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TRACCIA 6

1) *ILLUSTRARE LE PROPRIE ATTIVITÀ/ESPERIENZE PROFESSIONALI.*

2) *DESCRIVERE LA VITA OPERATIVA DI UN SATELLITE POST LANCIO E LE MODALITÀ PER LA RICEZIONE ED ELABORAZIONE DEI DATI DEGLI STRUMENTI SCIENTIFICI A BORDO.*

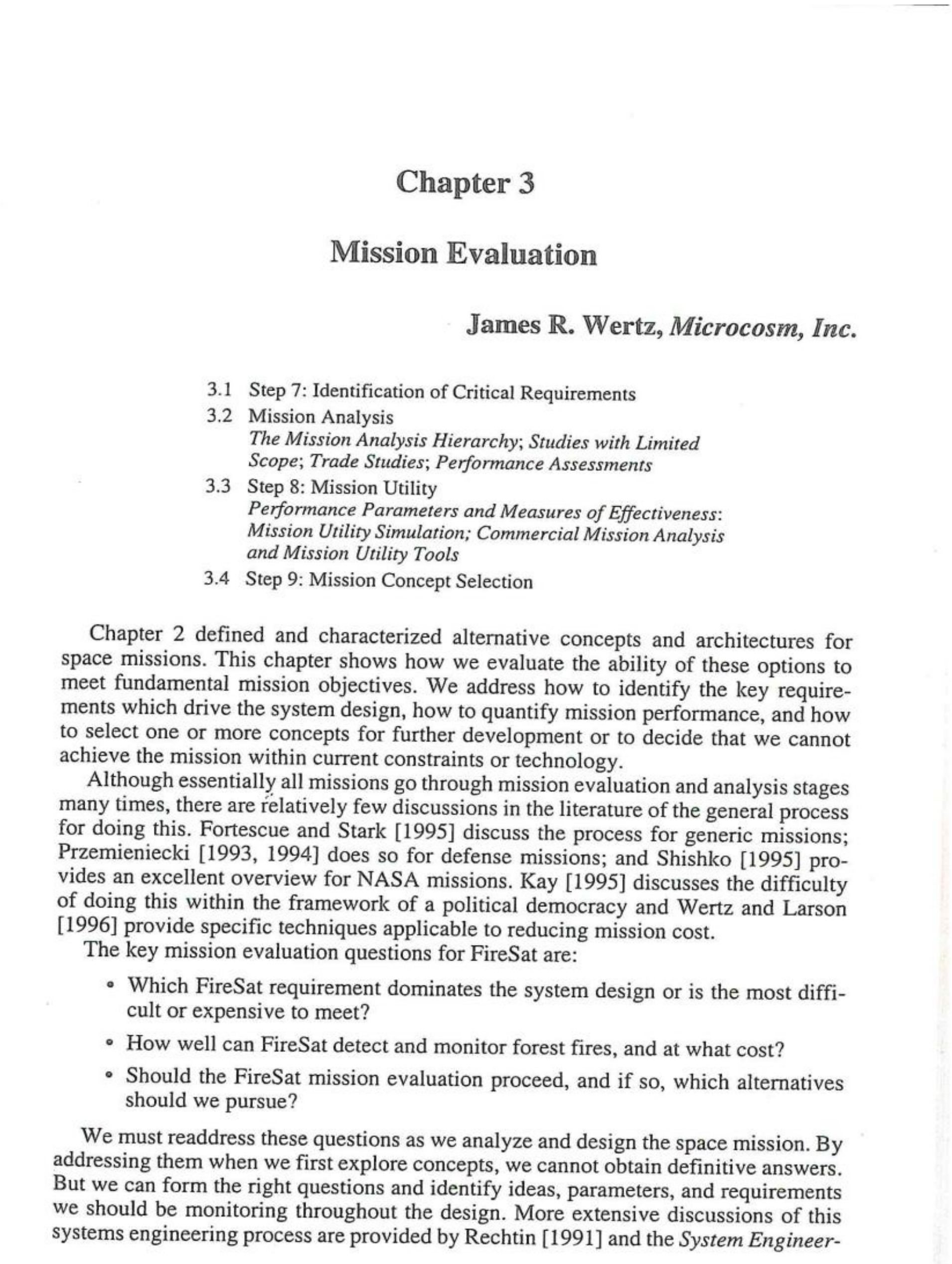
3) *IN UN ENTE DI RICERCA IL CANDIDATO INDIVIDUI IL SOGGETTO O I SOGGETTI CHE SVOLGONO ATTIVITÀ DI CONTROLLO E NE DESCRIVA I COMPITI.*

Esercitazione:

4) *IL CANDIDATO REALIZZI IN WORD UN DOCUMENTO CHE SPIEGHI UN'EQUAZIONE DI SUA SCELTA.*

Prova di Inglese:

5) LEGGERE E TRADURRE IL TESTO IN INGLESE SOTTOPOSTO DALLA COMMISSIONE.



Chapter 3

Mission Evaluation

James R. Wertz, ***Microcosm, Inc.***

Chapter 2 defined and characterized alternative concepts and architectures for space missions. This chapter shows how we evaluate the ability of these options to meet fundamental mission objectives. We address how to identify the key requirements which drive the system design, how to quantify mission performance, and how to select one or more concepts for further development or to decide that we cannot achieve the mission within current constraints or technology.

Although essentially all missions go through mission evaluation and analysis stages many times, there are relatively few discussions in the literature of the general process for doing this. Fortescue and Stark [1995] discuss the process for generic missions; Przemieniecki [1993, 1994] does so for defense missions; and Shishko [1995] provides an excellent overview for NASA missions. Kay [1995] discusses the difficulty of doing this within the framework of a political democracy and Wertz and Larson [1996] provide specific techniques applicable to reducing mission cost.

The key mission evaluation questions for FireSat are:

- Which FireSat requirement dominates the system design or is the most difficult or expensive to meet?
- How well can FireSat detect and monitor forest fires, and at what cost?
- Should the FireSat mission evaluation proceed, and if so, which alternatives should we pursue?

We must readdress these questions as we analyze and design the space mission. By addressing them when we first explore concepts, we cannot obtain definitive answers. But we can form the right questions and identify ideas, parameters, and requirements we should be monitoring throughout the design. More extensive discussions of this systems engineering process are provided by Rechtin [1991] and the *System Engineer-*

TRACCIA 5

1) *ILLUSTRARE LE PROPRIE ATTIVITÀ/ESPERIENZE PROFESSIONALI.*

2) *DESCRIVERE QUALI SONO LE TIPOLOGIE DI SISTEMI PROPULSIVI TIPICHE DI UNA MISSIONE SPAZIALE.*

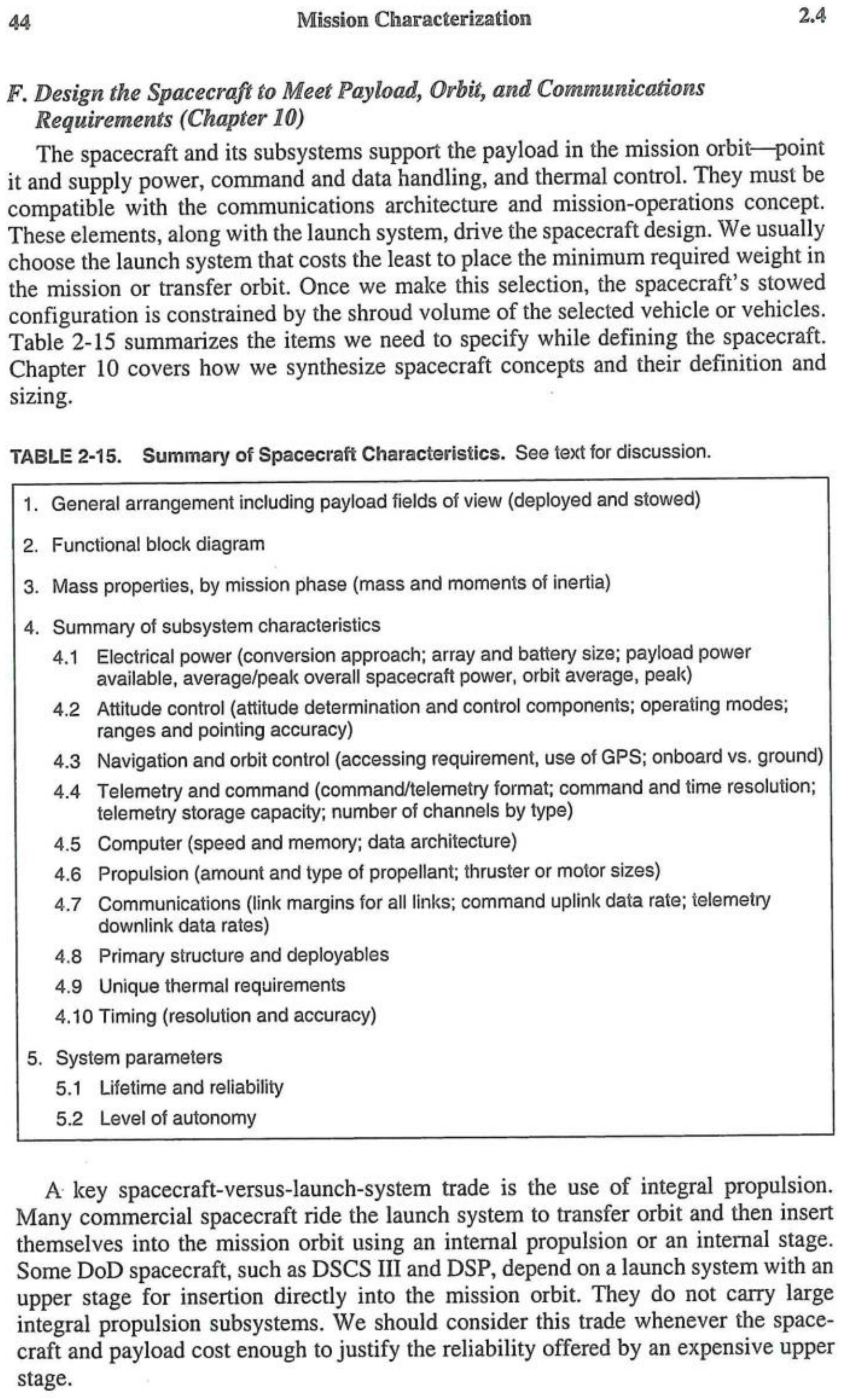
3) *IL CANDIDATO DESCRIVA I VIZI DI ANNULLABILITÀ DEL PROVVEDIMENTO AMMINISTRATIVO AI SENSI DELLA LEGGE 241 DEL 1990.*

Esercitazione:

4) *IL CANDIDATO REALIZZI IN WORD UN DOCUMENTO CHE SINTETIZZI LA SUA ESPERIENZA DI RICERCA.*

Prova di Inglese:

1) *LEGGERE E TRADURRE IL TESTO IN INGLESE SOTTOPOSTO DALLA COMMISSIONE.*



F. Design the Spacecraft to Meet Payload, Orbit, and Communications Requirements (Chapter 10)

The spacecraft and its subsystems support the payload in the mission orbit—point it and supply power, command and data handling, and thermal control. They must be compatible with the communications architecture and mission-operations concept. These elements, along with the launch system, drive the spacecraft design. We usually choose the launch system that costs the least to place the minimum required weight in the mission or transfer orbit. Once we make this selection, the spacecraft's stowed configuration is constrained by the shroud volume of the selected vehicle or vehicles. Table 2-15 summarizes the items we need to specify while defining the spacecraft. Chapter 10 covers how we synthesize spacecraft concepts and their definition and sizing.

TABLE 2-15. Summary of Spacecraft Characteristics. See text for discussion.

1. General arrangement including payload fields of view (deployed and stowed)
2. Functional block diagram
3. Mass properties, by mission phase (mass and moments of inertia)
4. Summary of subsystem characteristics
    - 4.1 Electrical power (conversion approach; array and battery size; payload power available, average/peak overall spacecraft power, orbit average, peak)
    - 4.2 Attitude control (attitude determination and control components; operating modes; ranges and pointing accuracy)
    - 4.3 Navigation and orbit control (accessing requirement, use of GPS; onboard vs. ground)
    - 4.4 Telemetry and command (command/telemetry format; command and time resolution; telemetry storage capacity; number of channels by type)
    - 4.5 Computer (speed and memory; data architecture)
    - 4.6 Propulsion (amount and type of propellant; thruster or motor sizes)
    - 4.7 Communications (link margins for all links; command uplink data rate; telemetry downlink data rates)
    - 4.8 Primary structure and deployables
    - 4.9 Unique thermal requirements
    - 4.10 Timing (resolution and accuracy)
5. System parameters
    - 5.1 Lifetime and reliability
    - 5.2 Level of autonomy

A key spacecraft-versus-launch-system trade is the use of integral propulsion. Many commercial spacecraft ride the launch system to transfer orbit and then insert themselves into the mission orbit using an internal propulsion or an internal stage. Some DoD spacecraft, such as DSCS III and DSP, depend on a launch system with an upper stage for insertion directly into the mission orbit. They do not carry large integral propulsion subsystems. We should consider this trade whenever the spacecraft and payload cost enough to justify the reliability offered by an expensive upper stage.

TRACCIA 4

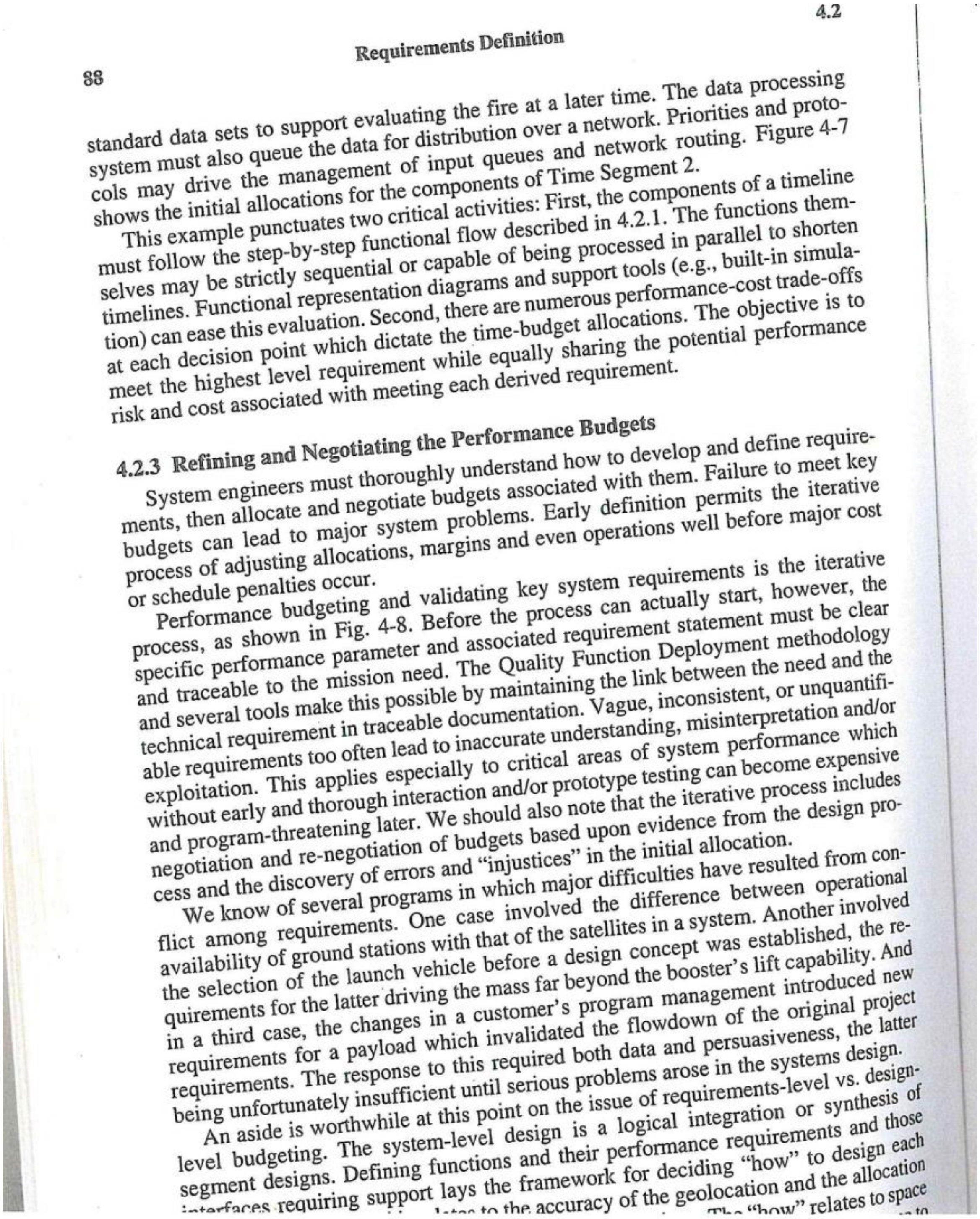
1) *ILLUSTRARE LE PROPRIE ATTIVITÀ/ESPERIENZE PROFESSIONALI.*
2) *DESCRIVERE COME VANNO TRATTATE LE MODIFICHE AI REQUISITI SCIENTIFICI E FUNZIONALI INDIVIDUATE IN FASE DI VERIFICA E TEST.*
3) *IL CANDIDATO ILLUSTRI IL DOVERE DELLA PUBBLICA AMMINISTRAZIONE DI CONCLUDERE IL PROCEDIMENTO AMMINISTRATIVO ENTRO UN CERTO TERMINE E LE CONSEGUENZE DELL'INADEMPIMENTO AI SENSI DELLA LEGGE N. 241 DEL 1990.*

Esercitazione:

4) *IL CANDIDATO REALIZZI IN EXCEL UNA TABELLA CON TESTO E NUMERI DI SUA SCELTA E IN SEGUITO NE ORDINI IL CONTENUTO SECONDO UN CRITERIO DI SUA SCELTA.*

Prova di Inglese:

1) *LEGGERE E TRADURRE IL TESTO IN INGLESE SOTTOPOSTO DALLA COMMISSIONE.*



standard data sets to support evaluating the fire at a later time. The data processing system must also queue the data for distribution over a network. Priorities and protocols may drive the management of input queues and network routing. Figure 4-7 shows the initial allocations for the components of Time Segment 2.

This example punctuates two critical activities: First, the components of a timeline must follow the step-by-step functional flow described in 4.2.1. The functions themselves may be strictly sequential or capable of being processed in parallel to shorten timelines. Functional representation diagrams and support tools (e.g., built-in simulation) can ease this evaluation. Second, there are numerous performance-cost trade-offs at each decision point which dictate the time-budget allocations. The objective is to meet the highest level requirement while equally sharing the potential performance risk and cost associated with meeting each derived requirement.

4.2.3 Refining and Negotiating the Performance Budgets

System engineers must thoroughly understand how to develop and define requirements, then allocate and negotiate budgets associated with them. Failure to meet key budgets can lead to major system problems. Early definition permits the iterative process of adjusting allocations, margins and even operations well before major cost or schedule penalties occur.

Performance budgeting and validating key system requirements is the iterative process, as shown in Fig. 4-8. Before the process can actually start, however, the specific performance parameter and associated requirement statement must be clear and traceable to the mission need. The Quality Function Deployment methodology and several tools make this possible by maintaining the link between the need and the technical requirement in traceable documentation. Vague, inconsistent, or unquantifiable requirements too often lead to inaccurate understanding, misinterpretation and/or exploitation. This applies especially to critical areas of system performance which without early and thorough interaction and/or prototype testing can become expensive and program-threatening later. We should also note that the iterative process includes negotiation and re-negotiation of budgets based upon evidence from the design process and the discovery of errors and “injustices” in the initial allocation.

We know of several programs in which major difficulties have resulted from conflict among requirements. One case involved the difference between operational availability of ground stations with that of the satellites in a system. Another involved the selection of the launch vehicle before a design concept was established, the requirements for the latter driving the mass far beyond the booster’s lift capability. And in a third case, the changes in a customer’s program management introduced new requirements for a payload which invalidated the flowdown of the original project requirements. The response to this required both data and persuasiveness, the latter being unfortunately insufficient until serious problems arose in the systems design.

An aside is worthwhile at this point on the issue of requirements-level vs. design-level budgeting. The system-level design is a logical integration or synthesis of segment designs. Defining functions and their performance requirements and those interfaces requiring support lays the framework for deciding “how” to design each [illegible] to the accuracy of the geolocation and the allocation [illegible] “how” relates to space

TRACCIA 2

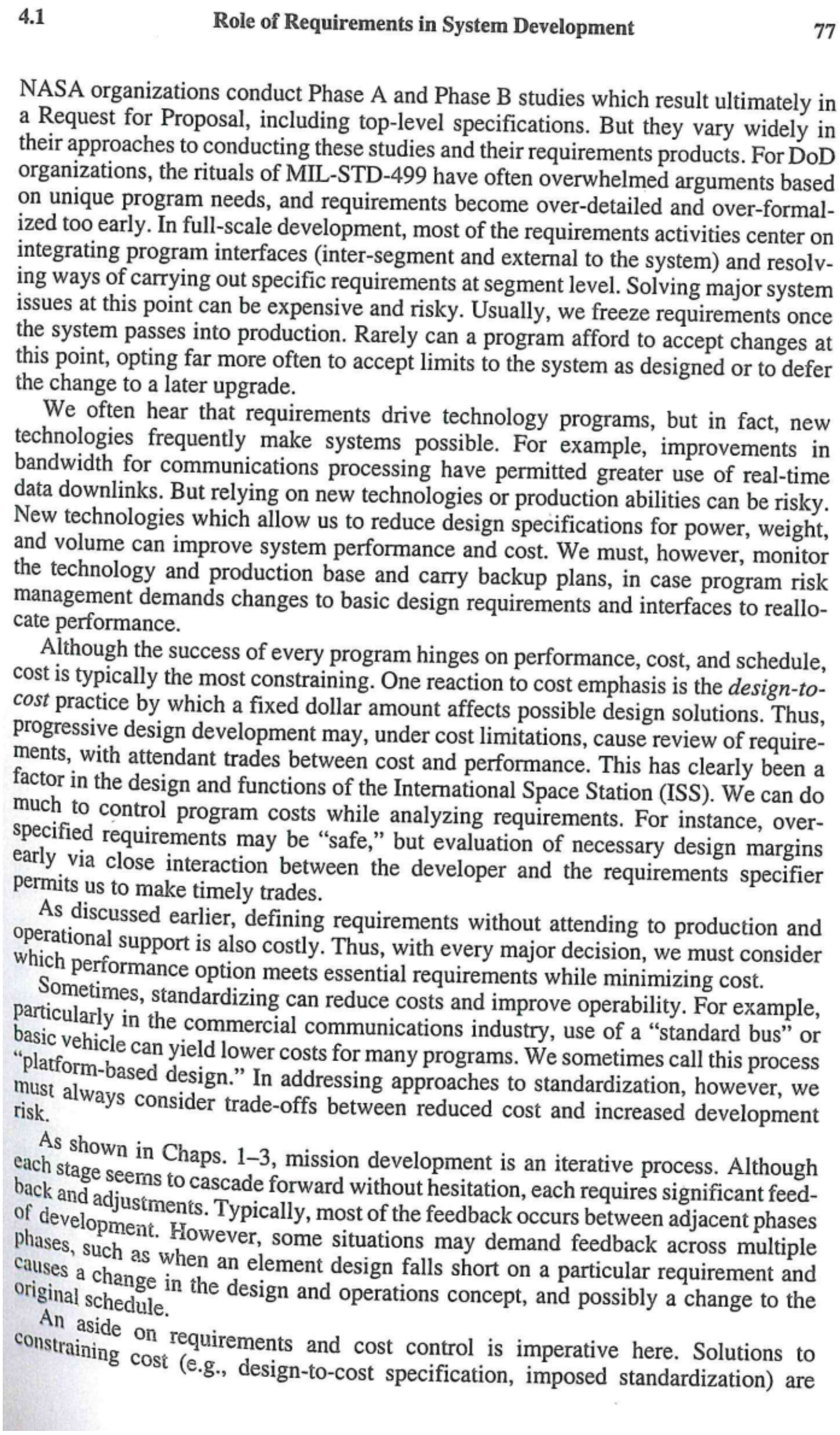
1) *ILLUSTRARE LE PROPRIE ATTIVITÀ/ESPERIENZE PROFESSIONALI.*
2) *DESCRIVERE LE DIFFERENZE FRA IL MODELLO DI QUALIFICA (QM) ED IL MODELLO DI VOLO (FM O PFM) DI UN PAYLOAD/ESPERIMENTO SCIENTIFICO PER UNA MISSIONE SPAZIALE.*
3) *IL CANDIDATO DESCRIVA LA FIGURA DEL DIRETTORE GENERALE DELL'ASI AI SENSI DELLO STATUTO.*

Esercitazione:

4) *IL CANDIDATO REALIZZI IN POWER POINT UNA PRESENTAZIONE CHE ILLUSTRI I RISULTATI DI UN PROGETTO TECNICO/SCIENTIFICO DI SUA SCELTA.*

Prova di Inglese:

1) *LEGGERE E TRADURRE IL TESTO IN INGLESE SOTTOPOSTO DALLA COMMISSIONE.*



NASA organizations conduct Phase A and Phase B studies which result ultimately in a Request for Proposal, including top-level specifications. But they vary widely in their approaches to conducting these studies and their requirements products. For DoD organizations, the rituals of MIL-STD-499 have often overwhelmed arguments based on unique program needs, and requirements become over-detailed and over-formalized too early. In full-scale development, most of the requirements activities center on integrating program interfaces (inter-segment and external to the system) and resolving ways of carrying out specific requirements at segment level. Solving major system issues at this point can be expensive and risky. Usually, we freeze requirements once the system passes into production. Rarely can a program afford to accept changes at this point, opting far more often to accept limits to the system as designed or to defer the change to a later upgrade.

We often hear that requirements drive technology programs, but in fact, new technologies frequently make systems possible. For example, improvements in bandwidth for communications processing have permitted greater use of real-time data downlinks. But relying on new technologies or production abilities can be risky. New technologies which allow us to reduce design specifications for power, weight, and volume can improve system performance and cost. We must, however, monitor the technology and production base and carry backup plans, in case program risk management demands changes to basic design requirements and interfaces to reallocate performance.

Although the success of every program hinges on performance, cost, and schedule, cost is typically the most constraining. One reaction to cost emphasis is the *design-to-cost* practice by which a fixed dollar amount affects possible design solutions. Thus, progressive design development may, under cost limitations, cause review of requirements, with attendant trades between cost and performance. This has clearly been a factor in the design and functions of the International Space Station (ISS). We can do much to control program costs while analyzing requirements. For instance, over-specified requirements may be "safe," but evaluation of necessary design margins early via close interaction between the developer and the requirements specifier permits us to make timely trades.

As discussed earlier, defining requirements without attending to production and operational support is also costly. Thus, with every major decision, we must consider which performance option meets essential requirements while minimizing cost.

Sometimes, standardizing can reduce costs and improve operability. For example, particularly in the commercial communications industry, use of a "standard bus" or basic vehicle can yield lower costs for many programs. We sometimes call this process "platform-based design." In addressing approaches to standardization, however, we must always consider trade-offs between reduced cost and increased development risk.

As shown in Chaps. 1–3, mission development is an iterative process. Although each stage seems to cascade forward without hesitation, each requires significant feedback and adjustments. Typically, most of the feedback occurs between adjacent phases of development. However, some situations may demand feedback across multiple phases, such as when an element design falls short on a particular requirement and causes a change in the design and operations concept, and possibly a change to the original schedule.

An aside on requirements and cost control is imperative here. Solutions to constraining cost (e.g., design-to-cost specification, imposed standardization) are