Part 2

C·O·S·T ENGINEERING II™

Economics of Satellites, Rockets and Space Organizations

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

- Part 2: Basics about Orbital Mechanics and Design of Satellites -

Content

- **General**
- **Satellite Science**
  - Ideal Rocket Equation
  - Solar System
  - Newton's Laws
  - Kepler's Laws
- **Definition**
  - Cost Engineering (Practice V)
- **Requests from Audience for Lectures**

General

Goal of Today's Lecture

No. 3

„You will learn about basics of satellite science and do some exercises with selected examples."

General

Contact

No. 4

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Rocket Equation

No. 5

$$\Delta p_{exhaust} = dM(u+v)$$
$$\Delta p_{rocket} = (M - dM)\,du.$$
$$dM\,(u+v) = (M - dM)\,du \approx M\,du.$$
$$M\,du + dM = 0 \quad \text{if} \quad u \ll v$$
$$du = -v\frac{dM}{M}$$
$$\int_{u_0}^{u} du = -v\int_{M_0}^{M}\frac{dM'}{M'},$$

$$u = v\ln\left(\frac{M_0}{M}\right) + u_0.$$

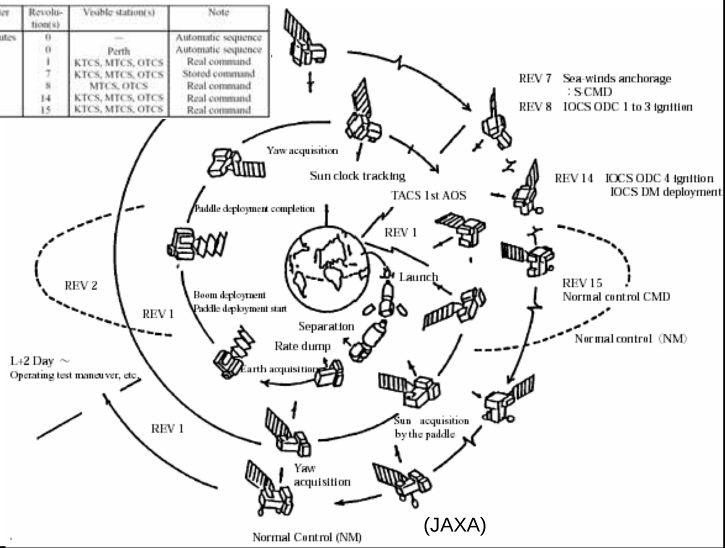
where *u* is the final rocket velocity, *v* is the velocity of the exhaust gases, M_0 *is the starting mass, M* is the ending mass of the rocket and u_0 is the initial rocket velocity prior to the fuel burn. This equation was published by Tsiolkovsky in 1903.

Rocket Equation

Major On-orbit Events (ADEOS-II)

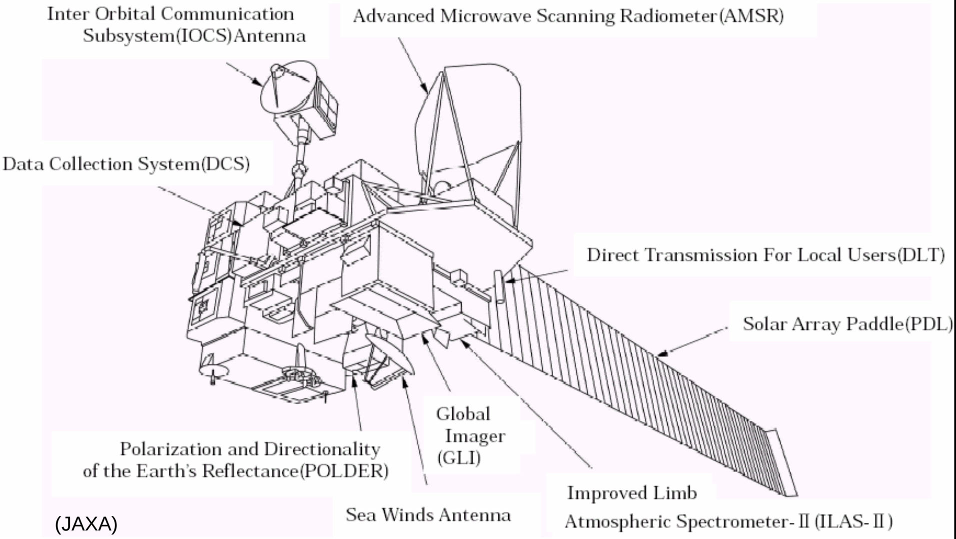
No. 6

Event	Time passed after liftoff	Revolu-tion(s)	Visible station(s)	Note
1) 2nd stage/ADEOS-II separation	00 hour(s) 15minutes	0	—	Automatic sequence
2) Paddle deployment	00 25	0	Perth	Automatic sequence
3) Paddle sun acquisition start	01 33	1	KTCS, MTCS, OTCS	Real command
4) SeaWinds anchorage	12 15	7	KTCS, MTCS, OTCS	Stored command
5) IOCS deployment 1	13 01	8	MTCS, OTCS	Real command
6) IOCS deployment 2	23 36	14	KTCS, MTCS, OTCS	Real command
7) Move to normal control mode	25 18	15	KTCS, MTCS, OTCS	Real command



(JAXA)

Rocket Equation
On-orbit Configuration (ADEOS-II)
No. 7



(JAXA)

Rocket Equation
Major Satellite Characteristics (ADEOS-II)
No. 8

Name	Advanced Earth Observing Satellite -II (ADEOS-II)
Orbit	Category: Sun-synchronous subrecurrent orbit Altitude: 802.92 km Inclination: 98.62 degrees Period: 101 minutes Recurrent period: 4 days Number of recurrence: 14 +1/4 revolutions/day Orbits per Recurrent: 57 revolutions Local time at descending node: 10:30 +/- 15 minutes Minimum inter-orbital distance: 703.07 km(over the equator) Recurrent accuracy: +/- 5 km
Configuration Size	A box shape with a solar array paddle, and antennas for Advanced Microwave Scanning Radiometer (AMSR), Inter Orbital Communication Subsystem (IOCS), and Data Collection System (DCS) Main body: 4m x 4m x 6m Solar array paddle: 3m x 24m
Mass	3.68 tons
Power generation	More than 5,359W (EOL)
Mission life	3 years

(JAXA)

Rocket Equation

HII-A F4 Satellites Separation

No. 9

(movie)

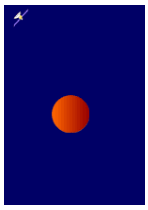
Solar System

No. 10

Newton‘s Laws

No. 11

1. Every body continues in a state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it.



2. The change of motion (linear momentum) is proportional to the force impressed and is made in the direction of the straight line in which that force is impressed.

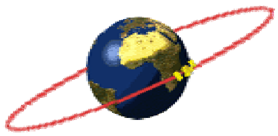
$$F = ma$$

3. To every action there is always an equal and opposite reaction; or, the mutual actions of two bodies upon each other are always equal, and act in opposite directions.

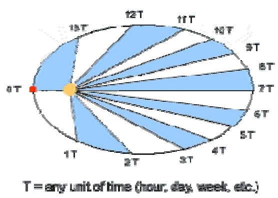
Kepler‘s Laws

No. 12

1. If two bodies interact gravitationally, each will describe an orbit that is a conic section about the common mass of the pair. If the bodies are permanently associated, their orbits will be ellipses. If they are not permanently associated with each other, their orbits will be hyperbolas (open curves).

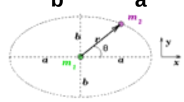


2. If two bodies revolve around each other under the influence of a central force (whether or not in a closed elliptical orbit), a line joining them sweeps out equal areas in the orbital plane in equal intervals of time.



3. Stating that the ratio of the square of the revolutionary period (in years) to the cube of the orbital axis (in astronomical units) is the same for all planets

$$T_a^2 / T_b^2 = R_a^3 / R_b^3$$



Example

New Markets: Madmen in Space

No. 13

(SpaceWorks Engineering)

Example

New Markets: Madmen on Surface

No. 14

(SpaceWorks Engineering)

Definition

Definition of Cost Engineering (Practice V)

Case C

- *Step 5: Discuss within your team the consequences of lower performance (= less payload) from an economical approach.*

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