps" followed by cancellations. And don't try to sell me on "spin-offs"; that's like keeping a high priced racehorse to get fertilizer.*

Background

Problem

Insights

*...if you feel all the things that humans have done in the past on the moon and in low earth orbit are not worth continuing, **why do you believe that humans on Mars will accomplish things that are worth the cost?**”*

Rec's

(<http://www.spaceref.com/news/viewnews.html?id=952>)



15.875 Project

Congressional Frustrations

- Our client: Bill Adkins, Staff Director for U.S. Congress House of Rep. Subcommittee on Space
- NASA programs involving manned spaceflight have historically fallen short in meeting promises
- Fear for new space initiative involving the Crew Exploration Vehicle (CEV) aka Project “Constellation”
- General concern in Congress regarding NASA’s management capabilities for *all* programs, not just CEV.

Prologue

Background

Problem

Insights

Rec’s



15.875 Project

Cost & Schedule Overruns in NASA Programs Are the Norm, Not the Exception



Space Shuttle Program

PLAN

Expected to fly 50x per year @ \$50 million per flight.



ACTUAL

Peaked at 9 flights in 1985, costs \$500 million per flight

Prologue

Background

Problem

Insights

Rec's



15.875 Project

Cost & Schedule Overruns in NASA Programs Are the Norm, Not the Exception



RLV (X-33)

PLAN

Goal: reduce launch cost by order of magnitude

Spent \$1 billion on development.



ACTUAL

Cancelled before first prototype was completed

Prologue

Background

Problem

Insights

Rec's



15.875 Project

Cost & Schedule Overruns in NASA Programs Are the Norm, Not the Exception



Prologue

Background

Problem

International Space Station

PLAN

Original 1984 plan: fully operational by 1992 at cost of \$8 billion.



ACTUAL

Insights

Rec's

Today: hope to reach full operations by 2008, est cost of \$100 billion



15.875 Project

What's Causing These Overruns?

Culture of field-center "fiefdoms"

Poor financial management systems

Lack of consensus on program goals

Cultural aversion to failure

Inadequate attention to iterative testing

Cost-plus contract structures

Commercial market draws away best talent

Incumbent power of legacy programs

Poor cost analysis & estimation capabilities

Inadequate lessons learned process

Focus on development vs operations

Aging workforce - declining experience base

Misaligned incentive systems

Union rules & Federal regulations limit workforce flexibility

Election cycles & changing priorities

Changes in the marketplace

Complexity of international cooperation

Managerial myopia creates long-term problems

Political drivers supersede rational management

Prologue

Background

Problem

Insights

Rec's



15.875 Project

Key Insight: Layers of Influence & Control

Prologue

Background

Problem

Insights

Rec's

EXECUTION

- Requirements controls
- Phase-level optimization
- Managerial incentives
- Stovepipe organizations
- Measurement systems
- Human resources
- Cultural Issues

PLANNING

- Cost analysis capabilities
- Past lessons learned
- Acquisition strategy
- Duopoly factors
- Incumbent's curse
- Legacy program power
- Budget expectations
- Managing optimism

EXTERNALITIES

- Election cycle instability
- Political drivers
- Multi-party process
- Market volatility



Everything has to align for projects & programs to succeed.



15.875 Project

Inadequate project cost and schedule estimation capabilities

Planning

- *Lack of accurate cost estimates – question of both ability to make good estimates and incentives to make them accurate*
- *Inadequate project cost and schedule estimation capabilities -- lack the skills and/or resource base necessary to generate accurate estimates*
- *Inadequate support infrastructure – esp. financial management and lessons learned / knowledge management systems – hinder effective project management, esp. over long-term multi-year efforts*
- *Genuine but misinformed optimism leads to underestimation of technical challenges and overestimation of RDT&E capabilities*

Prologue

Background

Problem

Insights

Rec's



15.875 Project

“Willful Ignorance” towards target achievability

Planning

- *Cost-plus contract structure allows firms to underbid up front and make up for it through later contract additions and modifications*
- *Culture encourages “liar’s club” behavior; everyone wants to hit aggressive targets, no one wants to say it can’t be done*
- *Legacy programs absorb resources in essentially flat budget environment; new programs must accept low budget just to get started*

Prologue

Background

Problem

Insights

Rec’s



15.875 Project

Program Myopia: Short-Term Optimization Drives Long-Term Overruns

Execution

Prologue

- *Each phase carries associated Cost, Schedule, Requirements, and Risk*

Background

- *Managing cost, schedule and requirements at the phase level may (and often does) increase risk at the project level*

Problem

- *For example, controlling development costs may increase production and/or operations costs*

Insights

- *Furthermore, controlling costs may increase risk of failure, and failure carries a cascade of associated costs (investigation, redesign, testing, new production, etc)*

Rec's



15.875 Project

Need for Measuring the “Right Things”

Execution

Prologue

- When it's not measured, it can't produce feedback to correct itself

Background

- Estimate of total lifecycle cost

Problem

- Actual progress: “I've spent 50% of the budget, so I must be 50% complete” (Not an actual quote)

Insights

- Budget

Rec's



15.875 Project

Permitting / Enabling Scope Creep

Execution

Honest Mistakes:

Lack of genuine unified project authority limits ability to control requirements & respond appropriately to new data and changing circumstances

Willful Ignorance:

Multi-party process with varying objectives & motivations virtually guarantees sub-optimal project management (President vs Congress vs Agency vs Contractors)

Lack of clearly defined rationale/justification for human spaceflight will create ongoing challenges for any & all new initiatives until the question is resolved

Prologue

Background

Problem

Insights

Rec's



15.875 Project

Multiple Parties Drive Programs

Externalities

- *Congressional pressures & election cycles*
- *Presidential attention & election cycles*
- *Industry forces (politics, multiple constituencies)*
- *Major projects take decades and the persons who make the influential decisions operate on a much shorter time scale*

Prologue

Background

Problem

Insights

Rec's



15.875 Project

Recommendations

Planning

Build world-class internal cost & schedule estimation capabilities at the HQ level; benchmark against industry standards

Contracting

Move toward award-fee compensation: payment and/or bonuses upon successful achievement of operational targets

Life-Cycle Management

Established life-cycle program management office for each new program to constantly oversee long-term impacts of phase-level decision-making & trade-offs

Measurement

Move aggressively to accelerate deployment of integrated financial management system & develop agency-wide mandates for utilizing real-time financials in measuring performance

Prologue

Background

Problem

Insights

Rec's



15.875 Project

Spiral Development: A Word of Caution

Prologue

Spiral Development calls for progress based upon achievement of intermediate objectives, with incorporation of new information in the planning and execution of subsequent stages

Background

Effectively a “real options” approach to minimizing overall project risk and maximizing results give limited resources

Problem

Insights

*However, any real option implies both an option to process AND an option *NOT* to proceed*

Rec's

The Spiral Development approach could lead, albeit logically, to the abandonment of human spaceflight...

Why have people in space?

Kennedy's Memo to Johnson, April 20, 1961

Do we have a chance of beating the Soviets by putting a laboratory in space, or by a trip around the moon, or by a rocket to go to the moon and back with a man?... Is there any other space program which promises dramatic results in which we could win?

Kennedy's Speech at Rice University, September 12, 1962

*Finally, in a field where the United States and the Soviet Union have a special capacity--in the field of space -- **there is room for new cooperation, for further joint efforts in the regulation and exploration of space...** Surely we should explore whether the scientists and astronauts of our two countries -- indeed of all the world -- cannot work together in the conquest of space, sending someday in this decade to the moon not the representatives of a single nation, but the representatives of all of our countries.*

*The contest will continue--the contest between those who see a monolithic world and those who believe in diversity--but **it should be a contest in leadership and responsibility instead of destruction, a contest in achievement instead of intimidation.***