University of Florida
Department of Mechanical and Aerospace Engineering

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Aerospace Design 1 (EAS4700)

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Outline

- Space Systems Design Facts
- Historical background on space systems development
- Systems Engineer
- Systems Engineering
- Our project
- How I grade, and how you should

1. High-tech in different disciplines

2. Standard procedures defined but continuously evolving

3. It is always a compromise (some would say it is always a "failure")

4. Aircraft industry has 80 years of experience, space has not quite the same background (> 40 years of gap)…for cars we almost do not know (google "first car")

5. DOD often constraints what can be done on the civilian side (see Cubesats, below 600 km)

6. <u>80-90% of failures due to lack of communication among disciplines AFRL SV and weather people do not talk to each other…</u>

Disciplines

1. Structures
2. Aerodynamics
3. Fluid dynamics
4. Vibroacustic
5. Control
6. Trajectory (guidance)
7. Testing
8. Simulation & Modeling
9. Plume / Aeroheating
10. Mission analysis
11. Propulsion
12. Thermal
13. Materials and processes
14. …

A balance among attributes of each disciplines must be found, iterations at systems level are carried out until then.

REMOVE CONFLICTS.

BALANCE STRINGENT REQUIREMENTS ON

- PERFORMANCE
- COST
- SCHEDULE
- RELIABILITY
- SAFETY
- OPERABILITY

THIS TAKES

- ENGINEERING SKILLS
- ORGANIZATION
- COMMUNICATION
- INTEGRATION
- JUDGEMENT

Customer
(NASA, DOD, etc.)

Often times the customer issues a request for proposals, not having a completely clear idea of the needs.
PRELIMINARY ITERATIONS

Designer
(you)

Error in early phases are hard to fix…space shuttle is an example of investment on operations rather than design.

USUALLY 90% BUDGET ALLOCATED IN FIRST 10% DECISIONS

Evolution:

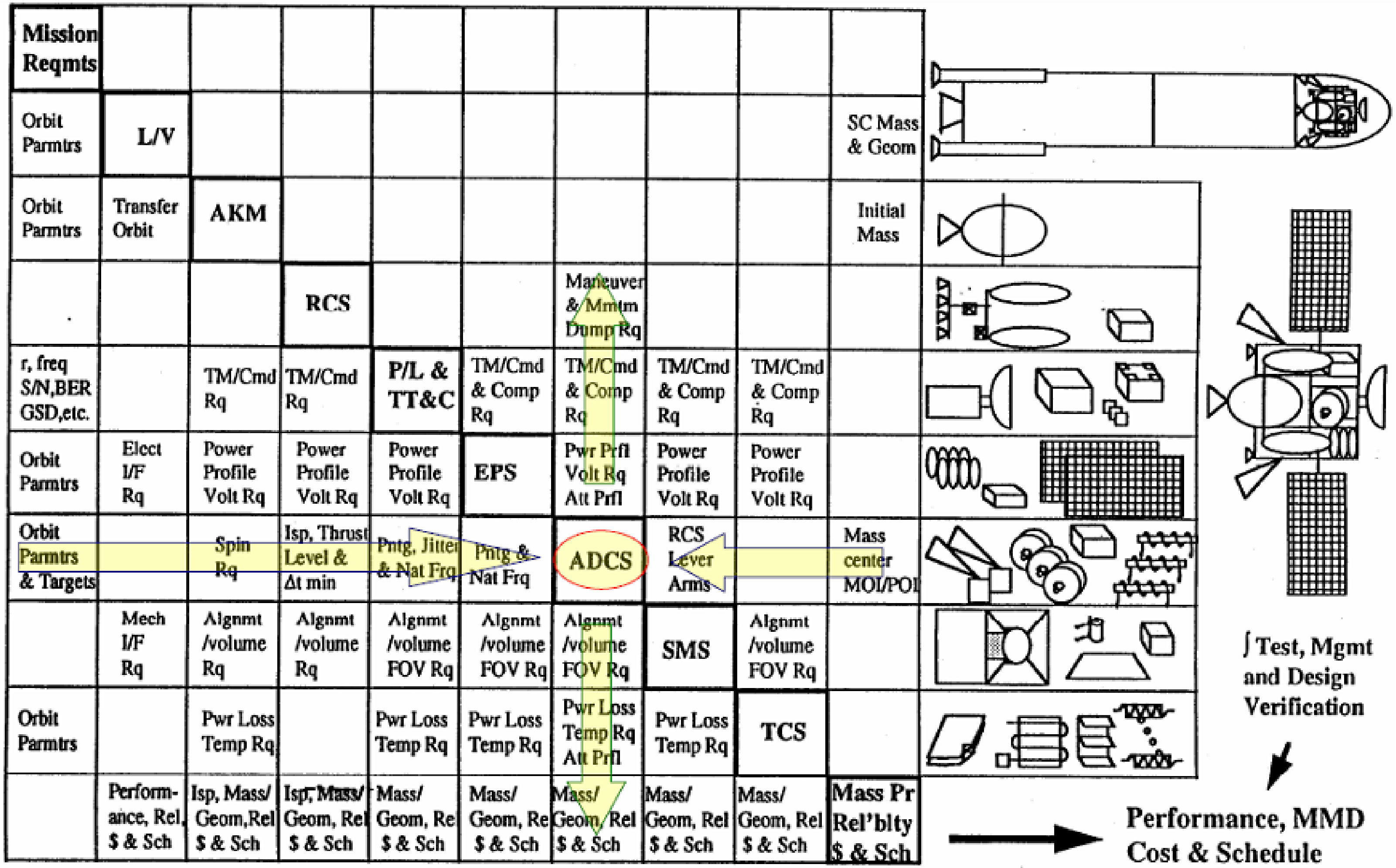
Sequential engineering

↓ SHORTER TIME TO MARKET

Concurrent engineering

↓ QUALITY

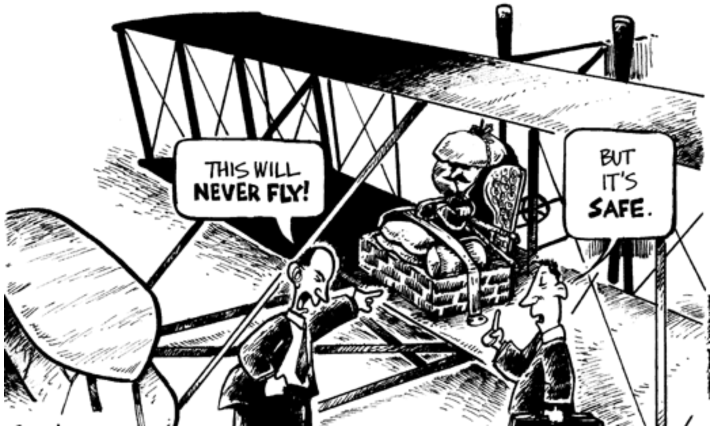
Systems engineering



* Columns=flow of requirements from "diagonal". Rows=flow of requirements to "diagonal".

Credit: Prof. Romano @ NPS, course AE3815, 2009

Until 1930 the designer was a single person, "jack of all trades". (Wright brothers December 17, 1903)

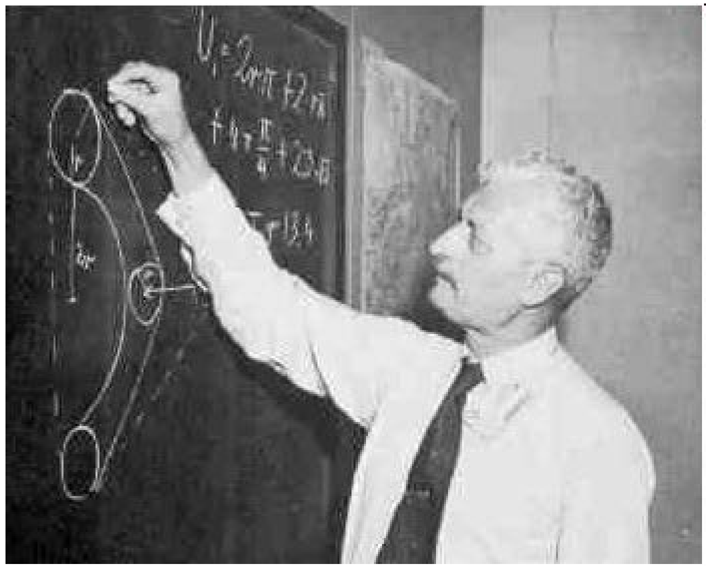


After 1930 various disciplines were born, specializations gained importance, and a single person could not hold all the details of a system. SYSTEMS ENGINEER

Konstantin Tsiolkovsky 1857-1935

Robert H. Goddard
1882-1945

Hermann Oberth 1894-1989



Wernher Von Braun

1912-1977

Mass production of missiles and fighters during WWII (1930-1950) needed the systems engineer figure.

Cold War (late 1950s) led the US to attract specialists in various disciplines, and the systems engineer lost its importance.
Lots of money to achieve goals no matter what, especially in military applications.

1970: aircraft industry starts, decline of space programs, S.E. comes back!

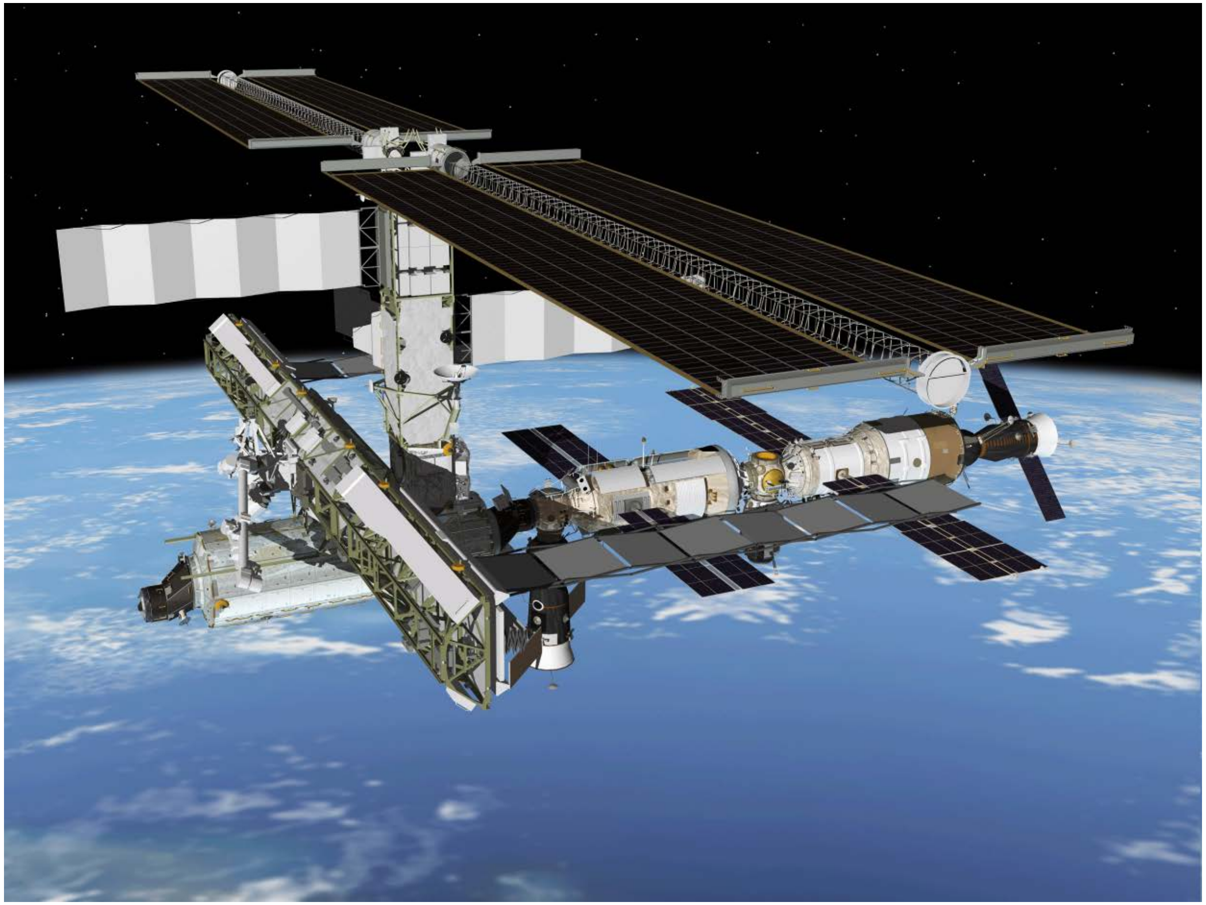
Two revolutionary developments

1) Computer Aided Design (CAD)

2) Military starts caring about balancing performance, costs, reliability, maintainability, etc. …. .

1980 Countries need to focus even more on quality of products: competitive market.

1990-today: big projects need big money! International collaborations.



Dennis Anthony Tito (born August 8, 1940 in Queens, New York) is a United States engineer, multimillionaire, and most widely known as the first space tourist to pay for his own ticket. In mid-2001, he spent nearly eight days in orbit on Soyuz TM-32, the International Space Station, and Soyuz TM-31.

20M $

http://www.space-tourism.ws/

Virgin Galactic, "only" 200k $

http://www.nasa.gov/home/hqnews/2010/aug/HQ_10-203_CRuSR_Awards.html

Who is a Systems Engineer?

Characteristics:

-Team player

-Team leader

-Maintains overall view of system and requirements (cost, schedule, performance)

-communication skills

-capable of interfacing with specialists (speak their language)

-maintain communication among specialists

-give clear guidance

-administrative, business, political skills

-human relation skills

<u>Sometimes more an artist than an engineer, he/she gets better with experience, solving real-world problems. Rarely academia generates systems engineers.</u>

MIL-STD-499A DoD definition:

System Engineering

the application of scientific and

engineering efforts to (a) transform an operational need into a description of system performance parameters and a system configuration through the use of iterative process of definition, synthesis, analysis, design, test, and evaluation; (b) integrate related technical parameters and ensure compatibility of all physical, functional, and program interfaces in a manner that optimizes the total system definition and design; (c) integrate reliability, maintainability, safety, survivability, human, and other such factors into the total engineering effort to meet cost, schedule, and technical performance objectives.

S.E. is critical in the early stage of the life-cycle of a product. Errors at early stages are difficult to compensate later on.

SYSTEM = a set of elements whose interrelated functions are coordinated to serve given human purposes.

What is a system for you can be sub-system for another person.

S.E. offers an orderly approach to the design of systems, EFFICIENTLY, ASSURING QUALITY. Common elements:

1) Identification studies
2) Problem definition
3) Determination of performance specifications
4) System synthesis
5) System analysis
6) System design
7) Evaluation of system performance
8) Sustaining engineering

Identification - Problem Definition

1) Recognize the need for new system, often a customer requires it. A market analysis often happens outside of Systems Engineering.

2) Collecting requirements, and selecting which ones are stringent. Define Functions of the system. Iterations with customer to understand needs and balance them.

Often this will clarify the customer's ideas.

Identify constraints on cost, weight, volume, reliability, etc. … .

3) Translate the problem definition into quantities, measurable inputs/outputs, that the engineer can use. Performances definition. DESIGN OBJECTIVES: framework to compare against, when design alternatives are developed.

4) Formulation of several system models (concepts) meeting the design objectives.

5) Selection of the best model, or combination of models. Analytical tools used to evaluate performances. First evaluation of costs can be done.

6) Translate the chosen model into hardware. <u>The cycle goes back and forth to system analysis</u> → <u>tradeoff studies</u>

<u>FINAL DESIGN</u> meets objectives
within costs
time of delivery respected

WHEN TO STOP? It depends on money.

7) First hardware comes out of the factory, having the customer getting what paid for.

TESTS→ RESULTS → BACK TO DESIGN FOR CORRECTIONS

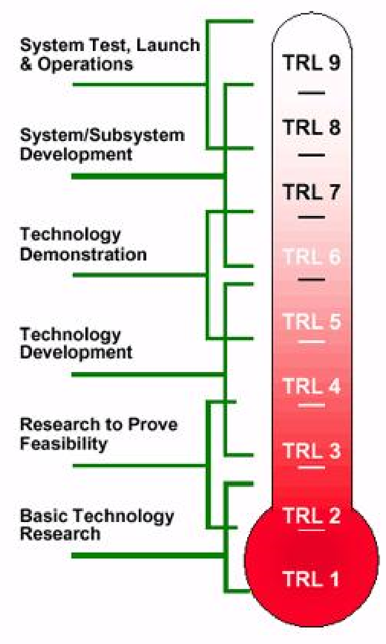
8) Installation and life cycle of the system. Often objectives vary and updates are performed to the system.

And….here is another homework:

Write a paragraph about what you think is the message from this document

References

NASA Technology Readiness Level (TRL)



ESA Technology Readiness Level (TRL)

ESA Technology Readiness Level Summary

TRL	Level description
1	Basic principles observed and reported
2	Technology concept and/or application formulated
3	Analytical & experimental critical function and/or characteristic proof-of-concept
4	Component and/or breadboard validation in laboratory environment
5	Component and/or breadboard validation in relevant environment
6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)
7	System prototype demonstration in a space environment
8	Actual system completed and "Flight qualified" through test and demonstration (ground or space)
9	Actual system "Flight proven" through successful mission operations

Online – **download them**:

NASA Systems Engineering Handbook

NASA PROCEDURES AND GUIDELINES

Our project!!!

Grading of presentations, papers, and your peers

Install STK completed?

1. Highly complex
2. Highly interconnected
3. Extreme energy density (for launchers, but also big spacecraft)
4. Lots of system/environment uncertainties
5. Advanced electronics in space is probably old on the ground, since space qualification takes years…
6. …the trend is changing: CubeSats & friends…Surrey in UK launches cell phones!
7. space is becoming closer, standards are originating at universities level.