ENGINEERING

How to become an excellent and competent engineer ?

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November 20, 2019
İTÜ Maslak

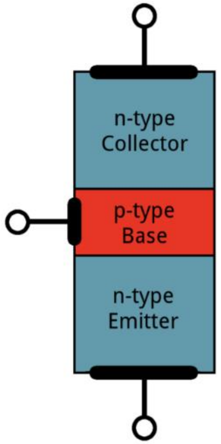
The first electronically controlled device
?

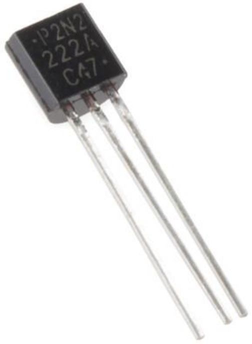
The first electronical device

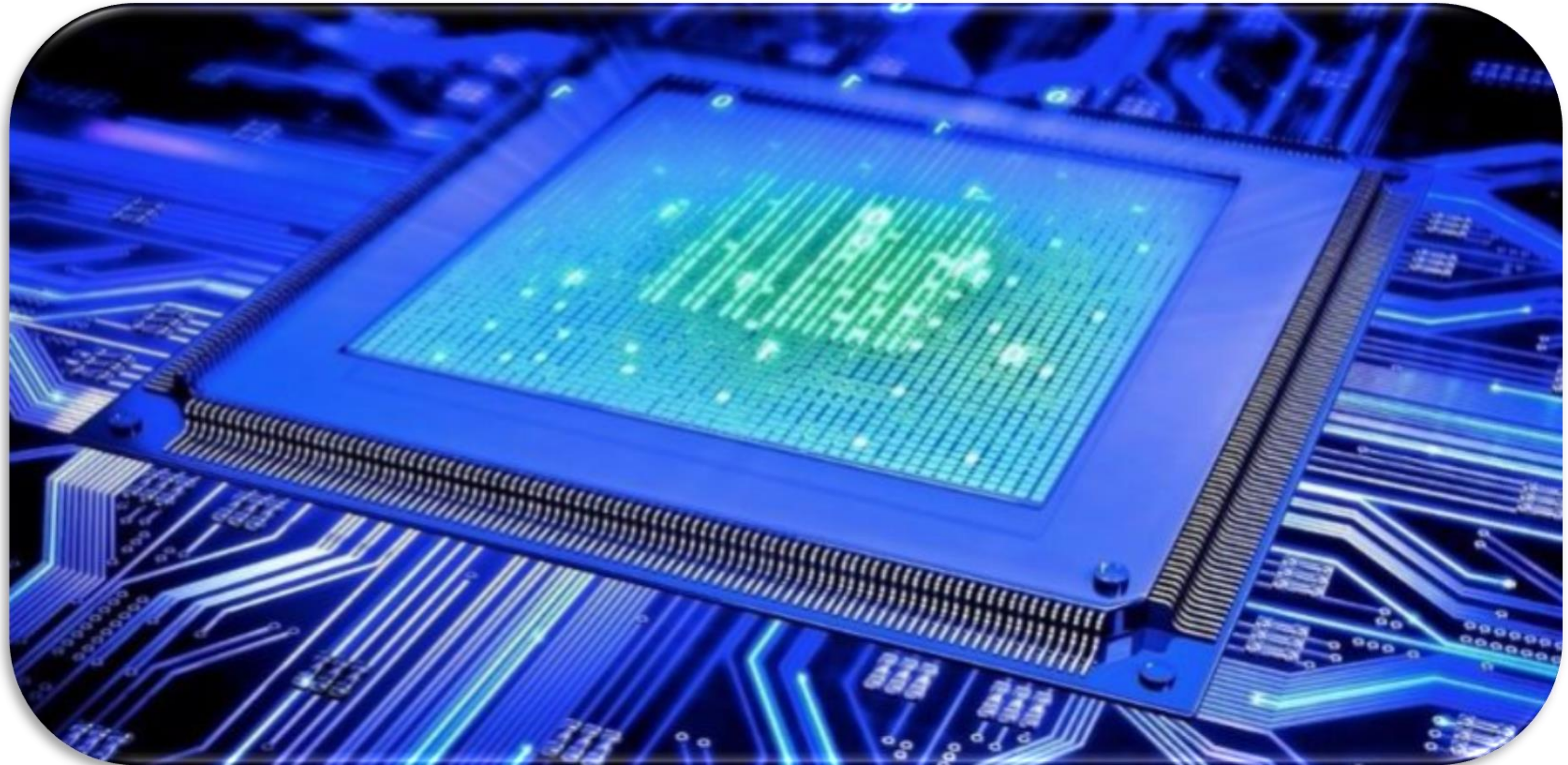
- The first electronic device ever invented is **the relay**, a remote switch controlled by electricity that was invented **in 1835** by **Joseph Henry**, an American scientist

New Generation Processors are scheduled to have

100 Million Transistors per square millimeter







One of the most complicated engineering systems

?

?

Engineering

- "The profession in which a knowledge of the **mathematical and natural sciences** gained by **study, experience, and practice** is applied with judgment to develop ways to utilize, **economically**, the **materials and forces of nature** for the **benefit of mankind**". *

  - **Use of Mathematics and Natural sciences**
  - **Study - Experience - Practise**
  - **Economy**
  - **Utilization of the materials and forces of nature**
  - **Benefit of Mankind is aimed**

**: Definition by ABET*

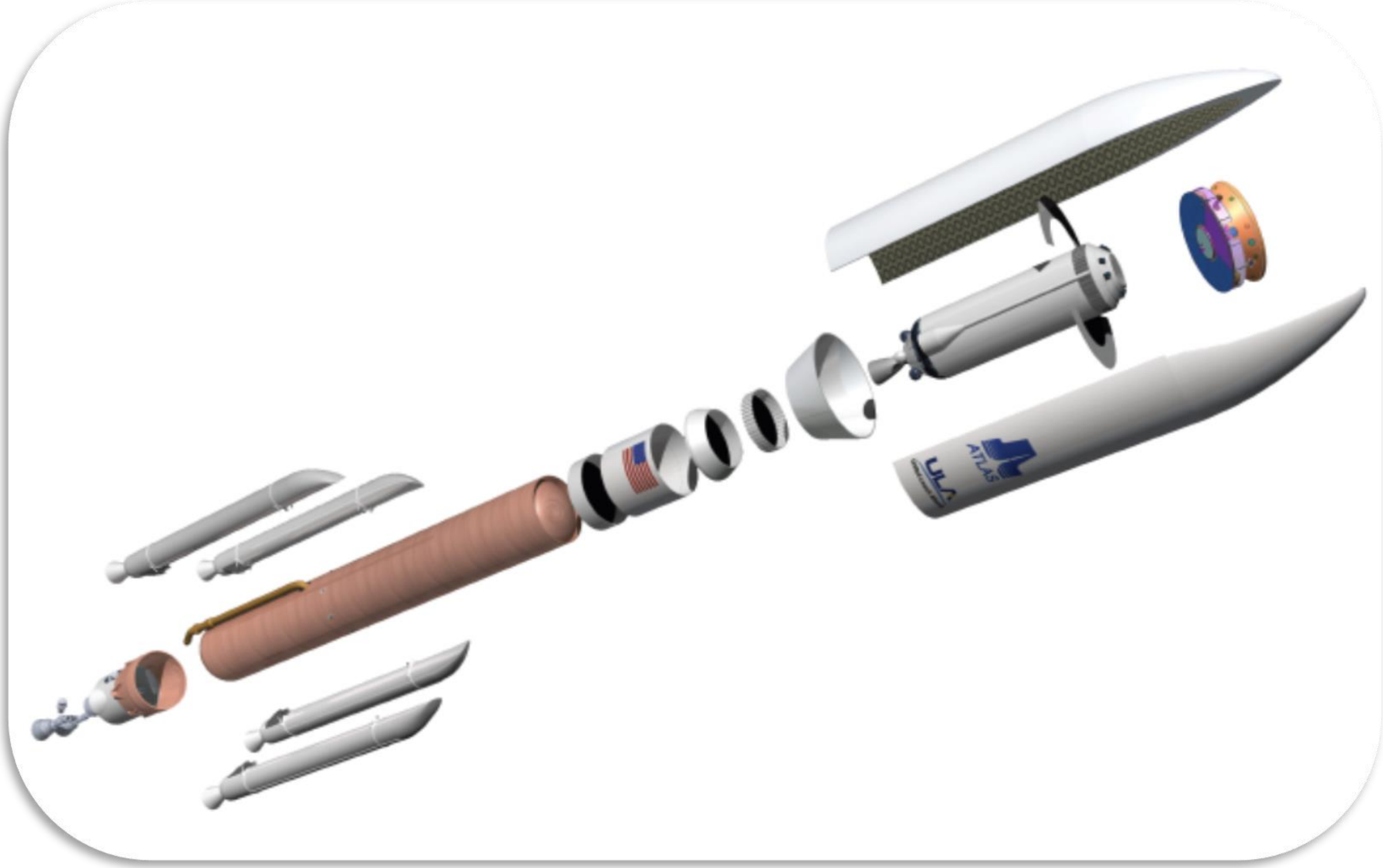
Engineering

- **Engineering** is the process of developing an **efficient mechanism** which **quickens and eases** the work using **limited resources**, with the help of **technology**.
- Engineers
  - Performs their tasks
    - **Efficiently**
    - **Quickly**
    - **Facilitatively**
  - Use
    - **Technology**
  - Put in practice with
    - **Limited resources**

An example: Mars rover - Curiosity

Difficulties?

Design



Challenging requirements

Design

Complex needs

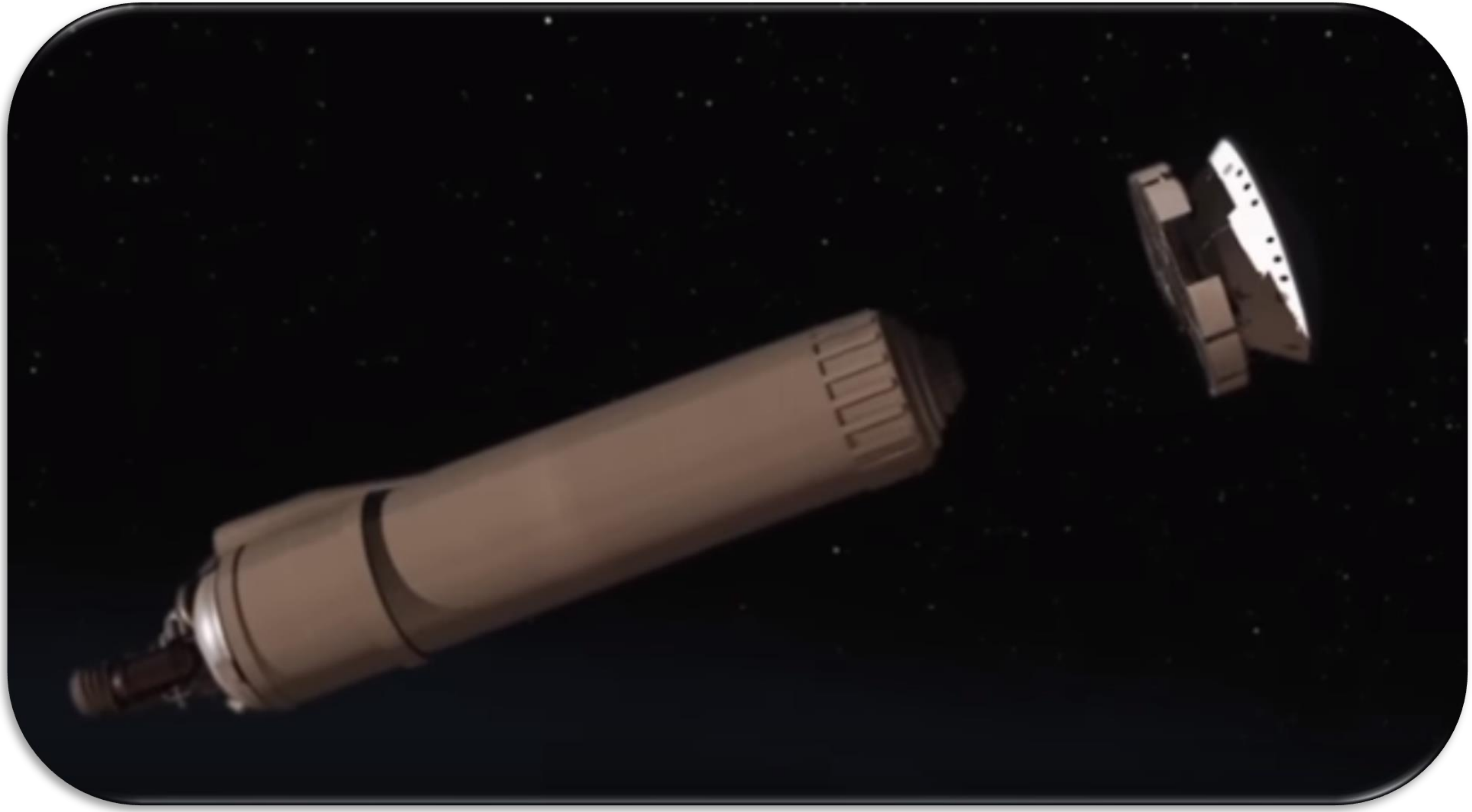
Launching

High energy requirement to launch

Passing through the Earth atmosphere

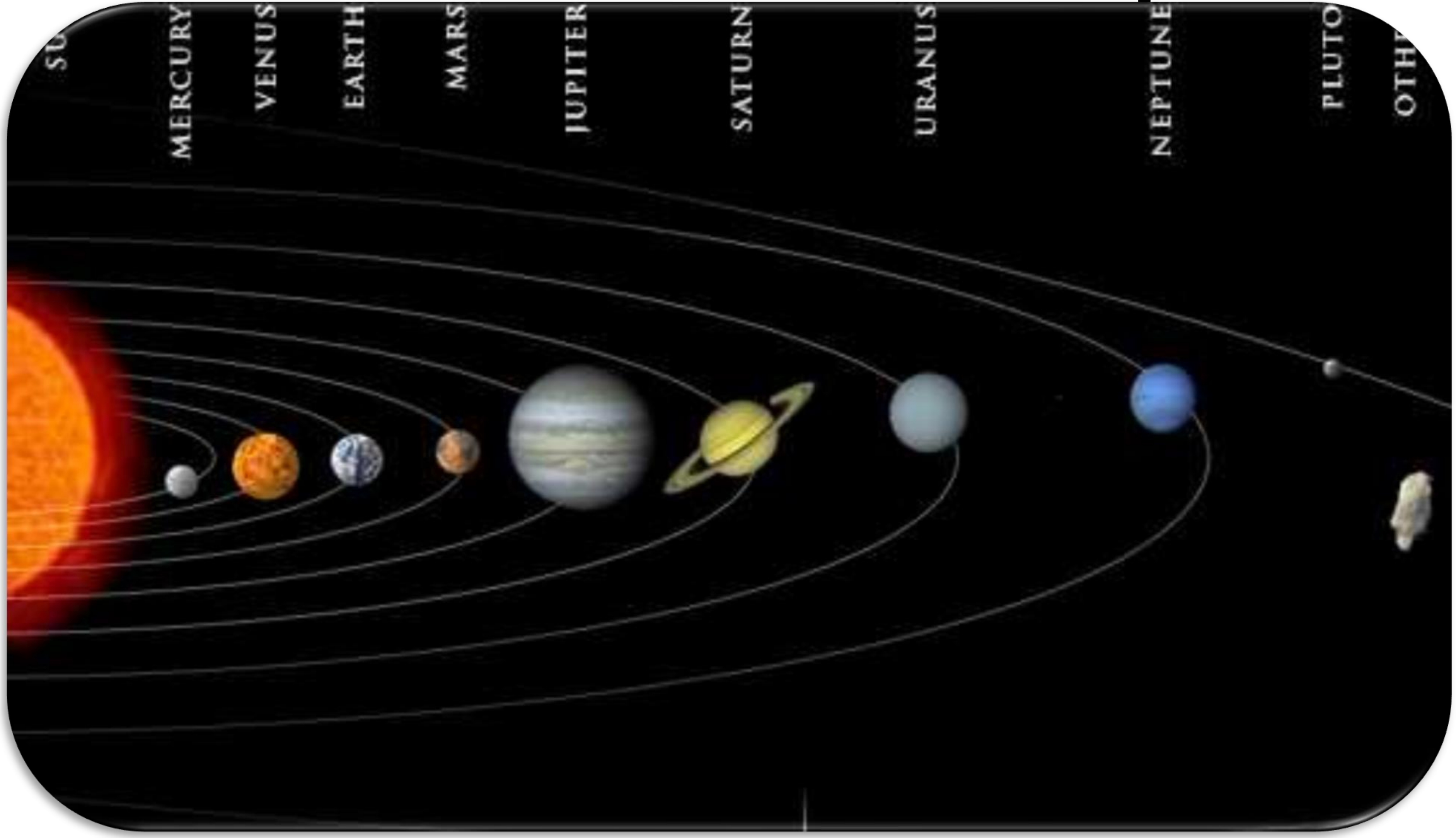
High temperature exposure

Journey through the space



Long travelling duration (6-9 months) in harsh conditions

The conditions to be exposed



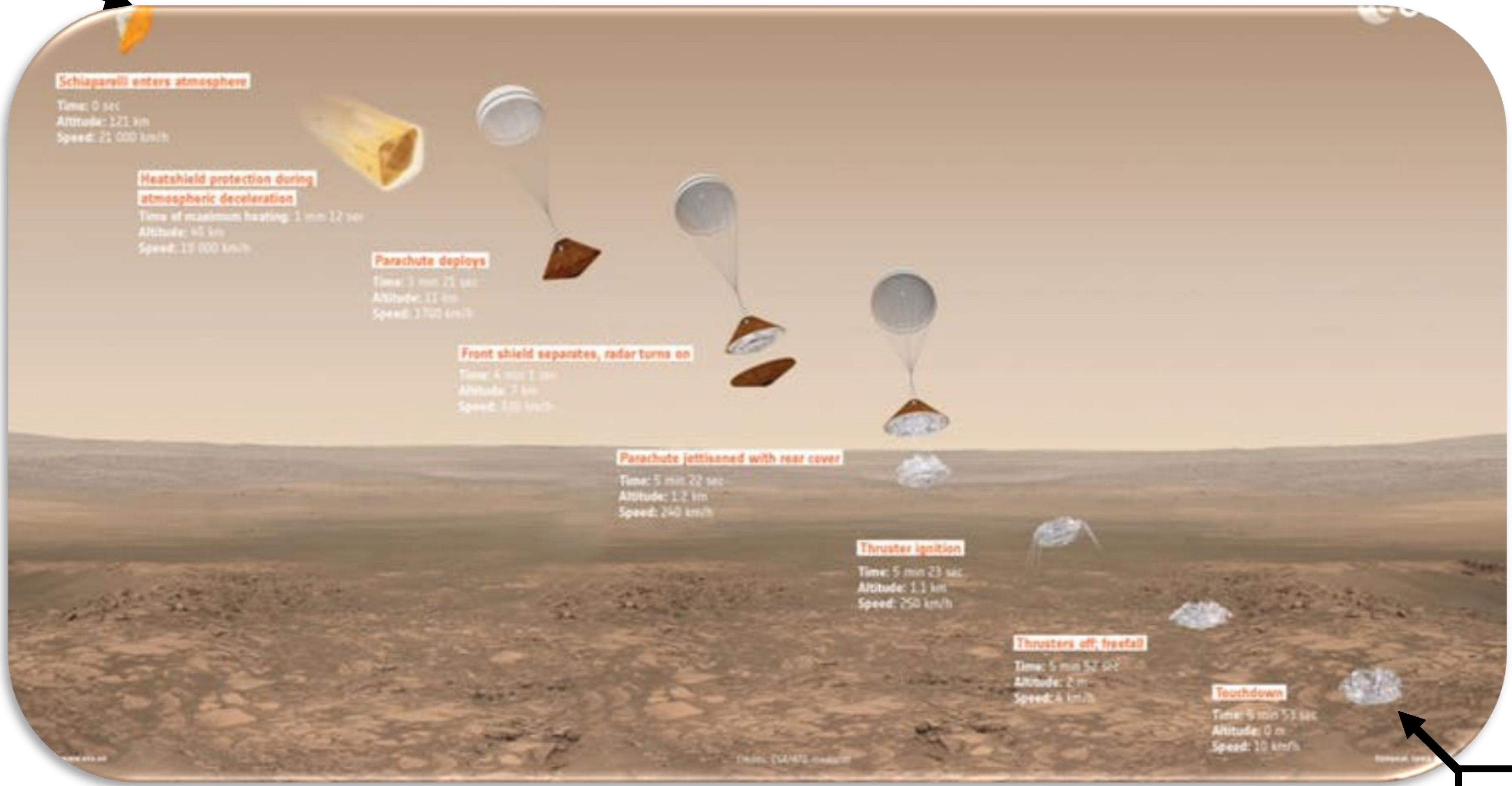
Approximately 57.600.000 km travelling distance between Earth and Mars

Passing through the Mars atmosphere

High temperature exposure, high velocity to be reduced

Preparation for landing

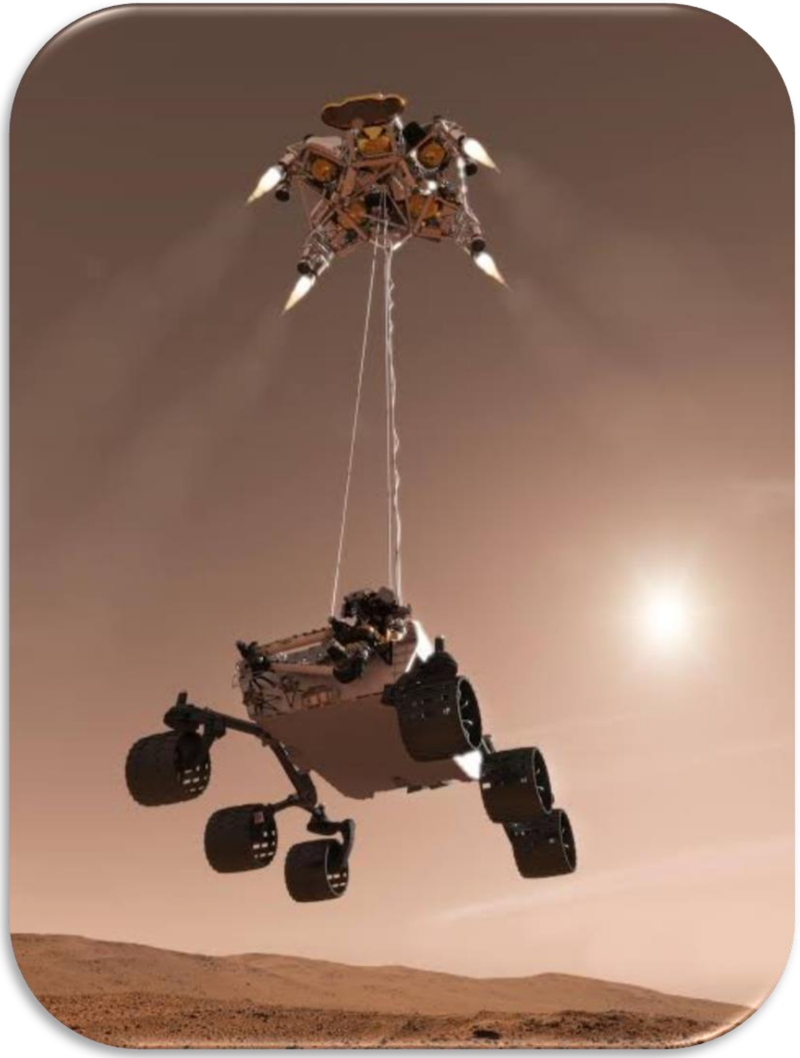
Altitude : 121 km
Speed : 21.000 km/h



Altitude : 0 m
Speed : 0 km/h

Approximately 6 minutes

Landing to Mars surface



Have a safe landing !

Operation

Operating temperature in Mars is approximately -60 ^oC, …

Difficulties

- Perfect design (there is no tolerance to fail, …)
- Launching (extremely hard conditions, …)
- Passing through the Earth atmosphere (against huge gravity force, …)
- Approximately 57.6 Million km travelling distance (Energy requirement, …)
- 21.000 km/h cruise speed, averagely (mechanical design, …)
- Approximately 6-9 months travel in (extremely hard conditions of) space
- Passing through Mars atmosphere (very high temperature due to friction,…)
- Landing to mars without any damage (21.000 km/h -> 0 km/h !, safely, …)
- Operation in very destructive environment (-60 ^{o}C,…)
- …

Engineers

always find solutions to problems

The Journey of Curiosity (simulation)

https://www.youtube.com/watch?v=gwinFP8_qIM

Any Control and Automation Engineering task in the mission?

How can we cope with this kind of challenging (huge) projects ?

Achievement in challenging (huge) projects

We need

- Skilled teams
- Study
- Learning
- Knowledge
- Experience
- Systematic approach
- …

Make investment for yourself

- You have to **invest** in **yourself,** **timely** and **wisely**
- As a "Control and Automation Engineer", **you** will be assigned to critical projects after you graduate (may be during your education)
- Be prepared…

Projects

- Turkey have challenging projects
  - MMU (National Fighter Aircraft)
  - ATAK (Helicopter)
  - HÜRKUŞ (National Plane)
  - …
- We need national projects in also civil domain, to obtain **high added-value** in the following technologies:
  - UAV
  - Drone
  - Robotics
  - Signalization
  - Automatization
  - …

Approach for huge projects

- Consideration of “Systems of System”
- System engineering concept
- Multidisciplinary work methodology (electronic, mechanical, material, chemical,…)
- Rules (standards) to be used (especially originated from lessons learned)
- Use of configuration management
- Comprehensive records and documentation
- Compliance with special standards (IEEE-xxx, MIL STD -xxx, …)
- …

To become a successful and competent engineer

Considerations to become a successful and competent engineer

1. Continuous learning
2. Imagination – Productivity - Planning
3. Problem solving
4. Logical thinking - realism
5. Attention to detail
6. Analytical ability
7. Mathematical ability
8. Communication skill
9. Teamwork
10. Leadership
11. System Engineering Concept (systems of sytem)
12. Ethic
13. …

1. Continuous learning

- **Technology and methodologies are constantly changing**.
- A successful engineer is able to keep abreast of the latest technology
- **Engineers are curious by nature.** They are interested in understanding how things work.
- **It is critical to constantly learn and stay up to date.**
- **Never assume you know everything.**

2. Imagination – Productivity - Planning

- Successful engineers have an innate ability to **'think outside the box'**.
- **Plans** the stages of the work **very well**
- Produce **reasonable** solutions
- Always pay attention to **practicality** when proposing solutions.
- Make **realistic** and **applicable** plans.

3. Problem solving

- **Any project**, no matter how big or small, will face **problems**.
- To effectively solve problems an engineer must also have the ability to **truly listen to the problem 'owner'.**
- An engineer must **meticulously study** the problem, **fully understand the impact** it has on the project, and then apply their **analytical skills in a methodical** and **efficient** way in order to identify **the root cause**.

4. Logical thinking

- To fully comprehend complex systems an engineer **must understand all aspects of the system**.
- An engineer **must know how the system works, what can go wrong and how to fix it**.
- This requires an ability to **think logically**, and **evaluate** and **understand** each element that makes it up.
- They have to be able to **analyze** an existing system, **understand how** the different pieces **work individually** and **as a unit**.

5. Attention to detail

- Successful engineers **pay meticulous attention to the smallest of details**.
- They understand that **the slightest error may cause a structure to fail**, a system to malfunction or software to glitch.
- **The smallest error can cost a significant amount of money** or, in some cases, be **fatal**.
- Complex projects may have a large number of steps to complete and **having one tiny thing out of place may delay an entire project.**
- **Never assume something is too small or insignificant to care about**.

6. Analytical ability

- In order to obtain an **effective solution**, it should be **studied sufficiently** during the **analysis phase.**

- Engineers need to think **analytically** to produce **suitable solutions**.

- The needs must be fully **understood** and the resources to **reach** the **optimum** result must be **emerged**

7. Mathematical ability

- Although most engineers do not need complex calculations in real life, they **need to know the mathematical foundations of engineering**.

- They must be able to understand that the **calculations are done correctly** and the **models are defined exactly** to **ensure** that the process is carried out **correctly**

8. Communication skills

- Communication is **more than reading, writing, speaking or listening**.

- An engineer should be able to communicate technical aspects **to others** in a **concise** and **effective manner**

- Communicating in a **respectful, clear and concise** manner is critical to ensuring the **effective** delivery of the main **message**.

9.Teamwork

- Teamwork plays a **key** role in the success of most projects. **No one** can **complete** an important project **alone**

- Although there are functions that can be performed individually, an engineer will often **be part of a larger team**.

- **Courtesy** and **subtlety** are important in building **team confidence**.

- An engineer must understand **everyone's position**, **inform** team members, and always **speak the truth correctly**.

10. Leadership

- Leadership requires **excellent interpersonal skills** and an ability **to inspire** and **motivate others** to drive a team to **achieve success**.

- A successful leader engineer must have **excellent mathematical skills, think logically** and **solve problems**.

- People who are **charismatic**, **well-spoken** and **friendly** are normally well-liked, so they are **easily be supported**.

11. System Engineering Approach

- Comprehensive projects require the use of systematic approaches
  - System’s of system concept
  - The use of multidisciplinary engineering
  - Manage large teams
  - Long project time
  - …
- System Engineering approach provides effective solutions to these issues

12. Ethic

- An engineer with ethics, can **help the society in a better way.**
  - To act for the benefit of society
  - Having chastity
  - Tell the truth
  - Remind wrong things
  - Avoid cheating
  - …

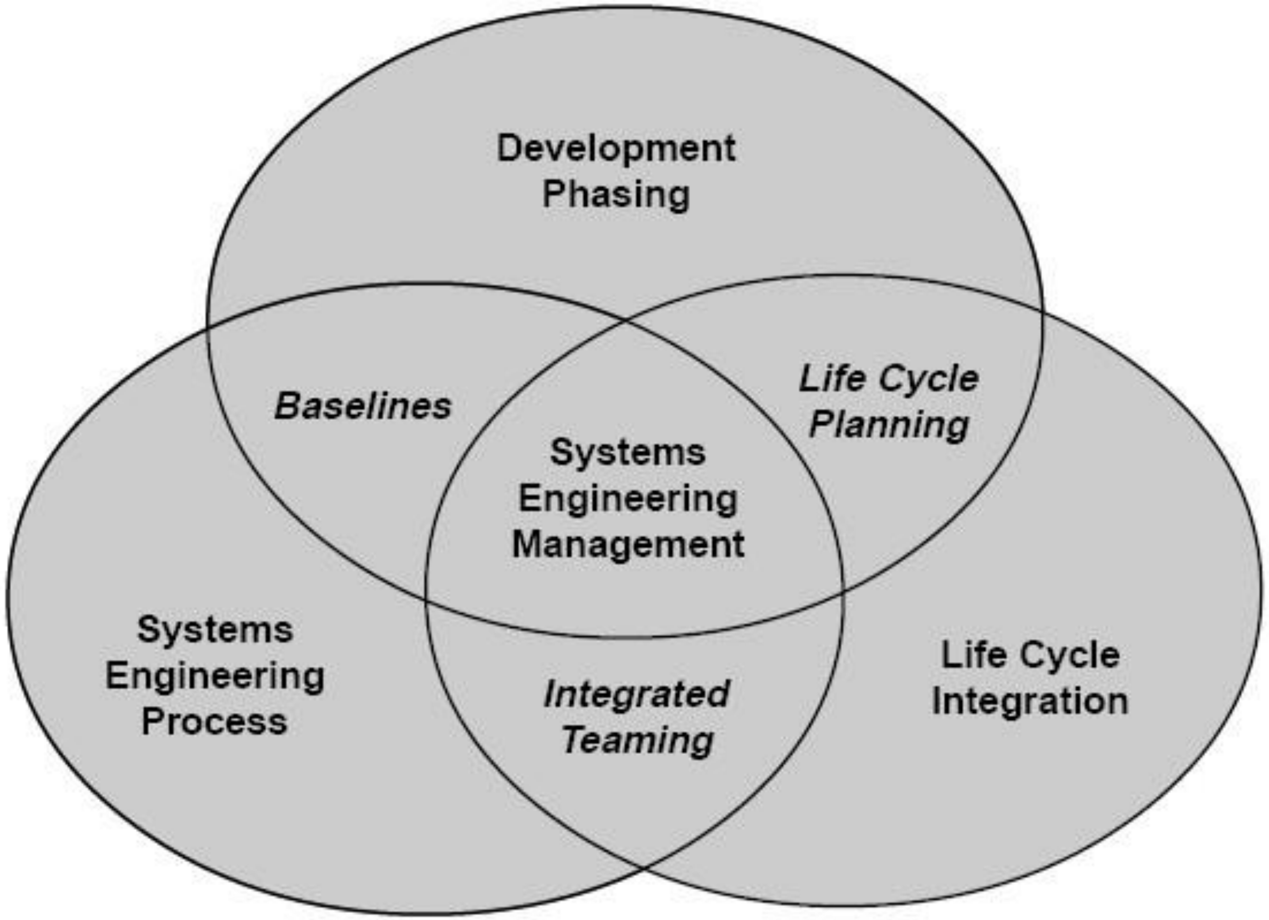
SYSTEM ENGINEERING

System

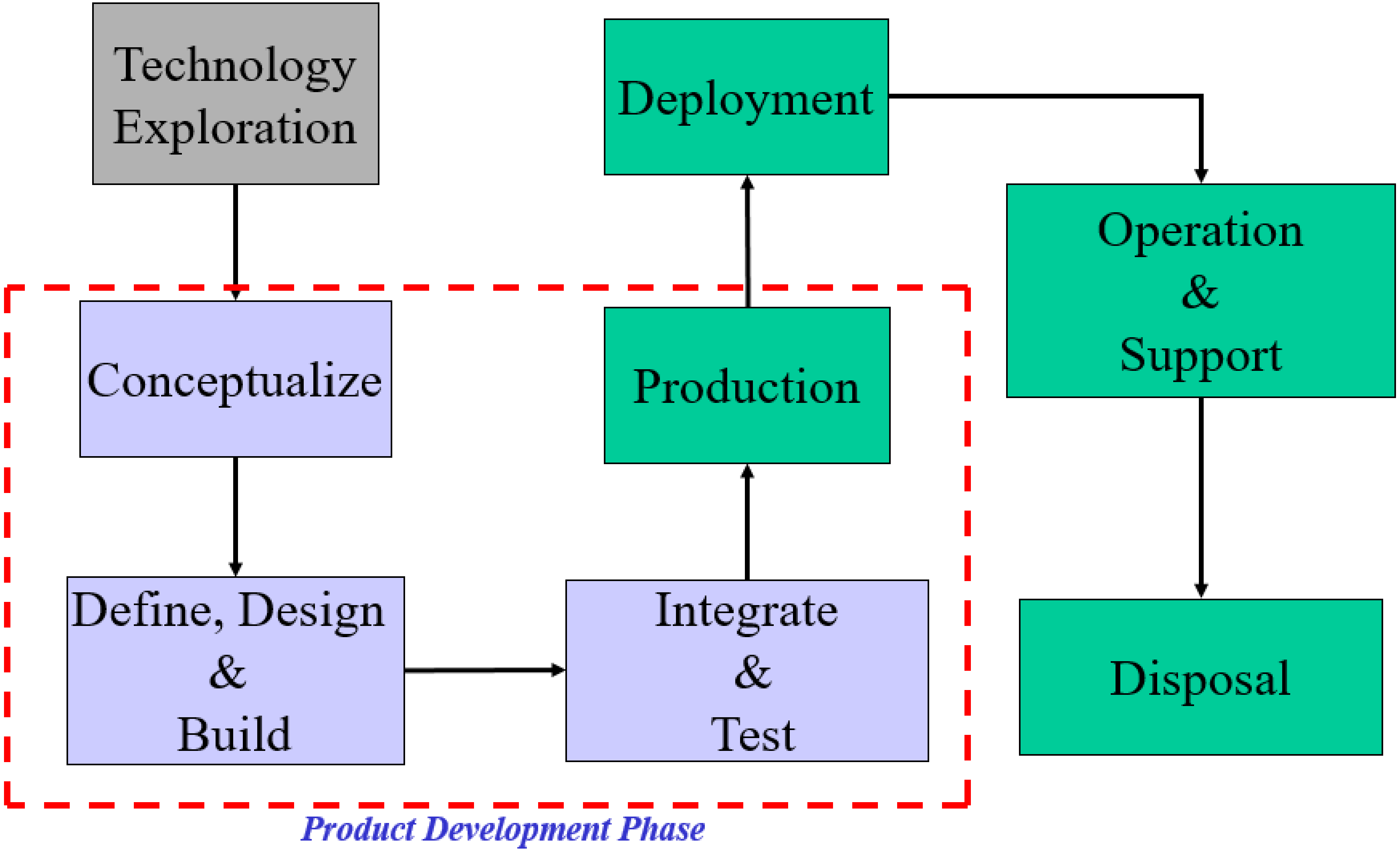
- System
  - Has a **purpose** and **function**
  - Has interacting parts (subsystems) which **communicate** and **interact** mutually
  - There are some **rules** in the functions between **subsystems**
  - **A whole**, functioning with **harmony**

- A system can be
  - physical
  - conceptual
  - combination of both

System Engineering

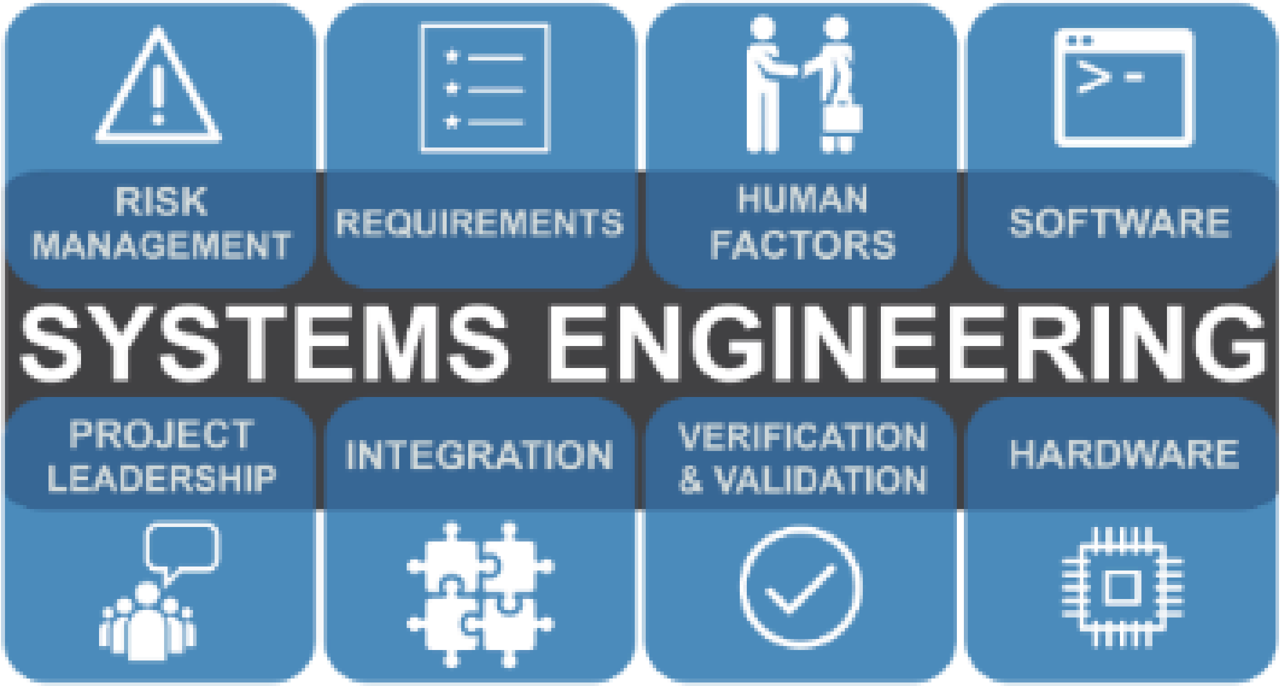


System Life Cycle Phases



System Engineering

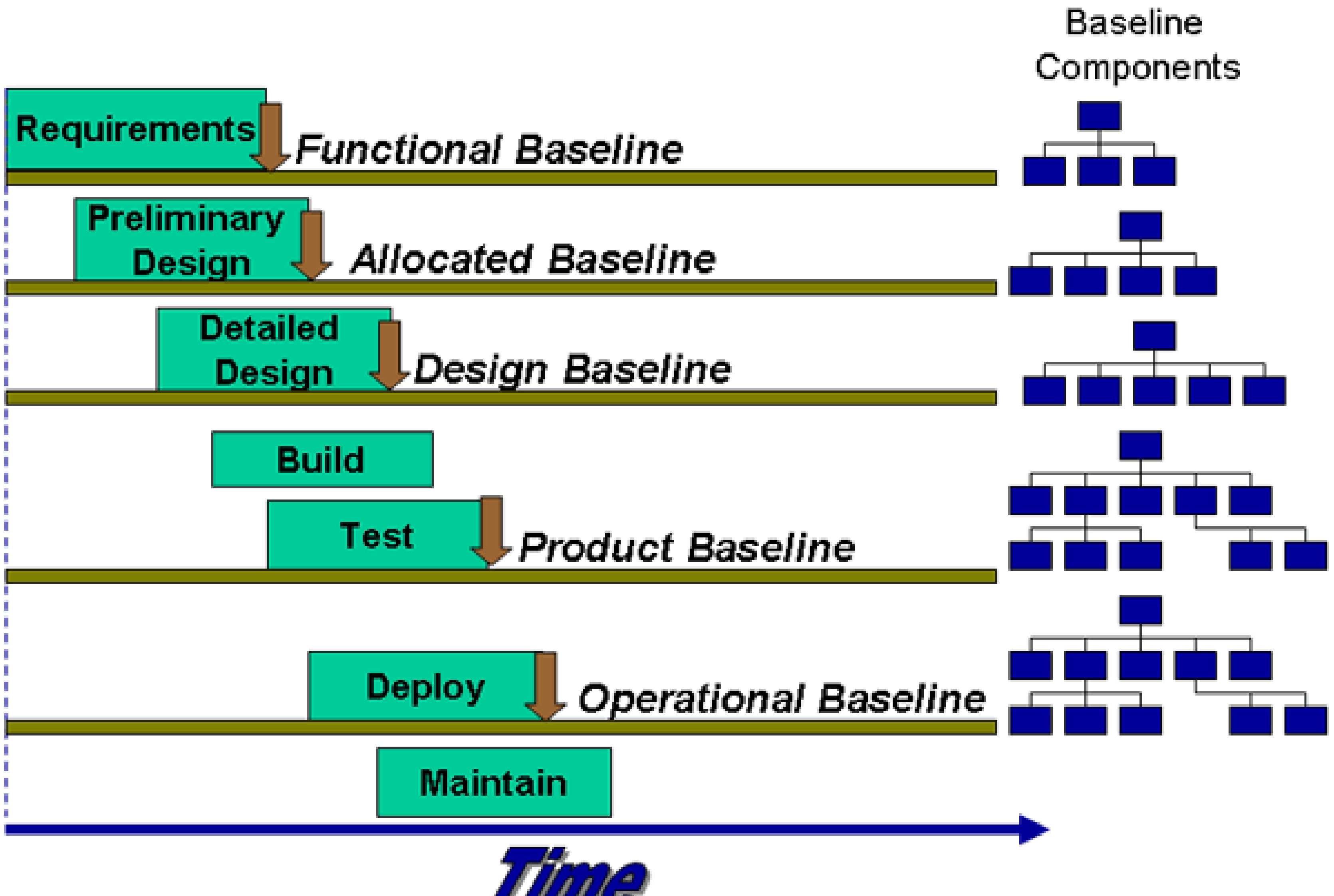
- Engineering systems may include
  - people
  - products
  - services
  - information
  - processes
  - natural elements
  - …



System engineering

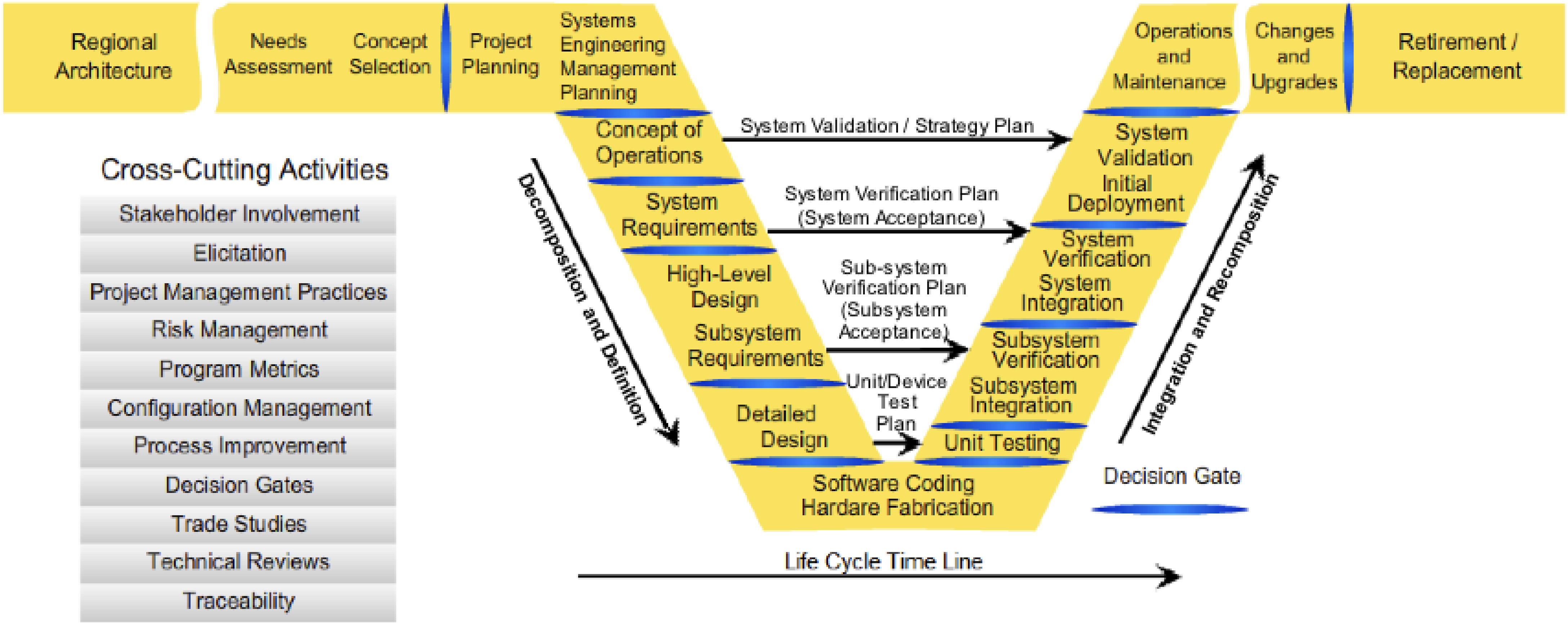
- Uses **system principles** and **concepts**, **scientific**, **technological** and **management methods**
- **Explains** the rules for the **successful implementation**, **use** and **disposal of engineering systems**
- An **interdisciplinary** and **integrative** approach

System Engineering



System Engineering

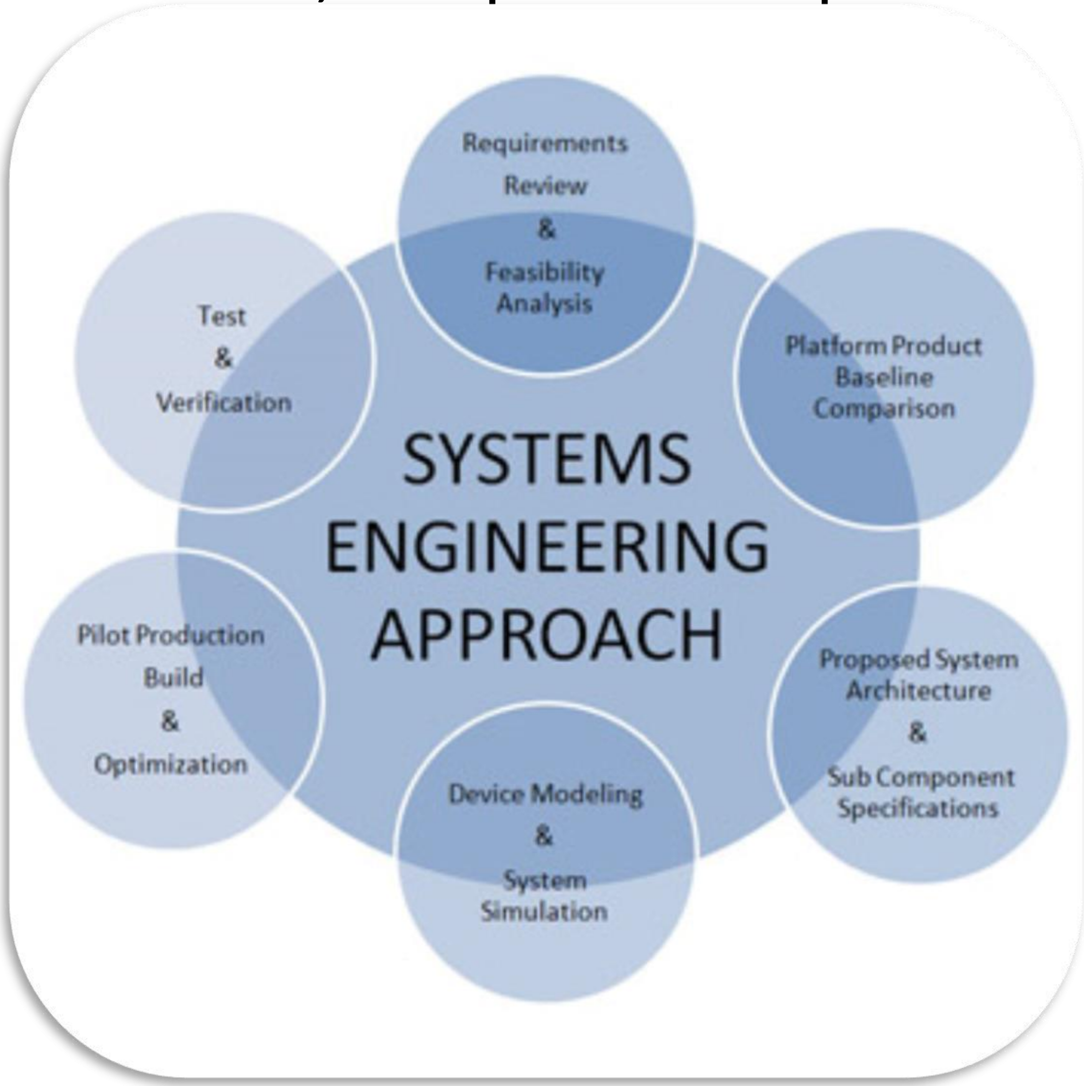
Phase -1	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Interfacing with Planning and the Regional Architecture	Concept Exploration and Benefits Analysis	Project Planning and Concept of Operations Development	System Definition and Design	System Development and Implementation	Validation, Operations and Maintenance, Changes & Upgrades	System Retirement / Replacement



System Engineering

- **Generate information** for decision makers, and provides input for the next level of development

- **The process** includes
  - inputs and outputs
  - requirements analysis
  - functional analysis and allocation
  - requirements loop
  - synthesis
  - design loop
  - test
  - verification
  - system analysis and control
  - …

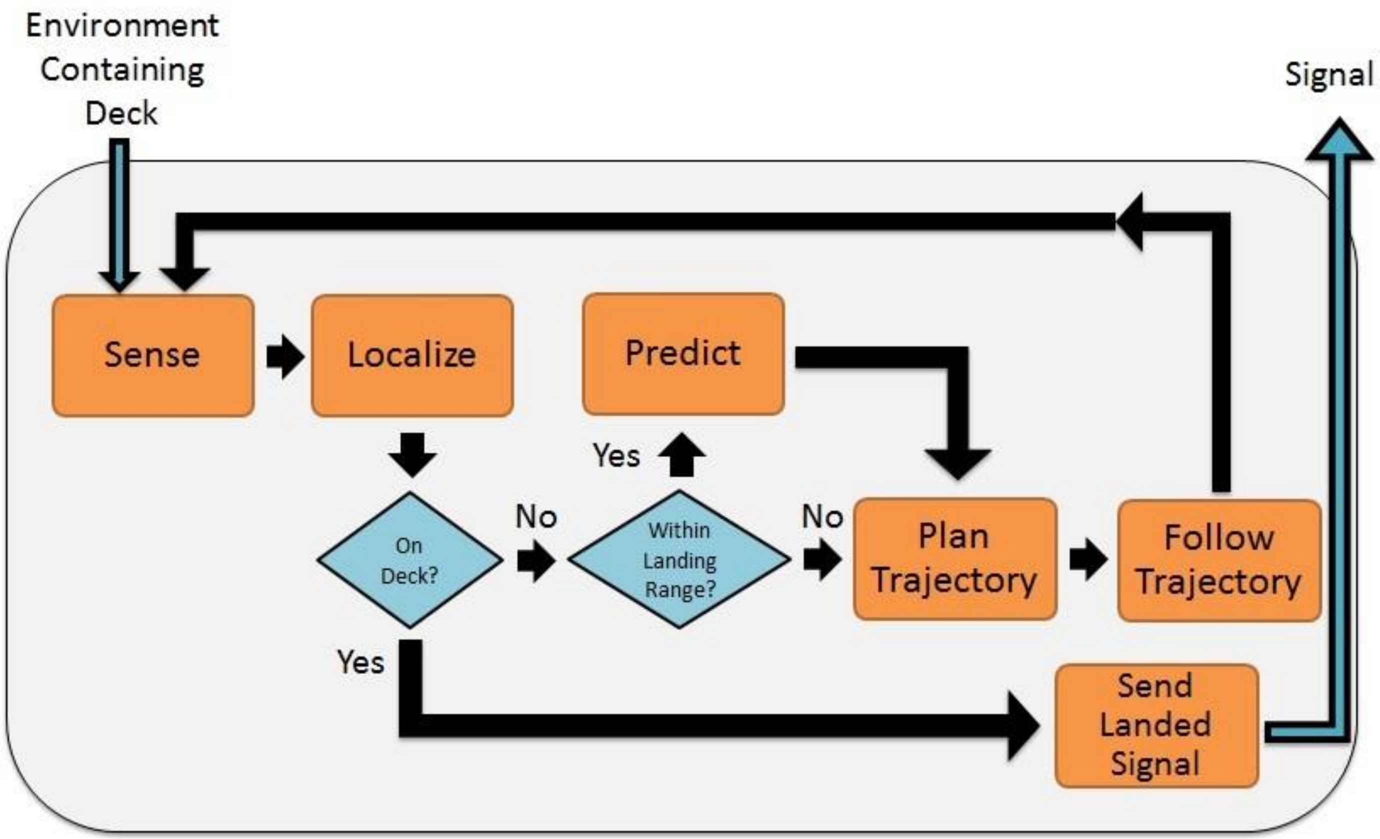


Requirements Analysis

- Requirements analysis is used to obtain functional and performance requirements;
- **Customer requirements are translated into a set of requirements that define what the system must do and how well it must perform.**
- Requirements must be
  - understandable
  - unambiguous
  - comprehensive
  - complete
  - concise

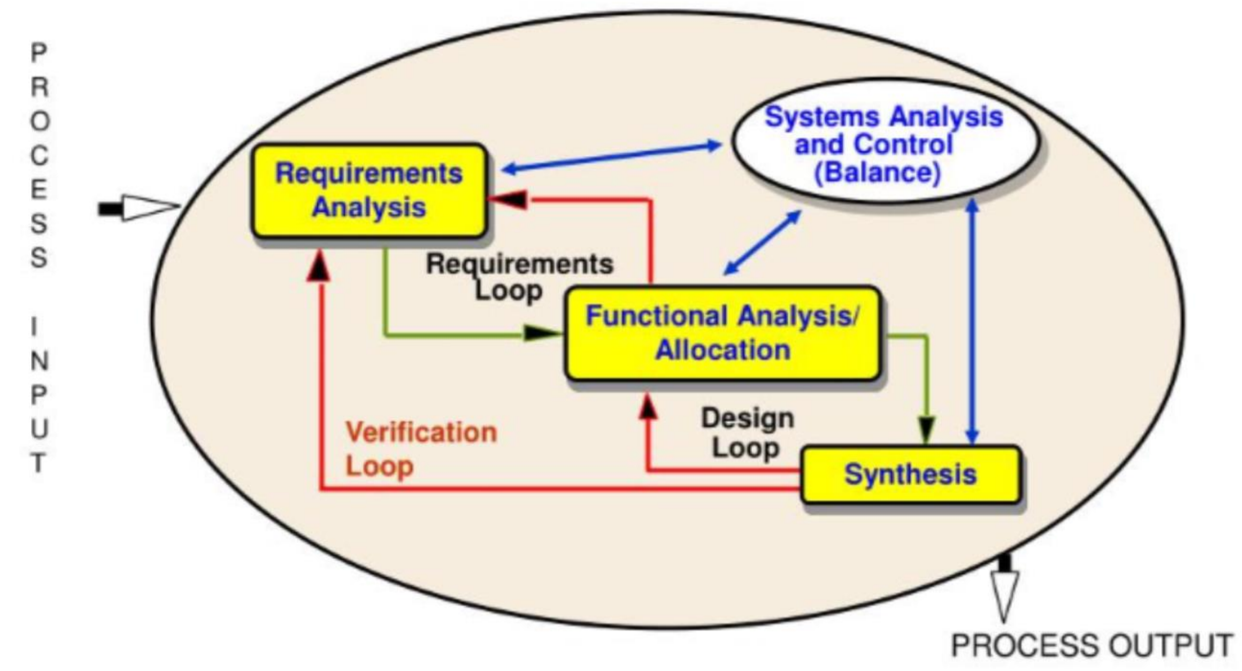
Functional Analysis/Allocation

- Functions are analyzed by decomposing **higher level** functions identified through requirements analysis into **lower-level** functions.
- This definition is often referred to as the **functional architecture** of the product or element.



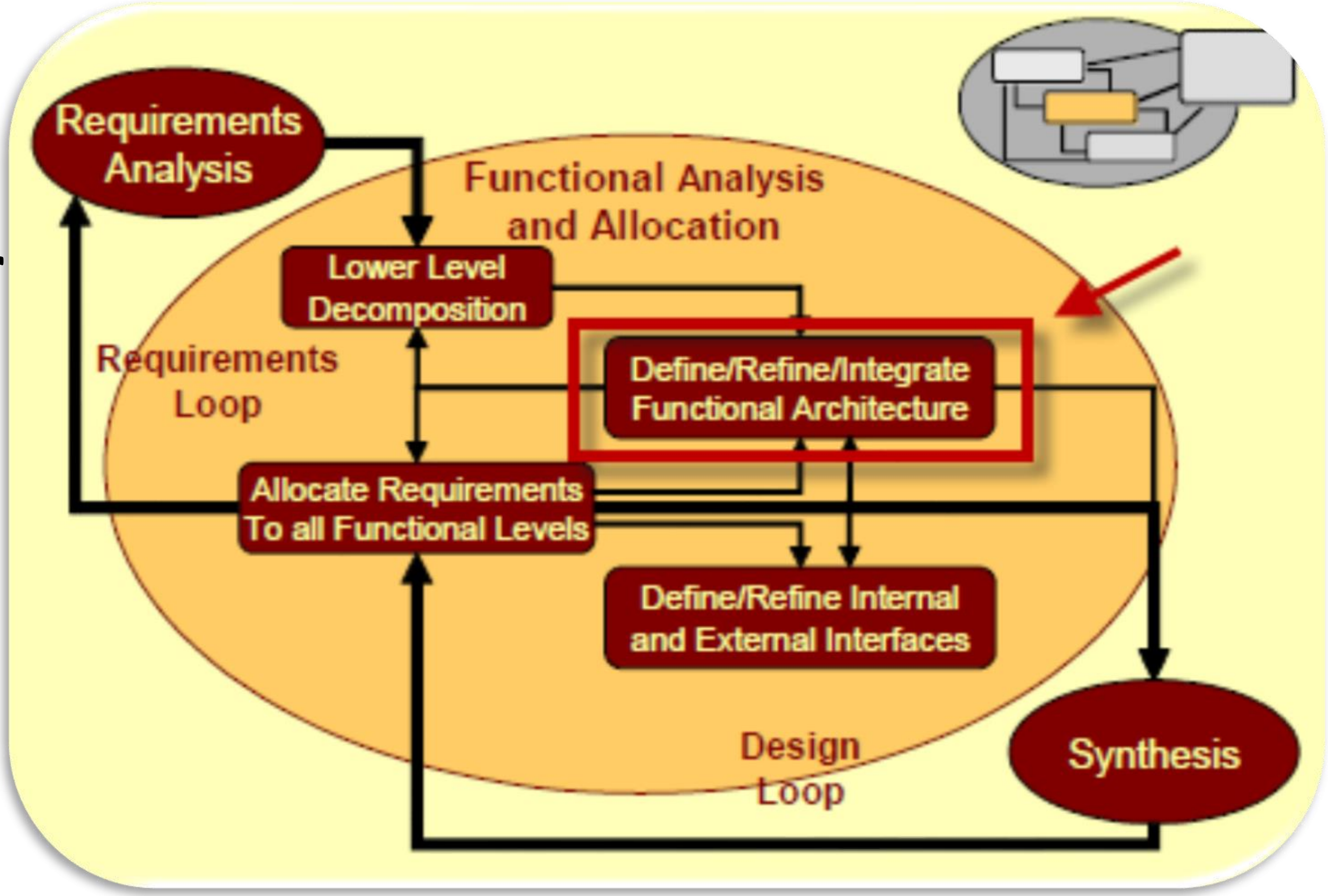
Functional Analysis/Allocation

- Functional analysis and allocation **allows for a better understanding** of:
  - what the system needs to do
  - In what ways can you do?
  - priorities and conflicts related to low-level functions.
- Key tools in functional analysis and allocation are
  - Functional Flow Block Diagrams
  - Time Line Analysis
  - Requirements Allocation Sheet.



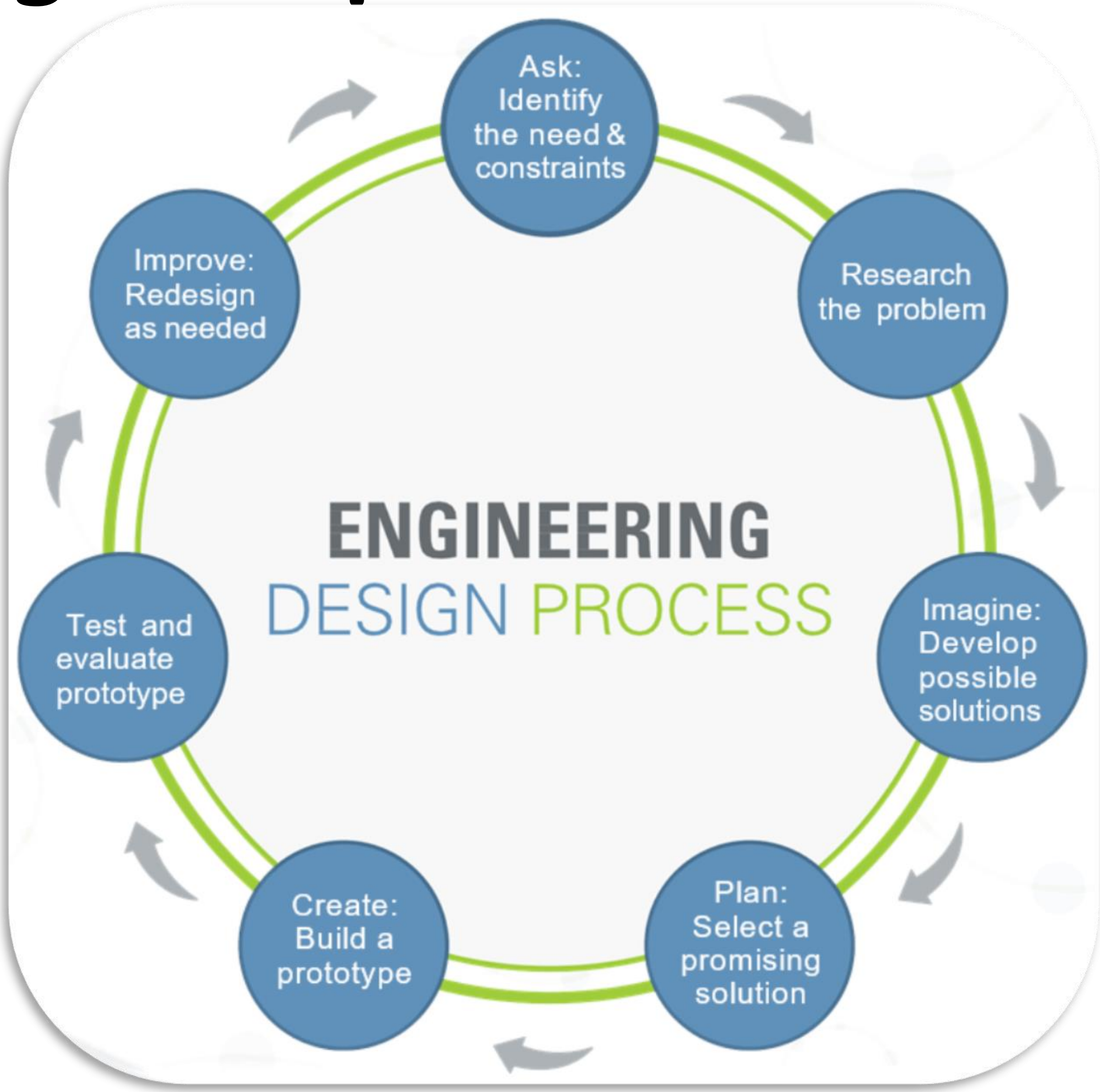
Requirements Loop

- Performance of the **functional analysis and allocation results in** a **better understanding of the requirements** and should provide **reconsideration of the requirements analysis**.
- **Each function** identified should be **traceable back to a requirement**.



Design Loop

- Revisiting the functional architecture to **verify that the physical design synthesized** can **perform** the **required functions at required levels of performance**.
- The design loop permits **reconsideration** of how the system will perform its mission, and this **helps optimize the synthesized design**.

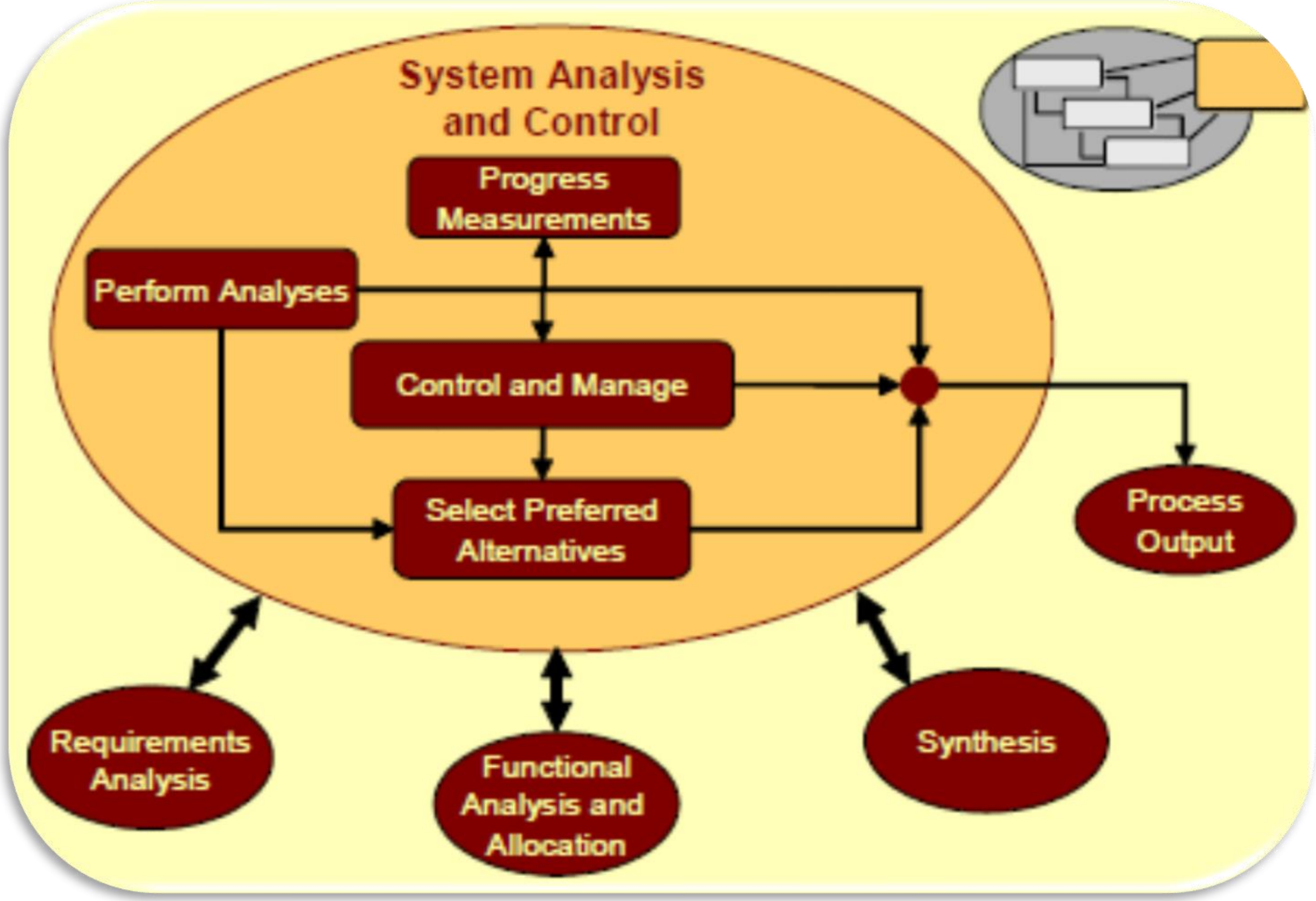


Verification

- For each application of the system engineering process, **the solution will be compared to the requirements**.
- This part of the process is called the verification loop, or more commonly, **Verification**.

Systems Analysis and Control

- Systems Analysis and Control include **technical management activities** required to
  - Measure progress
  - Evaluate alternatives
  - Select alternatives
  - Documentation
  - Decisions



System Engineering

- The system engineering process is the **engine** that ensures a **balanced developmen**t of system products and sub-processes **in each development step.**

- The **output** of each application is the **input** to the next process application.

AN EXAMPLE PROJECT

AIRBORNE UNDERGROUND IMAGING SYSTEM (HAYGÖR)

TECHNICAL SPECIFICATIONS

TS.1 - The system will remain in the air for at least 30 minutes.

TS.2 – The airborne system will automatically detect buried non-metallic objects larger than 30 cm in diameter.

TS.3 – The system will create audio -visual alerts when detection occurs.

TS.4 - The height of the system from the ground will be given to the user

TS.5 - ...

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Requirments

RQ.1 - The system will be equipped with a platform that can move in the air.

RQ.2 - The system will remain in the air for at least 30 minutes.

RQ.3 - There will be a sensor that detects non-metallic objects.

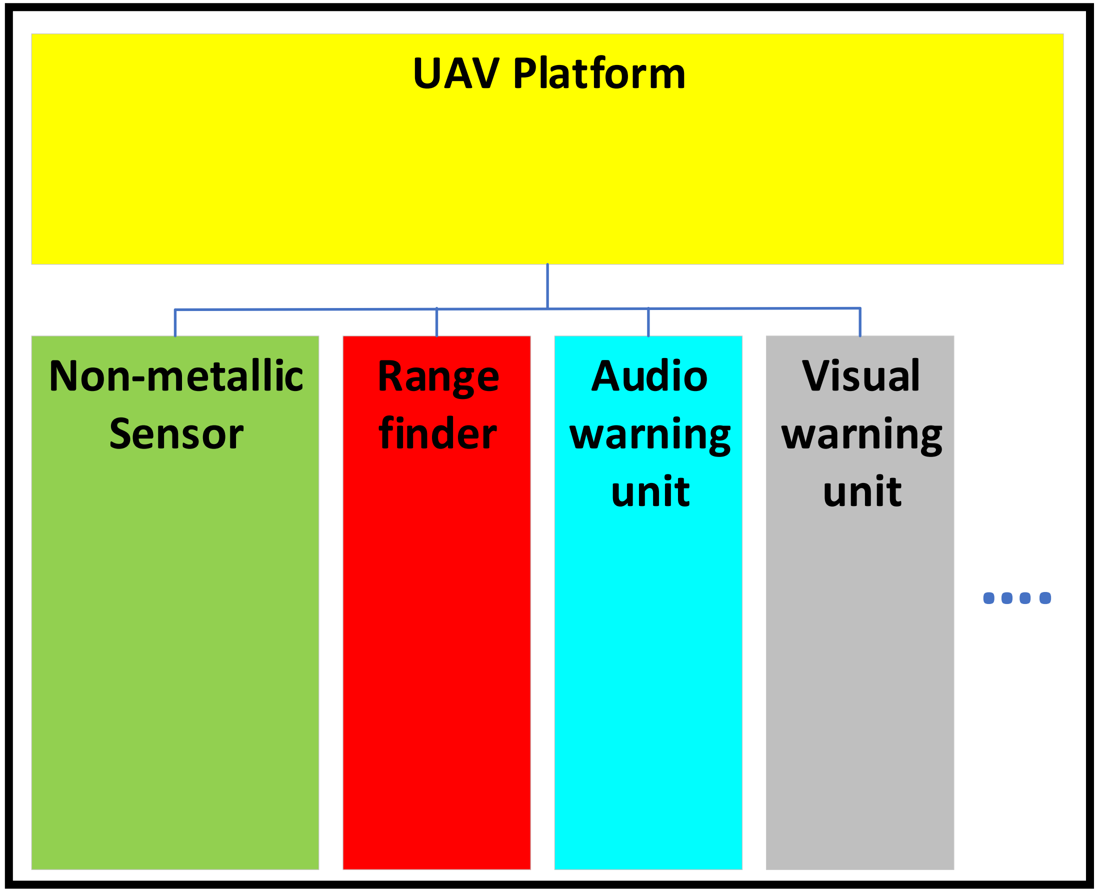
RQ.4 - System will have automatic detection function

RQ.5 - There will be visual warning function in the system

RQ.6 – There will be audio warning function in the system

RQ.7 - The height of the system from the ground will be given to the user

PRELEMINARY DESIGN



AIRBORNE UNDERGROUND IMAGING SYSTEM (HAYGÖR)

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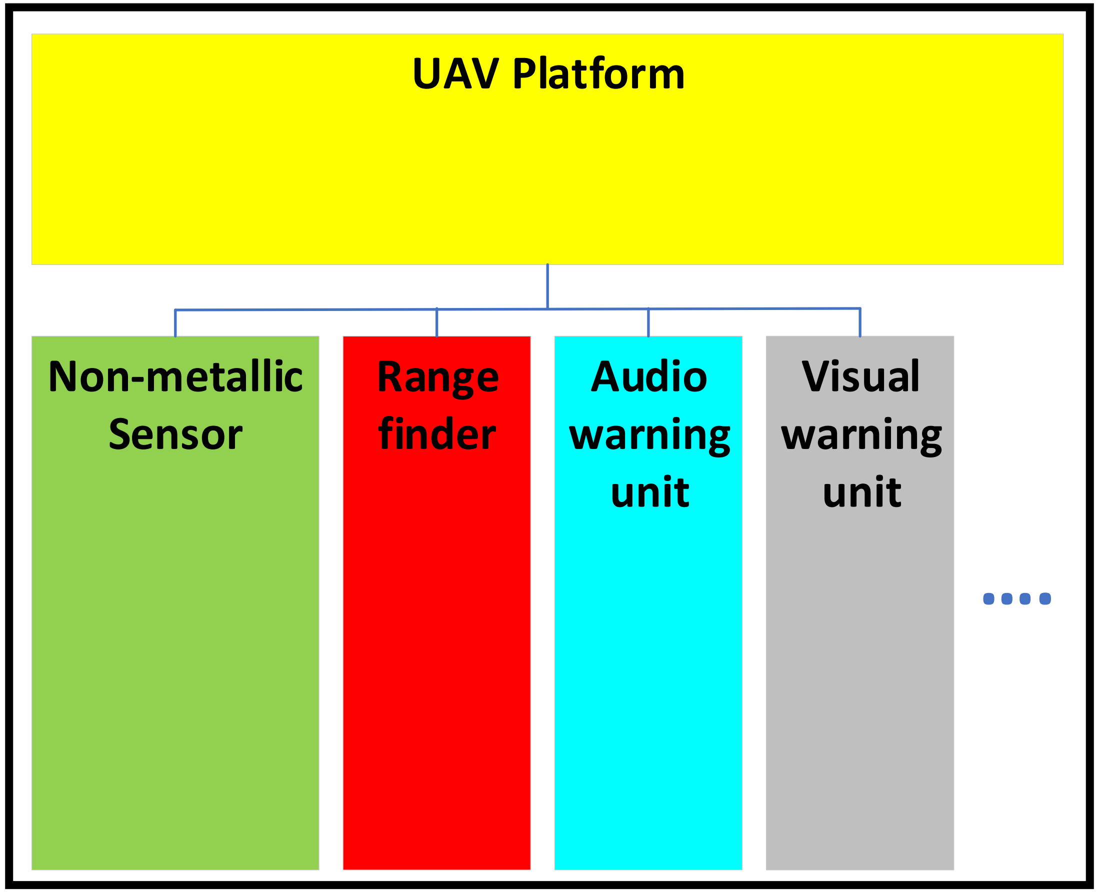

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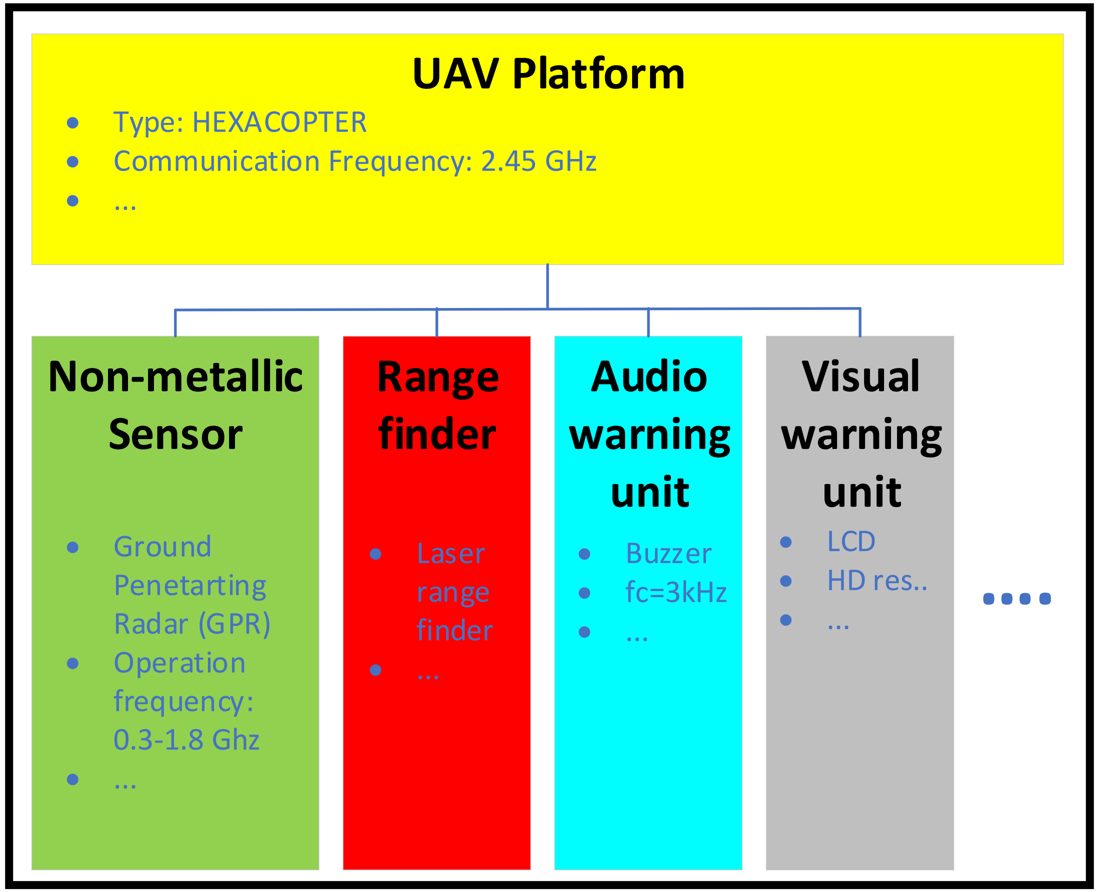

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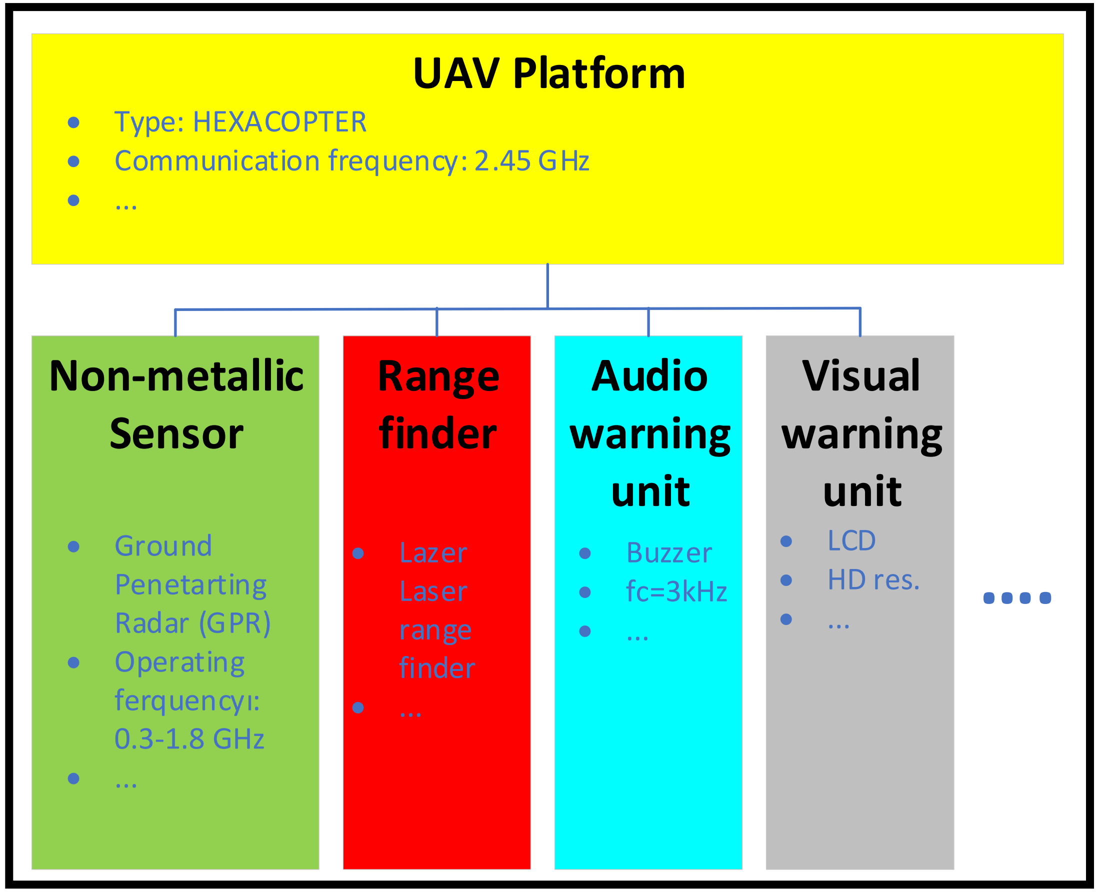


AIRBORNE UNDERGROUND IMAGING SYSTEM (HAYGÖR)

REALIZATION – TEST - DESIGN CYCLE

1. Realize / buy subsystems (UAV, GPR, laser distance meter, audio interaction unit, visual interaction unit,...)

2. Test the subsystems

3. Make any necessary changes / corrections to the resulting incompatibilities

4. Realize the system by integrating the subsystems (*HAYGÖR*)

5. Make any necessary changes / corrections to the resulting incompatibilities of the entire system

6. Continue this cycle (1-5) until the requirements satisfy the technical specifications of the system (*HAYGÖR*).

AIRBORNE UNDERGROUND IMAGING SYSTEM (HAYGÖR)

ACCEPTANCE

- Perform acceptance tests of the system with the customer (after completing the required changes) and deliver the product (*HAYGÖR*).
- Arrange training for the users about the use of the system (*HAYGÖR*)

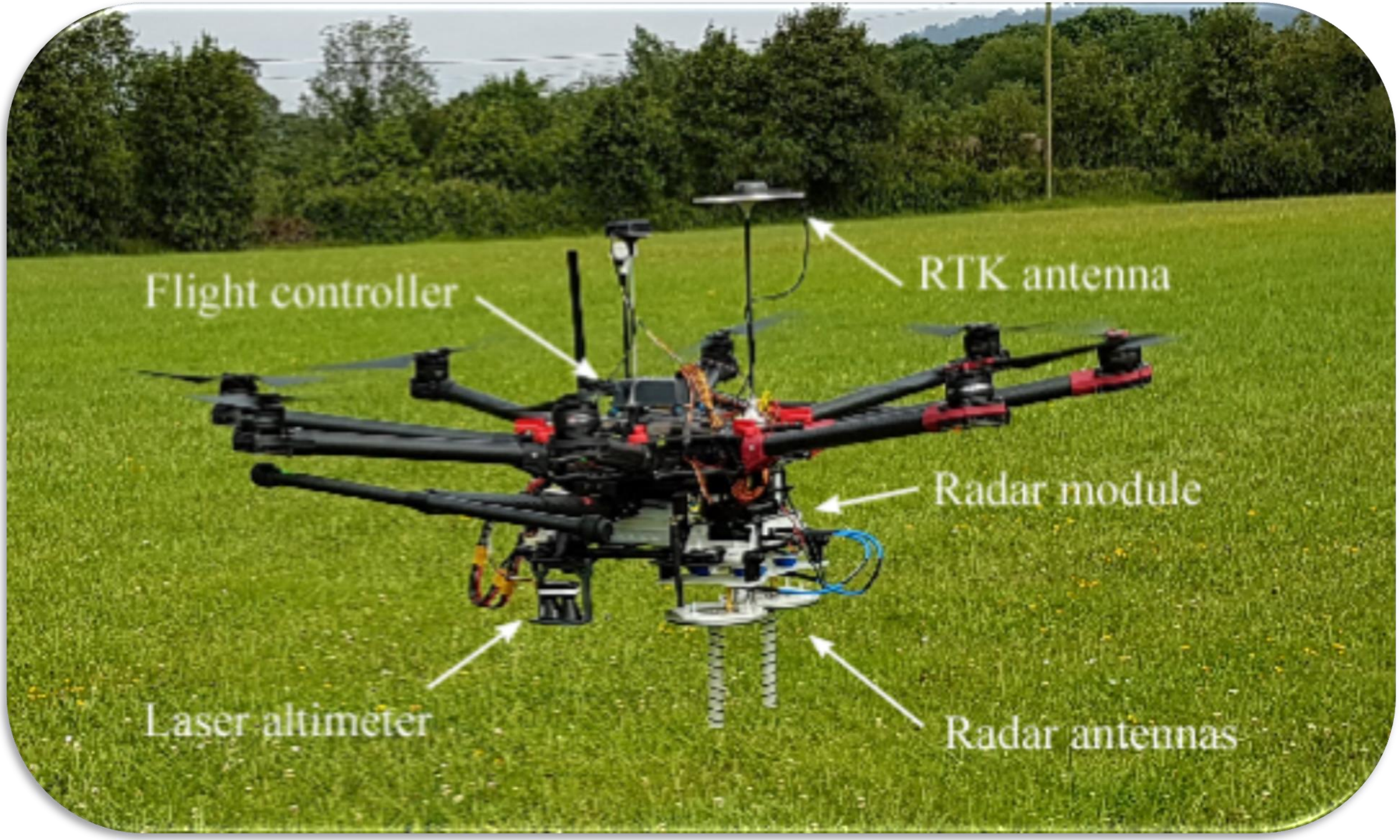
FIELD SUPPORT

Provide technical support to the user in the field for the system (*HAYGÖR*)

DISPOSAL MANAGEMENT

Follow the previously determined plan on how to make disposal management after product (*HAYGÖR*) life is complete.

- Perform the procedures specified in the relevant directive / standard for for Li-ion batteries
- Perform the procedures specified in the relevant directive / standard for parts manufactured from aluminum
- Perform the procedures specified in the relevant directive / standard for parts made of carbon fiber.
- ...


Flight controller
RTK antenna
Radar module
Laser altimeter
Radar antennas

"If you really look closely, most overnight successes took a long time"

-- Steve Jobs

CONCLUSION (1/2)

To realize Cutting-edge (advanced technology) projects

- **Systematic approach**
- **Skillful and experienced teams**
- **Knowledge**
- **Budgets**

CONCLUSION (2/2)

- **Time to go beyond yourself**
  - **Study**
  - **Learn**
  - **Be determined**
  - **Achieve**
  - **Repeat cycle…**

Thank you for your attention…

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