Part 4

C·O·S·T ENGINEERING™

„Design and Marketing of Rockets"

Lecture Series given by Dr.-Ing. Robert Alexander Goehlich

- Part 4: Strategies to Reduce Cost -

Content

- **General**
- **Strategies to Reduce Cost**
  - for Development
  - for Production
  - for Operation
- **Definition**
  - Cost Engineering (Practice IV)
- **Requests from Audience for Lectures**

General
Contact

Dr.-Ing. Robert Alexander GOEHLICH
Mobile: +81-(0)90 1767 1667
Fax: +81-(0)45-566-1778
Email: mail@robert-goehlich.de
Internet: www.robert-goehlich.de

Ms. Akiko FUJIMOTO (Teaching Assistant)
Mobile: +81-(0)80-5039-6222
Email: af07302002@yahoo.co.jp

Mr. Kenji HASEGAWA (Webmaster)
Mobile: n.a.
Email: malayzaru@hotmail.com

Keio University
Department of System Design Engineering
Ohkami Laboratory
(Space System Engineering)
Office 14-609/14-620
3-14-1 Hiyoshi
Kohoku-ku
Yokohama 223-8522
JAPAN

General
Goal of Today's Lecture

„You will learn about cost-saving strategies and the difficulties to implement them in practice. Why cost-saving strategies are necessary? There is a need for changes, otherwise it may not be possible to operate e.g. RLVs economically."

Business as Usual

- Over-specification
- High bureaucracy
- Many design changes
- Extended schedules
- Parallel work on sa[illegible]
- Poor comm[illegible]

Impossible!

Smart Business

Costs have to be taken into account as a main decision criterion for whole program duration.

Necessary!

Overview of Cost-saving Strategies

Development (based on D.E. Koelle) No. 5

• Customer Organization	⇒	Small interface teams
• Program Organization	⇒	Clear-cut prime-/ subcontractor relationship
• Type of Contract	⇒	Award fee contracts
• Duration of Development	⇒	Depends on vehicle type, organization, etc.
• Annual Funding Profile	⇒	Bell shaped curve
• Schedule Deviation	⇒	Avoid unplanned extension / acceleration
• Mass Estimates	⇒	Add a mass margin of 10 % (of Phase A)
• Technology Readiness	⇒	Use existing components
• Rapid Prototyping	⇒	Early construction
• Information Management	⇒	Regular cost reviews
• Step-by-Step Method	⇒	Build a subscale test vehicle
• Engine Over-designing	⇒	Over-design engines by some 10 %
• Vehicle Concept	⇒	Low development cost, but high Cost per Flight and v.v

Overview of Cost-saving Strategies

Clue: Engine Over-designing (Development) No. 6

The number of test firings performed during engine qualification program has the major impact on development cost and not the type of propellant or specific impulse. Effective operational engine reliability depends not only on number of qualification tests but also on operational thrust level used. The strategy is to over-design engines by some 10 % compared to the flight thrust level requirement. This increases mass and pre-development cost but allows reducing number of qualification firings resulting in total development cost reduction.

Example:

Jet engines are qualified through about 12 000 endurance cycles before flight-testing, thus achieving an operational reliability of 0,9999 (Whitehair and Hickman, 1992).

Space Shuttle Main Engine Test Firing (NASA)

Overview of Cost-saving Strategies

Production

- High Annual Production Rate ⇒ Modular Production
- Engine Chamber Pressure ⇒ Avoid pressures in excess of 130 bar
- Engine Propellant Combination ⇒ Avoid liquid hydrogen engines
- Timing of Production ⇒ Low launch rate in batches, while high launch rate as continuous production
- Type of Contract ⇒ Fixed price contracts

(based on D.E. Koelle)

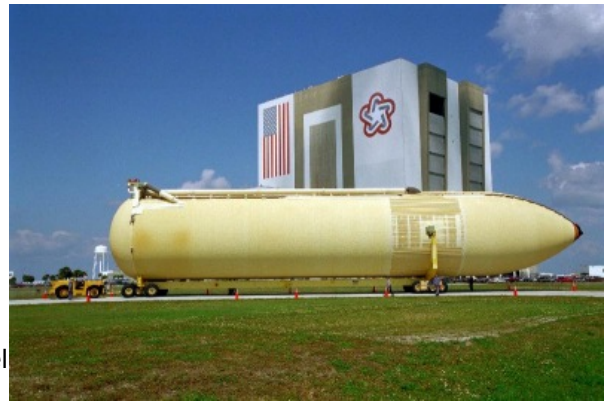
Overview of Cost-saving Strategies

Clue: High Annual Production Rate (Production)

When large units are built in a special facility as the only product, total annual cost is almost constant independent of number of units produced, caused by learning factor. Cost savings could be achieved for RLVs by modular design of subsystems in particular tanks, hot structures and engines.

Example:

Space Shuttle system's External Tank, where the difference between $340 million for 6 units per year and $380 million for 12 units per year (D.E. Koelle, 2000) represents mostly the material cost.



Space Shuttle External Fuel Tank (NCFI)

Overview of Cost-saving Strategies

Operation

- Pre-launch Ground Operations ⇒ Incorporation of a self-diagnosis system
- Propellants ⇒ Close-by production
- Spaceport User Fees ⇒ Regulation philosophy similar to airports
- Catastrophic Failure Rate ⇒ Reduce changes of materials, processes and component suppliers
- Refurbishment ⇒ Reduce number of life-time flights
- Flight Rate ⇒ Achieve a higher flight rate
- Payload Capability ⇒ Achieve a higher payload capability

(based on D.E. Koelle)

Overview of Cost-saving Strategies

Clue: Flight Rate (Operation)

A higher flight rate leads to lower operation cost due to process improvements and learning curve effects.

Example:
In case of Space Shuttle operations, a 30 % increase of flights per year (from 6 to 8 launches/year) leads to a 22 % decrease in Cost per Flight.

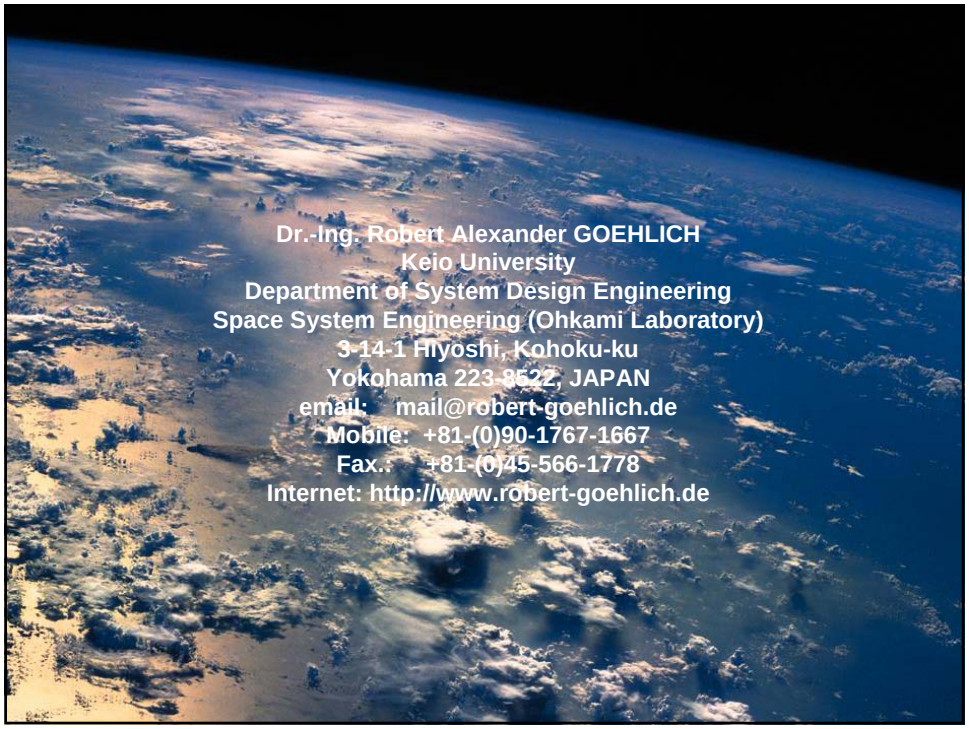
Space Shuttle System (NASA)

Definition

Definition of Cost Engineering (Practice IV)

Case C

- *Step 1: Build a Rocket within 15 minutes in a team by achieving minimum life-cycle costs.*
- *Step 2: Discuss within your team, how you can safe costs during development, production, operation and abolition and collect your facts on a flip chart.*
- *Step 3: Present your results.*
- *Step 4: Discuss within your team, how you can apply each of the 25 cost-saving strategies to your "Paper Rocket" life-cycle. Collect your ideas on a flip chart and present them.*



Dr.-Ing. Robert Alexander GOEHLICH
Keio University
Department of System Design Engineering
Space System Engineering (Ohkami Laboratory)
3-14-1 Hiyoshi, Kohoku-ku
Yokohama 223-8522, JAPAN
email: mail@robert-goehlich.de
Mobile: +81-(0)90-1767-1667
Fax.: +81-(0)45-566-1778
Internet: http://www.robert-goehlich.de