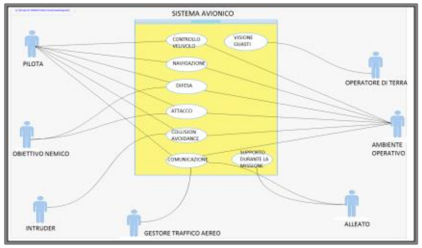

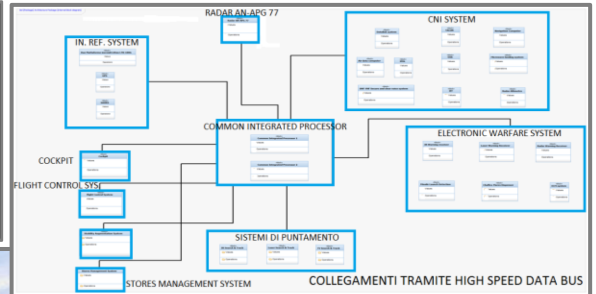

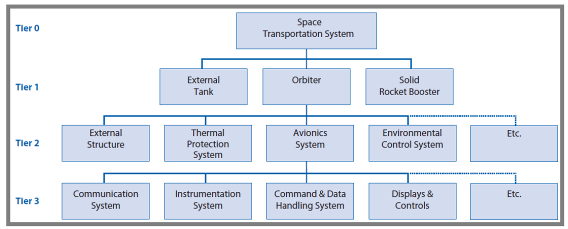

SYSTEMS ENGINEERING IN ITALIA "WHY, WHAT AND WHO"

Politecnico di Torino, giovedì, 3 ottobre , 2013

INTRODUZIONE E FONDAMENTI DEL SYSTEMS ENGINEERING

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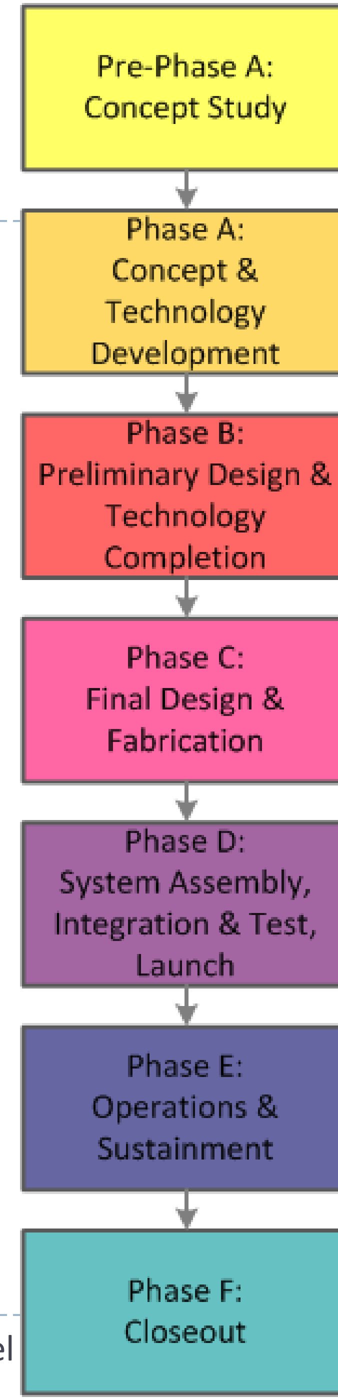
SYSTEMS ENGINEERING

- **Systems engineering** is the art and science of developing an **operable system** capable of **meeting requirements within imposed constraints**.
- **Systems engineering** is a **methodical, disciplined approach** for the **design, realization, technical management, operations,** and **retirement of a system,** i.e. during all **product's life cycle**.
- A "**system**" is a construct or collection of **different elements that together produce results not obtainable by the elements alone**. The **elements**, or parts, can **include people, hardware, software, facilities, policies, and documents**; that is, all things required to produce system-level results.
- The **value added by the system as a whole**, beyond that contributed independently by the parts, is primarily created by the **relationships among the parts**; that is, how they are interconnected. **It is a way of looking at the "big picture" when making technical decisions**.

SYSTEM >> Σ PARTS

SYSTEM = Σ PARTS + RELATIONSHIPS



WHAT IS A SYSTEM?

A SYSTEM may be considered to be
a nucleus of elements structured
in such a manner as to accomplish a function
to satisfy an identified need.

Equipment/components/devices (hardware)

Facilities/infrastructures

Data/software

Services/functions

Personnel

mission

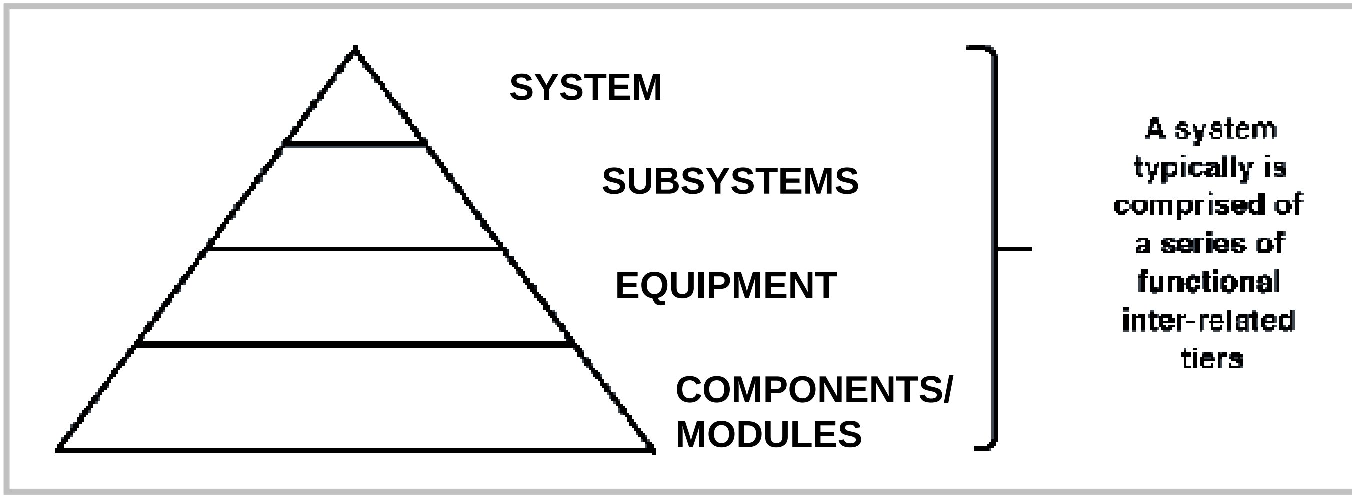
by the customer

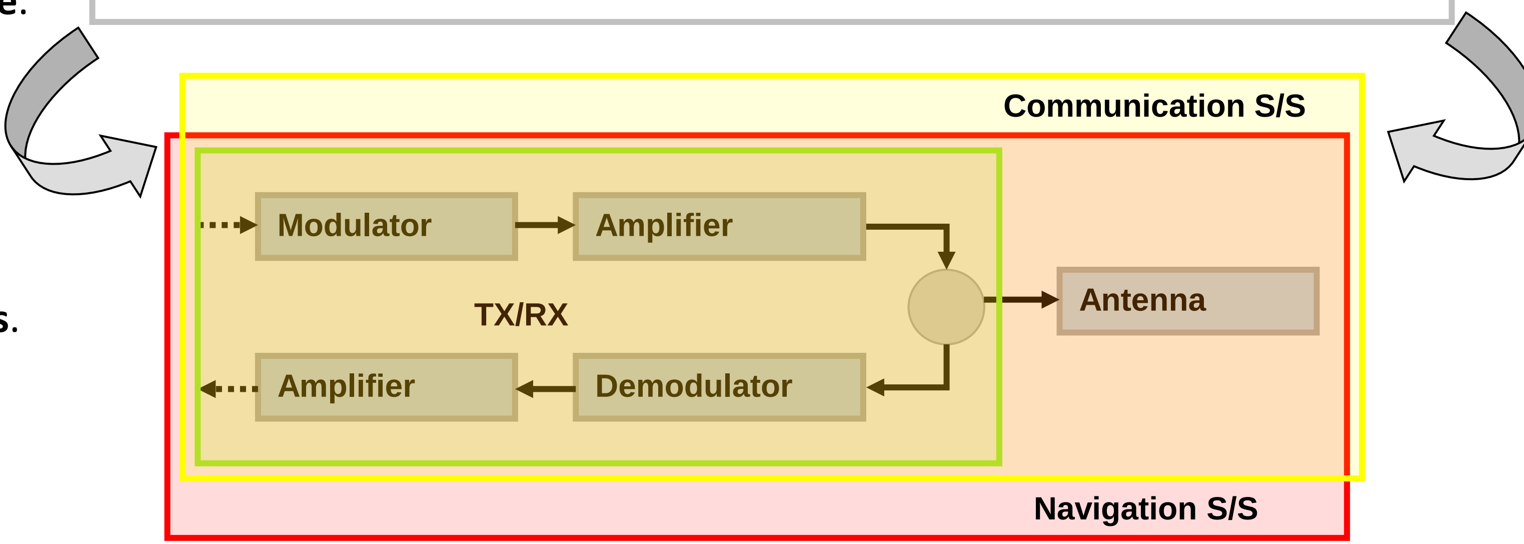
Required for its preparation, operation and support

A self-sufficient entity in its intended operational environment throughout its planned life cycle

WHAT IS A SYSTEM?

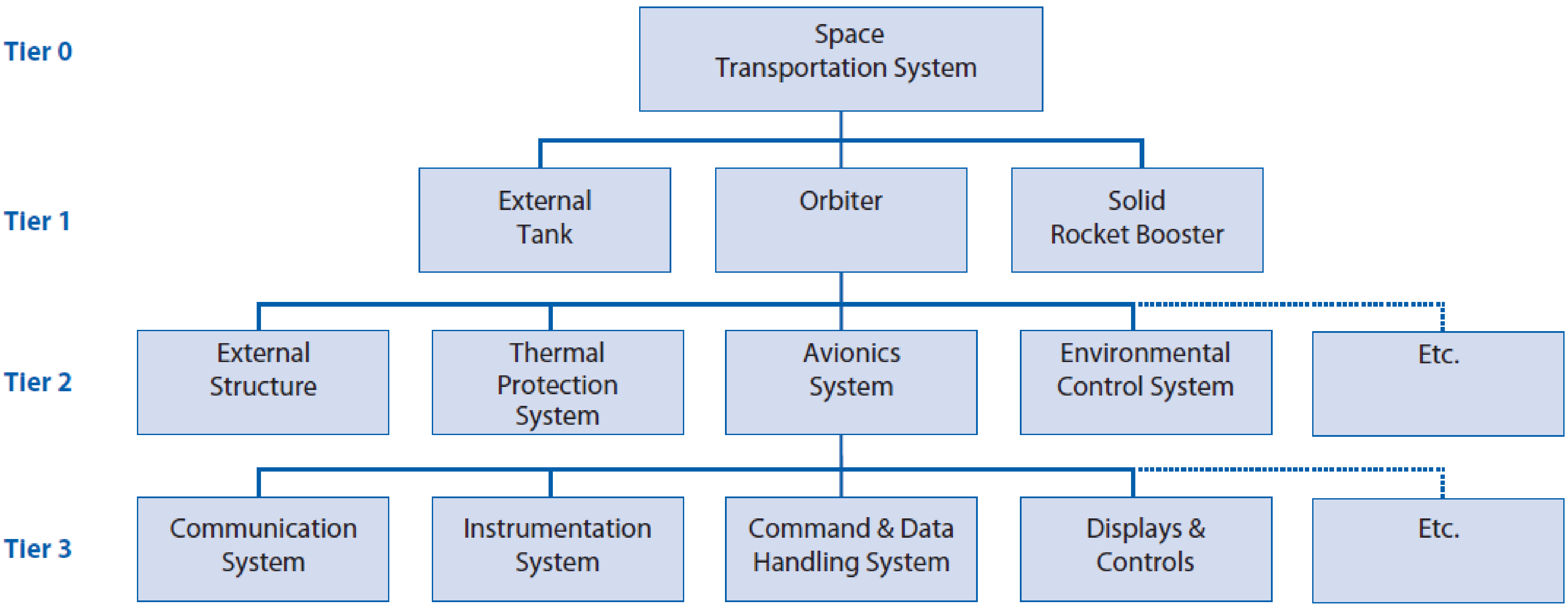
- A **system** consists of **different items** which are **all related** and which **co-operate aiming at the global system performance**.
- A **system** comprises **subsystems, equipment** and **components**.





WHAT IS A SYSTEM?

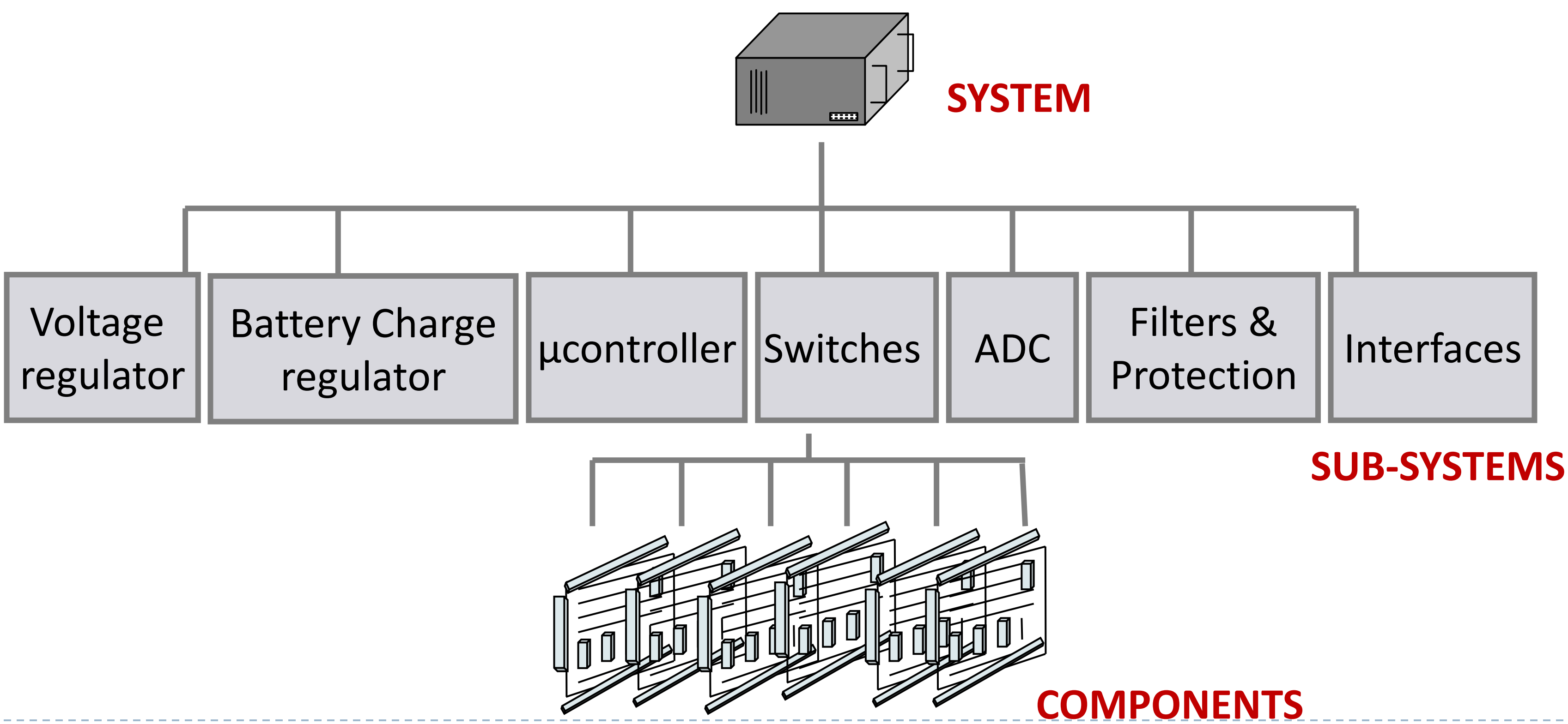
- The overall effect may be likened to a **pyramid** where the **total system depends upon all the lower tiers**.
- The figure below depicts the **product breakdown structure** of a space transportation system, whose **success depends upon the integration of all items of its lower tiers**. **Breakdown** and **integration** are fundamental processes of Systems Engineering.



WHAT IS A SYSTEM?

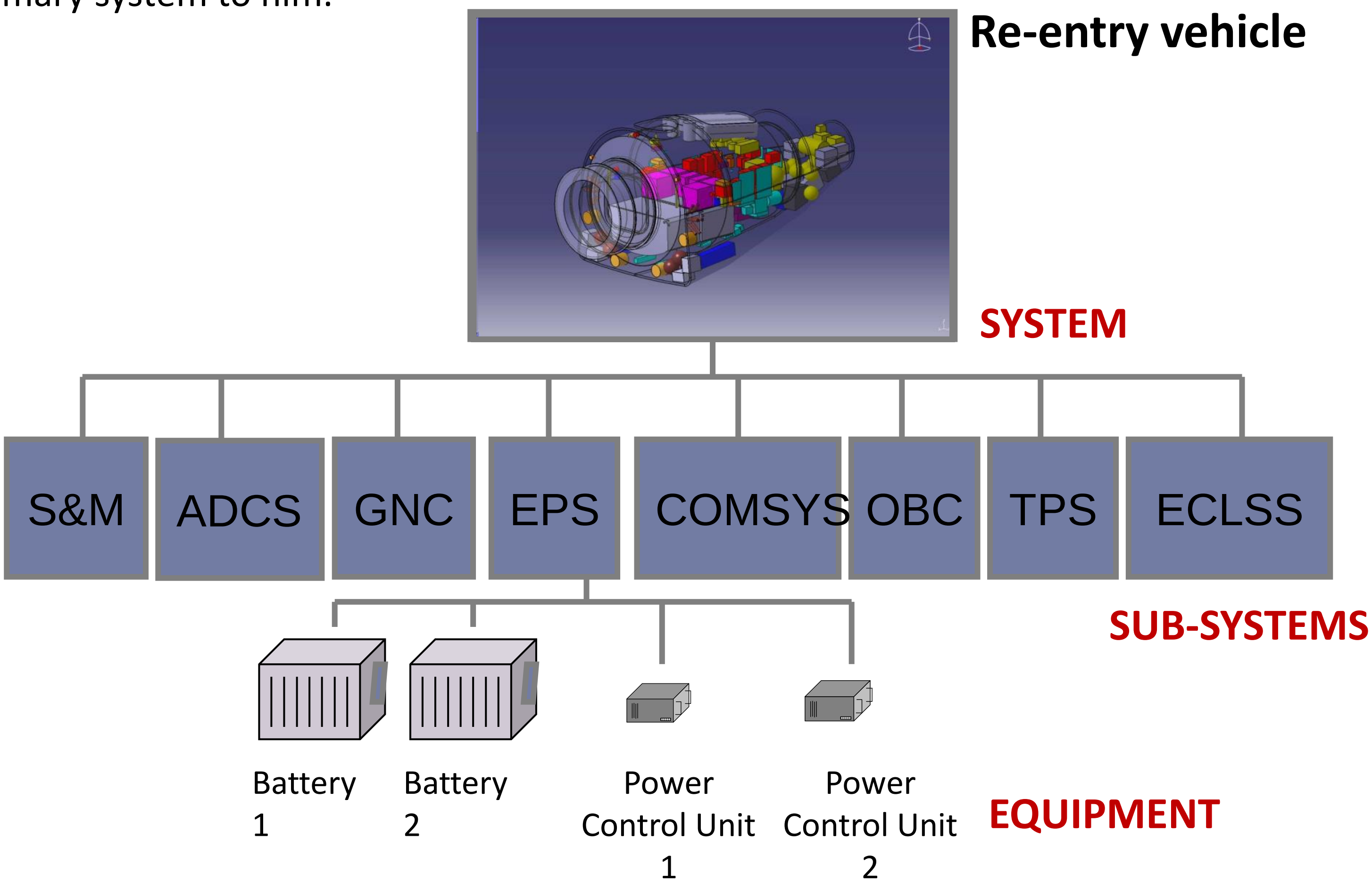
- According to circumstances, the **concept of system might vary**.
  - As far as the builder of the power control unit is concerned, the power control unit is the system which includes the voltage regulator, the battery charge regulator, etc….as subsystems.

Power Control Unit



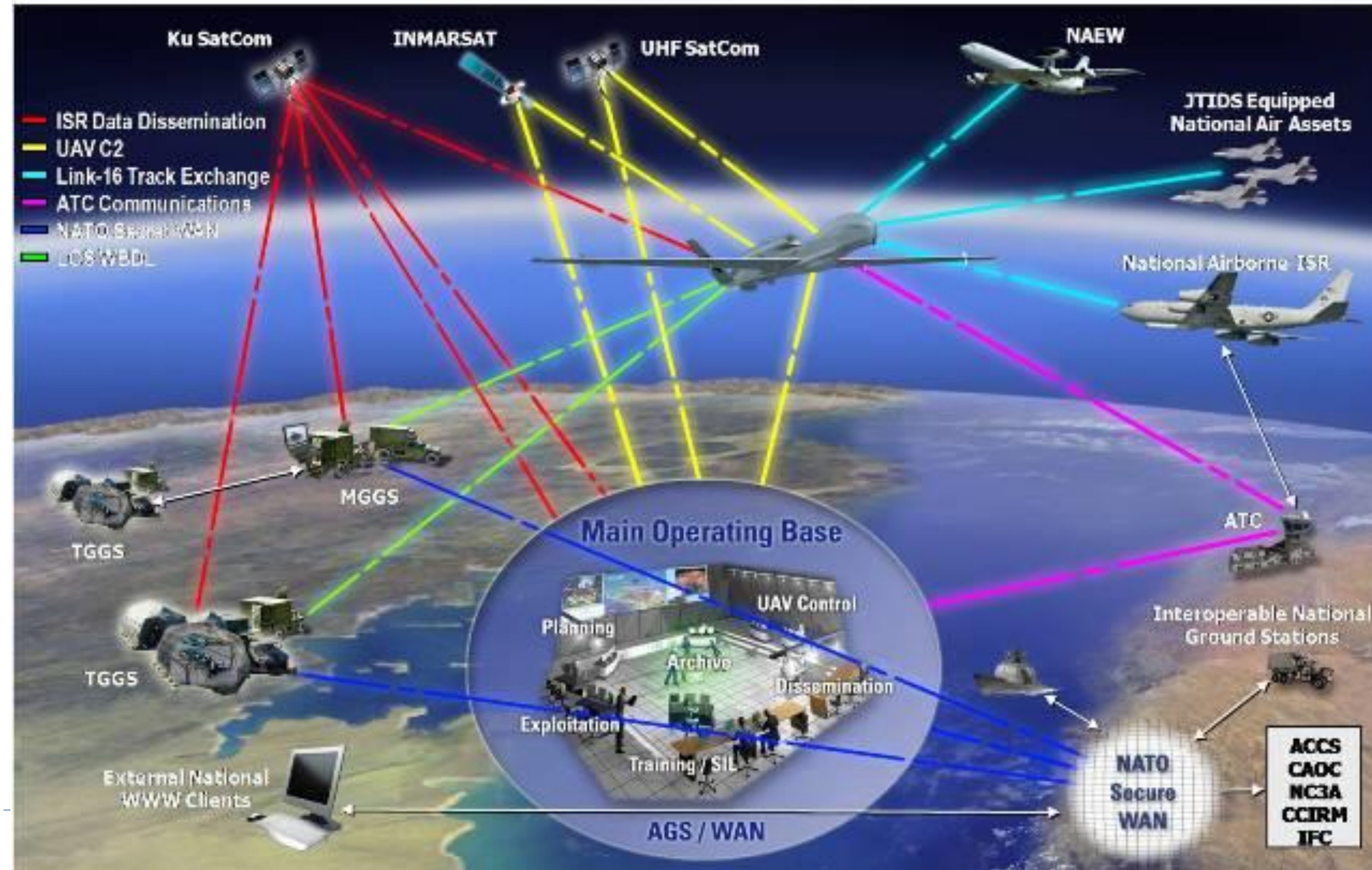
WHAT IS A SYSTEM?

- As far as the launch vehicle builder is concerned, the mentioned power control unit is only an equipment of the electrical power subsystem of the launcher, which represents the primary system to him.



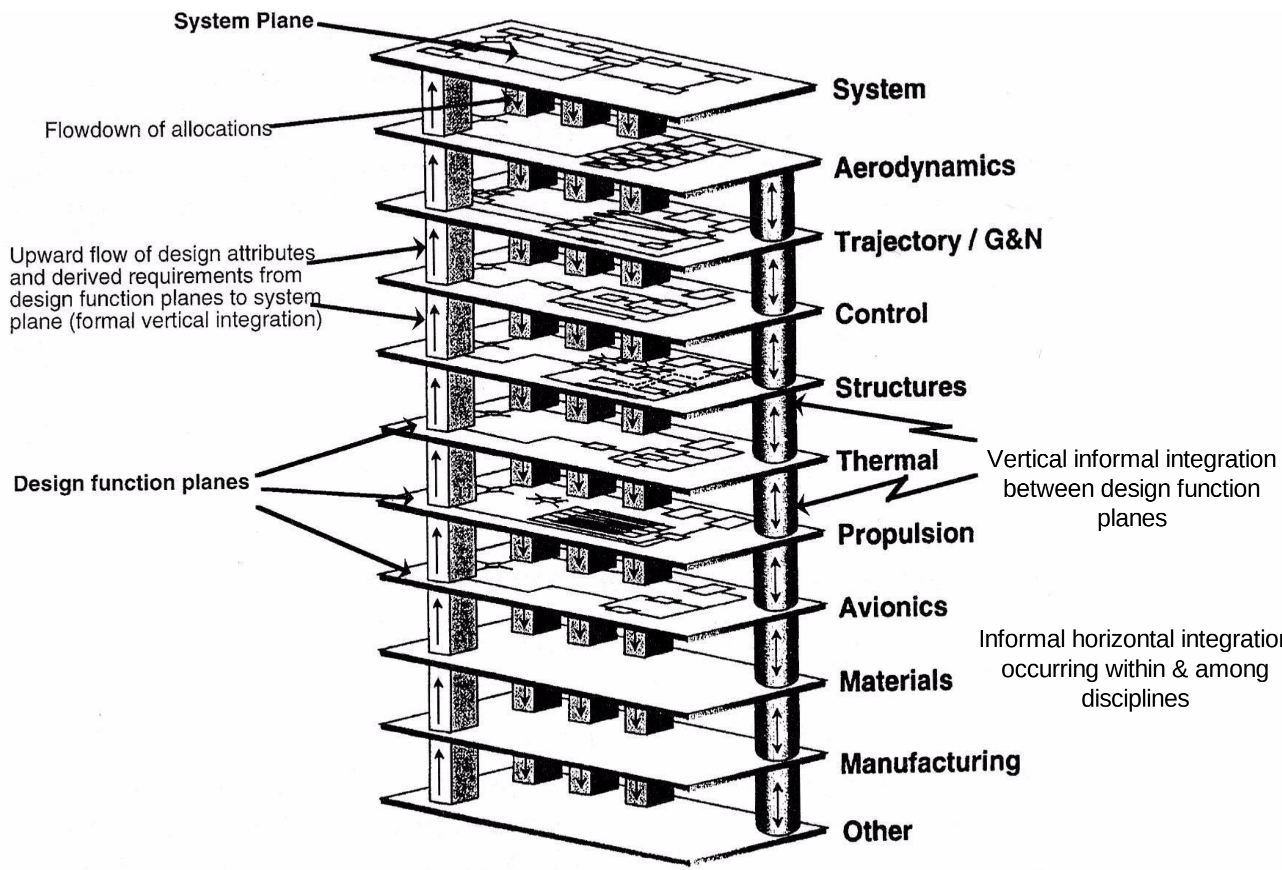
WHAT IS A SYSTEM?

- As far as the national space agency is concerned, the launcher is a system of the wider, global system, the so-called **system of systems**, which consists of payload, launch facilities, personnel training, customer services, maintenance services, etc.



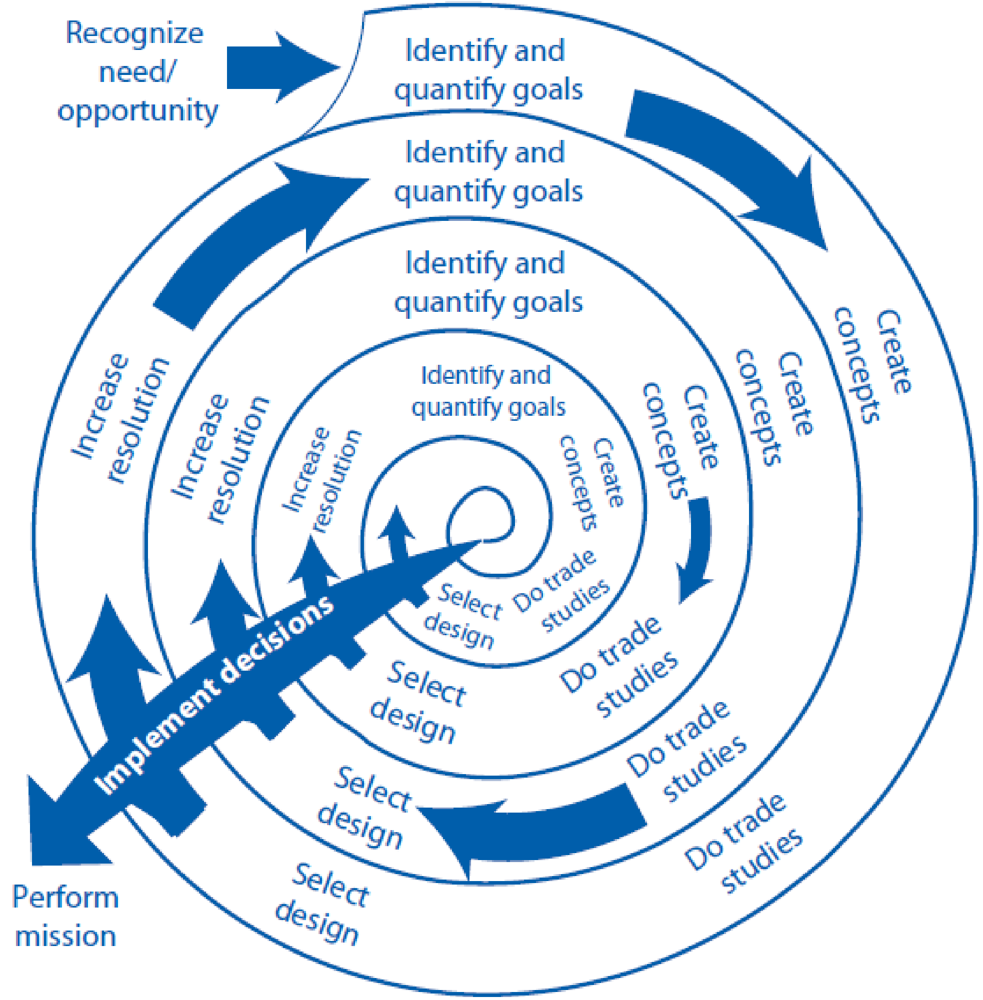
SYSTEMS ENGINEERING: MAIN FEATURES

- **Systems engineering** is a **holistic, integrative discipline**, wherein the contributions of structural engineers, electrical engineers, mechanism designers, power engineers, human factors engineers, and many more **specialist disciplines are evaluated and balanced, one against another, to produce a coherent whole** that is **not dominated by the perspective of a single discipline**.
- Systems engineering seeks a **safe and balanced design in the face of opposing interests and multiple, sometimes conflicting constraints**.
- The system engineer focuses efforts on **assessments to optimize the overall design, and not favor one system/subsystem at the expense of another**.
- **Optimization of single elements does not imply optimization of the whole system, when all single elements are integrated**.



SYSTEMS ENGINEERING: MAIN FEATURES

- **Systems engineering** is a **doctrine of successive refinements.** Each create concepts step involves a **recursive** and **iterative design loop**.
  - **Iterative** is the “application of a process to the same product or set of products to correct a discovered discrepancy or other variation from requirements”.
  - **Recursive** is defined as adding value to the system “by the repeated application of processes to design next lower layer system products or to realize next upper layer end products within the system structure. This also applies to repeating application of the same processes to the system structure in the next life-cycle phase to mature the system definition and satisfy phase success criteria.”



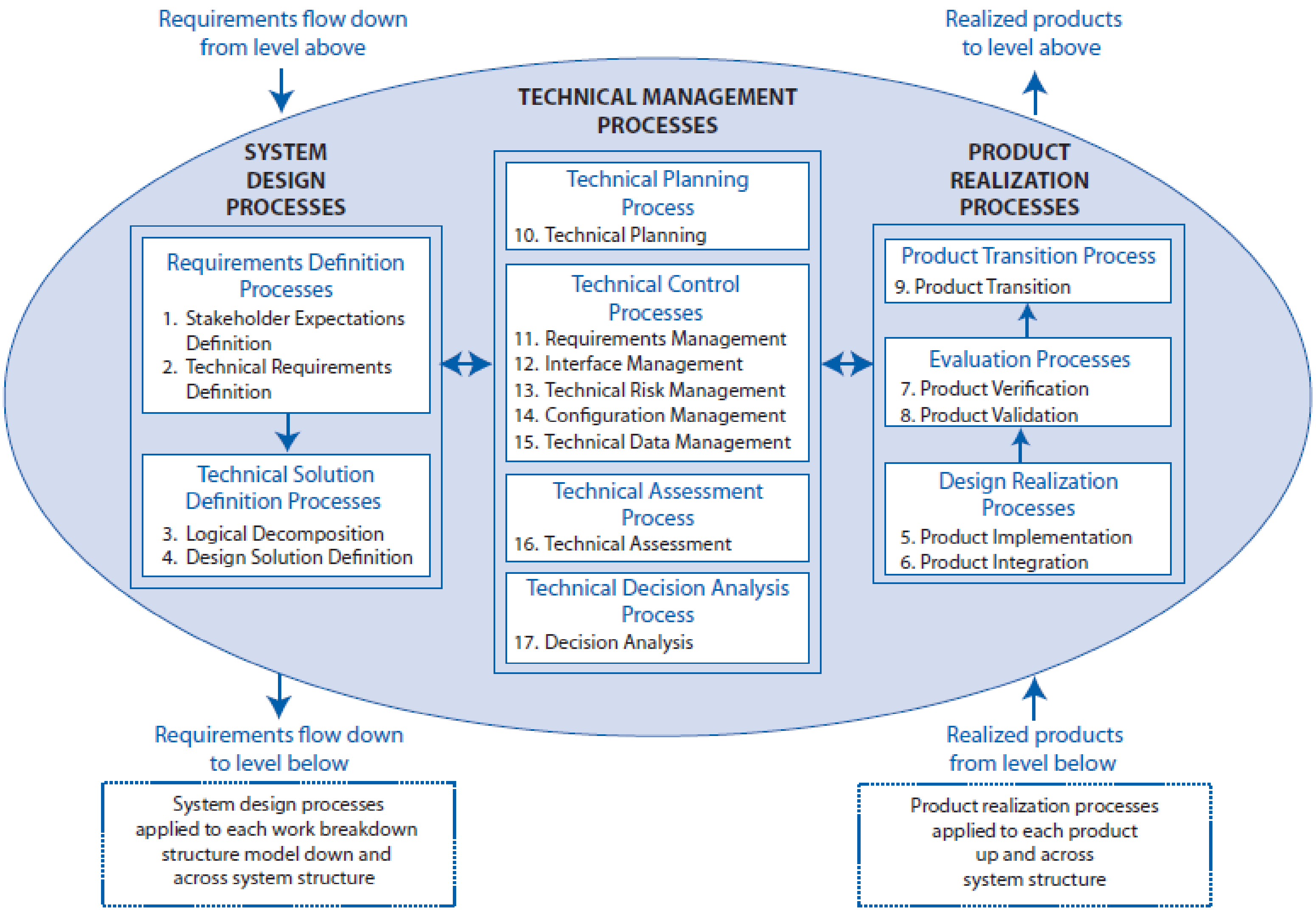
SYSTEMS ENGINEERING: MAIN FEATURES

- The application of scientific and engineering efforts within Systems Engineering is devoted to:
  - **Transform an operational need into a description of system performance parameters and a preferred system configuration** through the use of an **iterative and recursive process** of various analyses, activities, syntheses and tests.
  - **Integrate related technical parameters** and **assure compatibility of all physical, functional, and program interfaces** in a manner that **optimizes the total system definition and design**.
  - **Integrate reliability, maintainability, logistic support, safety, producibility, security, survivability, structural integrity, human factors**, and other related specialities into the total engineering effort.

The **system engineering process** has as its **goal** the **achievement of the proper balance between operational, economic and logistics factors, to reach a cost-effective solution**.

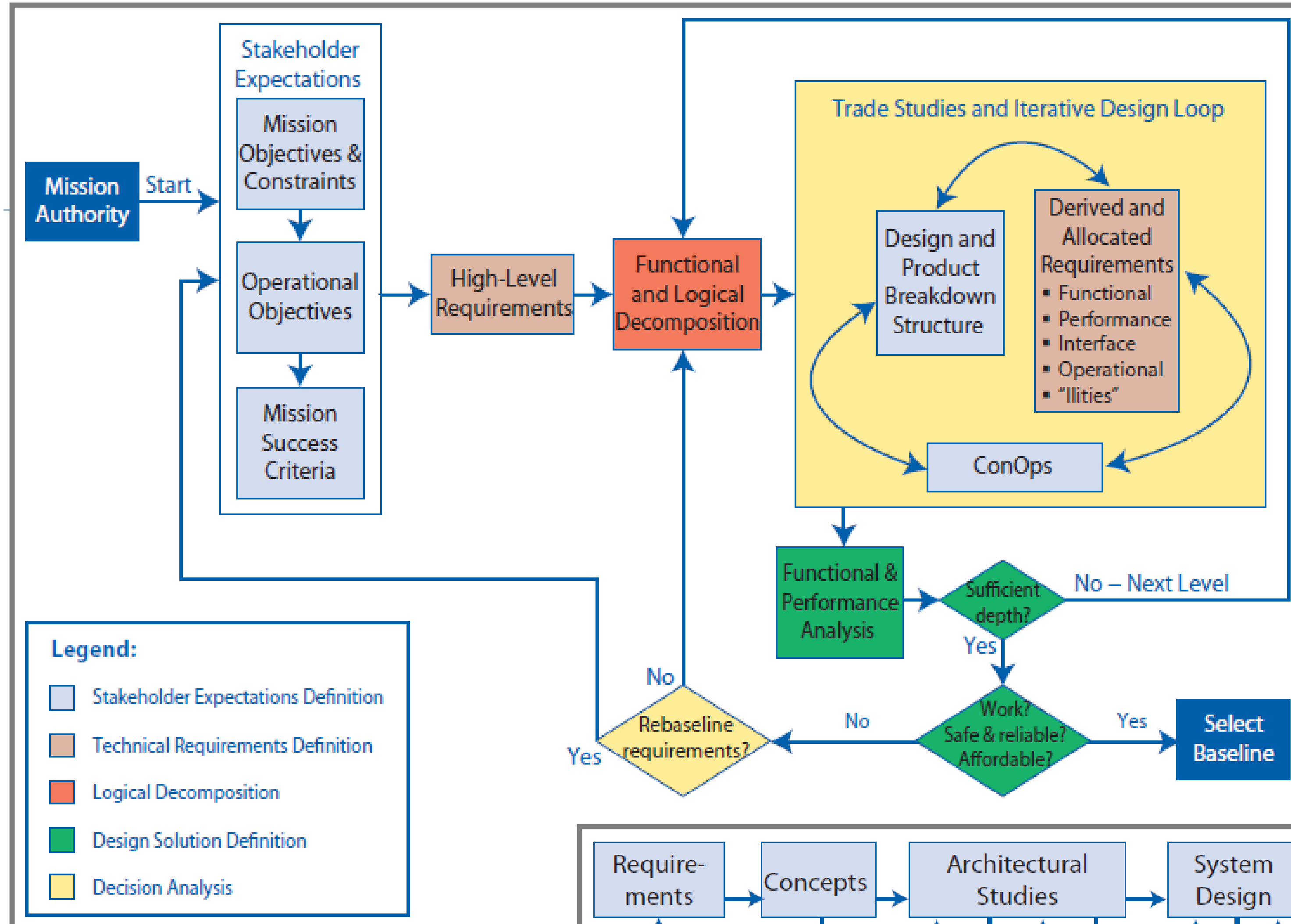
LOOK AT THE SYSTEM AS A WHOLE

SYSTEMS ENGINEERING: PROCESSES

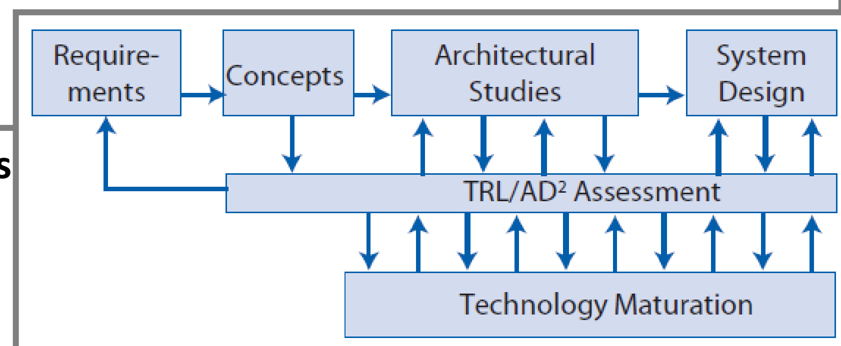


SYSTEM DESIGN PROCESS

- The figure beside shows the interrelationships among the system design processes.
- **Once the concept has been formulated, the identification of critical technologies has to be made.**

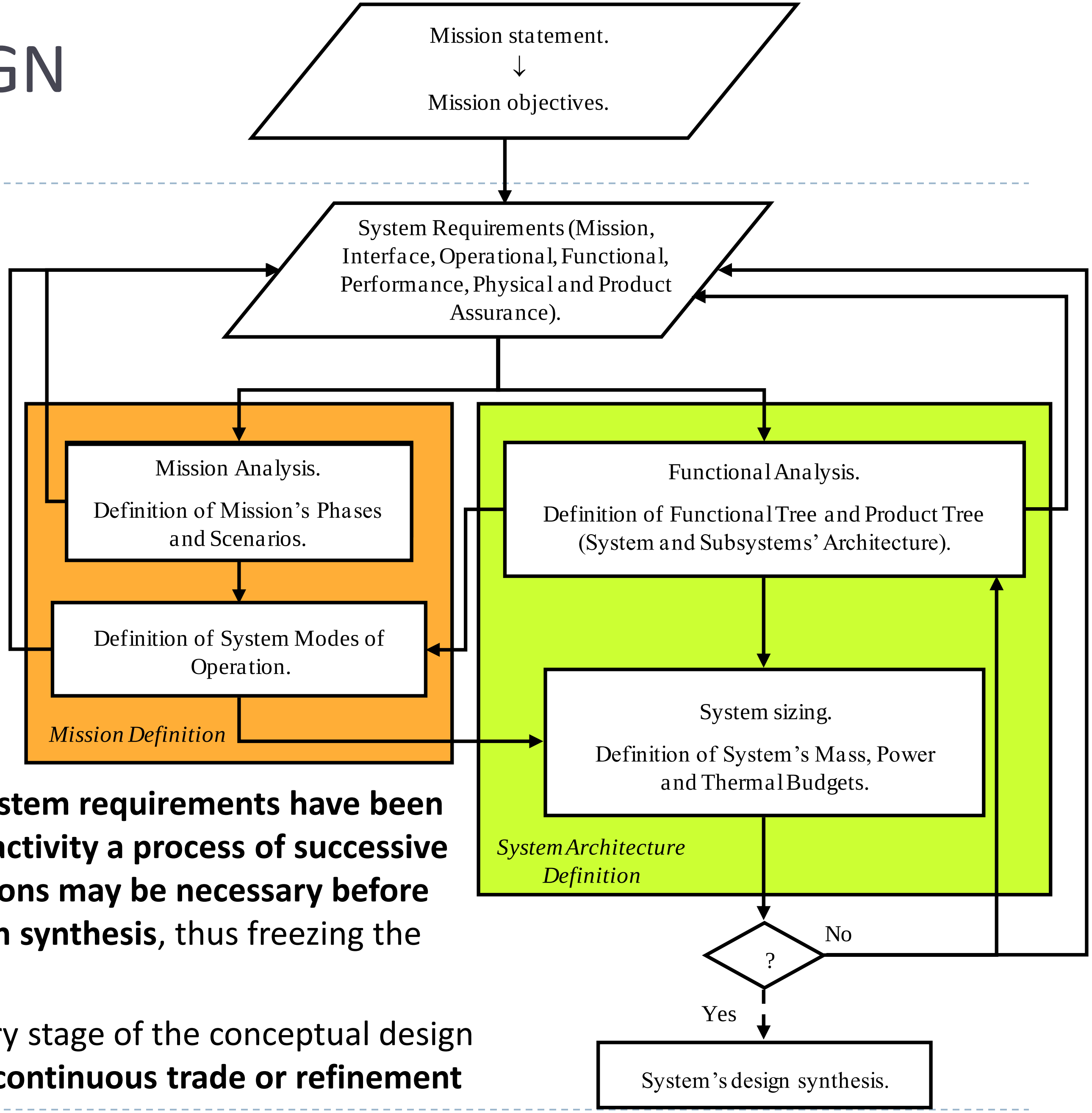


- A **continuous relationship between architectural studies and maturing technology advances** is imperative. The architectural studies must incorporate the results of the technology maturation, planning for alternative paths and identifying new areas required for development.



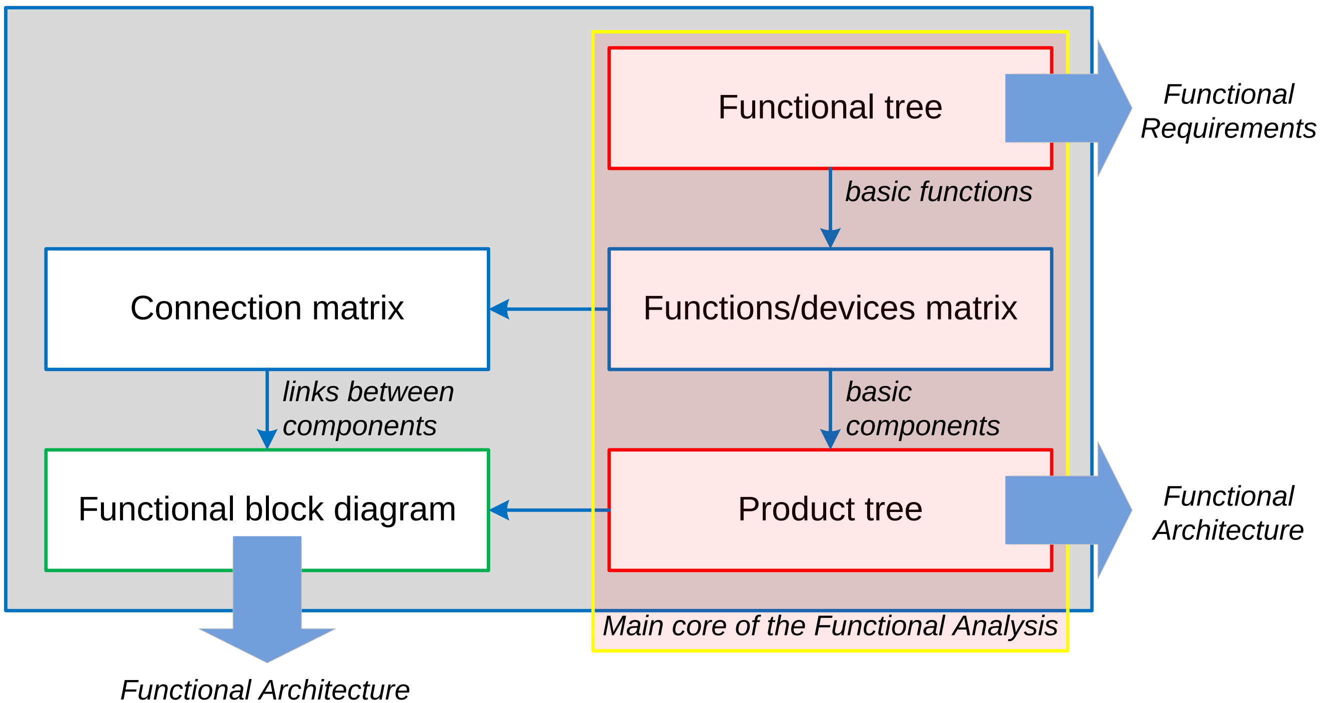
SYSTEM DESIGN PROCESS

- The figure beside shows the flow-chart of the **conceptual design process**.
- On the basis of the **system requirements**, the conceptual design process evolves through the **system architecture and** the **mission definition.**
- Once both the mission and the system architecture have been preliminary defined, it is important to **verify whether or not all system requirements have been satisfied**. Being the **design activity a process of successive refinements**, **several iterations may be necessary before achieving the system design synthesis**, thus freezing the system design.
- Iterations may occur at every stage of the conceptual design process, thus resulting in a **continuous trade or refinement of system requirements**.

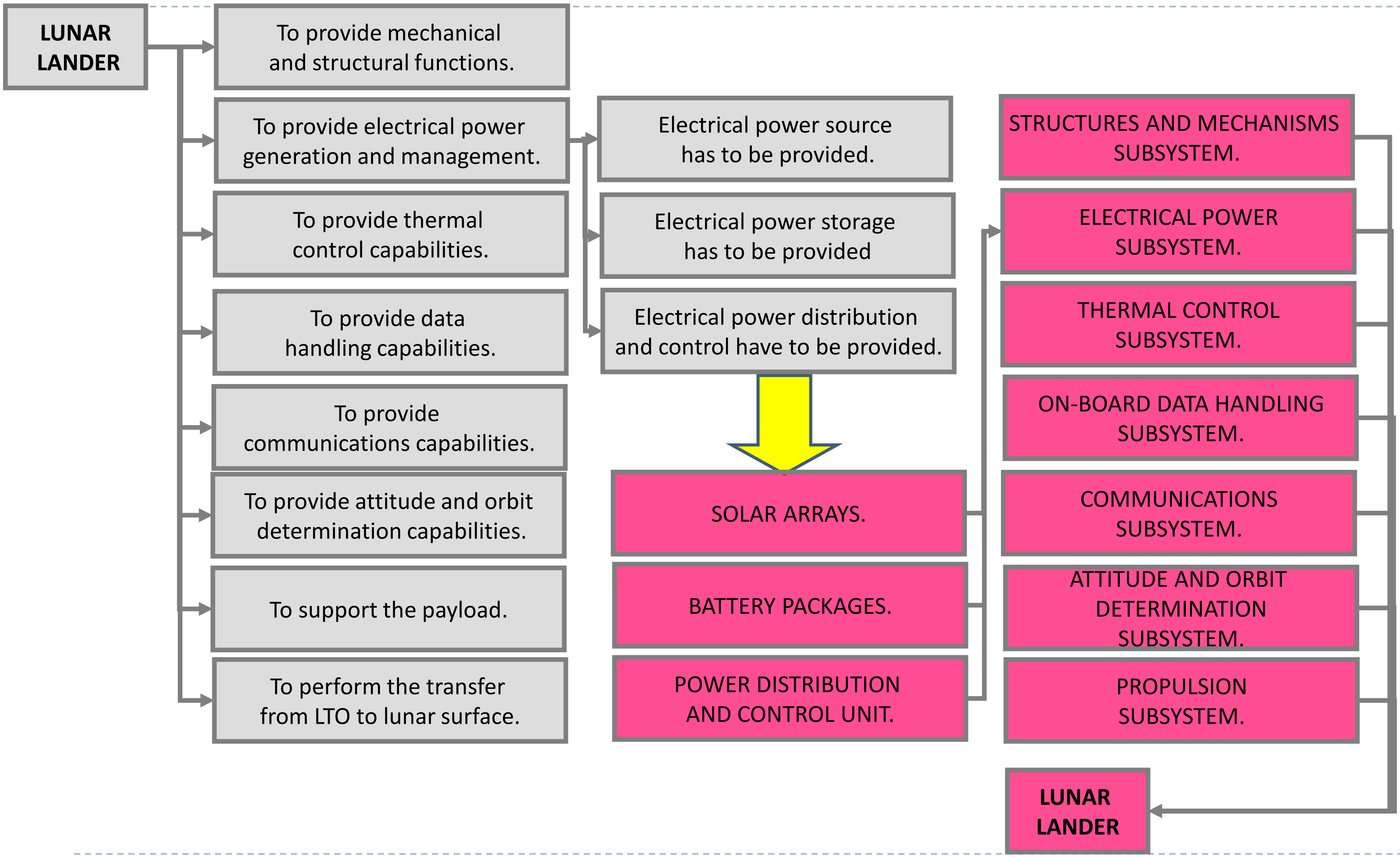


SYSTEM DESIGN PROCESS: THE FUNCTIONAL ANALYSIS

- Starting from the mission objectives/top level system requirements or directly from the mission statement, the **Functional Analysis allows identifying the physical components, the so-called building blocks**, which constitute the future product, **and how they are interrelated to build up the functional architecture of the future product**. **Physical components are identified by mapping functions to physical components**.
- Moreover through Functional Analysis the **functional requirements can be defined or anyway refined**.



THE FUNCTIONAL ANALYSIS: EXAMPLE OF APPLICATION



CONCLUSIONS

- **Systems Engineering** is a **fundamental approach to the design of complex systems**.
- **Innovative and flexible tools** are very important **to support the design activity**.
- We pursue the Systems Engineering approach by educating **undergraduate and graduate students**, by working at **national and international research programs** in collaboration with industrial partners and by participating to various **cultural activities**.