UNDERSTANDING THE RAM CONCEPT

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Abstract.

One of the practices that is emerging to improve maintenance is RAM Analysis, an acronym for Reliability, Availability and Maintainability. This article will explain the origin of RAM, what it is, how it should be used and how it articulates with supportability to ensure system availability at an affordable cost, concluding with an analysis to determine whether it belongs to maintenance or Asset Management.

Article.

One of the practices that are emerging to improve maintenance is RAM Analysis, an acronym for Reliability, Availability and Maintainability.

The oldest publication that talks about RAM is the "DoD Guide for achieving Reliability, Availability, and Maintainability"[1], published by the U.S. Department of Defense in 2005, which states that the main objective of the Department of Defense Acquisition System (DoD) is "to acquire quality products (systems) that satisfy user needs with measurable improvements to mission capability and operational support in a timely manner, and at a fair and reasonable price"[2]. It also indicates that this guidance supports this objective and addresses reliability, availability and maintainability (RAM) as essential elements of mission capability.

The guide defines reliability and maintainability according to IEC 60050 chapter 191, where the first is defined as "the probability that an item will perform a required function under specified conditions for a specified period of time" and the second as "the ability of an item to be retained or restored to a specified condition when maintained by personnel with specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair". The definition of availability differs from that stated in the mentioned standard, establishing it as "a measure of the degree to which an item is in an operable state and can be committed to at the start of a mission when it is in an operable state", stating that it is "a measure of the degree to which an item is in an operable state and can be committed at the start of a mission when the mission is called for at an unknown (random) point in time" and adding that it is a function of the frequency of failures requiring corrective maintenance, the frequency with which preventive maintenance is performed, the speed with which indicated failures can be isolated and repaired, the speed with which preventive maintenance tasks can be performed, and the time that delays in logistical support contribute to downtime.

The guide also states that it is important for a system to achieve specified levels of RAM because of the effect it has on its readiness, safety, mission success, total cost of ownership,

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[1] Department of Defense. (2005). Guide for achieving Reliability, Availability, and Maintainability. http://everyspec.com/DoD/DoD-PUBLICATIONS/RAM_Guide_080305_5593/.

[2] DoD Directive 5000.1, The Defense Acquisition System, May 12, 2003, paragraph 4.2, page 2.

and logistics footprint and that the key to developing and fielding military systems with satisfactory levels of RAM is to incorporate this concept as an integral part of the Systems Engineering Process to systematically manage the elimination of failures and failure modes through their identification, classification, analysis, and elimination or mitigation. In that sense, it sets out the following four key steps that can be taken to achieve satisfactory levels of RAM (see Figure 1, figure 1-3 of the Guide).

These stages match the first three stages of the assets life cycle.

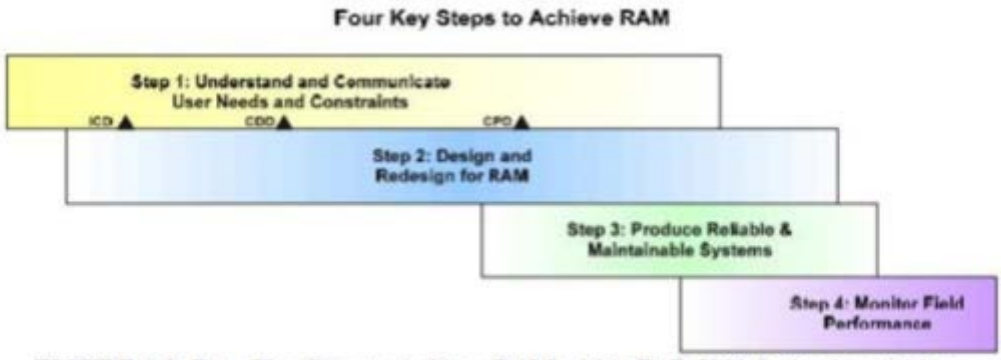

FIGURE 1-3: Four Key Steps to Achieve RAM within DoD 5000 Series Acquisition Management Framework

Figure 1

Analyzing what has been illuminated so far, it seems that RAM is a means to an end, in this case to acquire products (systems) that allow for maximizing the value delivered by the Armed Forces. At this point, it is necessary to analyze the meaning of each parameter that composes RAM.

Reliability and maintainability are both intrinsic attributes of an asset that is defined by when it leaves the factory. Once the asset is incorporated into a system and starts operating, its reliability must be kept at the original factory level through preventive and corrective actions and, if necessary, as is indicated in the RCM, it should be redesigned to improve its reliability.

In parallel, maintainability does not vary with the use of the asset and, if it is too difficult to maintain, it should be redesigned to make it simpler, an action that is not easy. It seems an obvious truth, but I feel it is necessary to point out that maintainability should not be confused with maintenance.

In summary, reliability and maintainability are designed and built/acquired in the first two stages of the assets' life cycle and once the system is in operation, they must be maintained to ensure its reliability.

Regarding Availability, the guide indicates that reliability and maintainability do not ensure availability, putting it in the following terms: "systems engineering activities can be directed to designing and manufacturing reliability and maintainability into the system, but availability is the function of this inherent reliability and maintainability as well as the system's supportability and producibility".

Figure 2 summarizes this concept, adding the operational context in which the system will operate and should have been taken into account in the first design phase as part of the users' needs and constraints, since it will condition the performance of the and,

consequently, the support capacity required to maintain the balance.

For example, a system that is unreliable, difficult to maintain, difficult to operate and/or operating in hostile environments will require a much greater support effort than one that is reliable, simple to maintain and/or operates under normal conditions. So, availability is the result of the balance between the intrinsic attributes of the assets and the system's support capability.

Note that another attribute appears in the figure: "operability". The DoD states that "A product that is difficult to operate due to its design characteristics requires individuals with greater cognitive or manual dexterity skills than one that is less complex"[3] and has been defined as the "Set of characteristics that will make the asset "friendly" to operators, taking into account ease of operation, safety and ergonomics"[4]. The conditions of operability are the same as those of maintainability; if it was poorly designed at the beginning, it will be very difficult to make an asset simple to operate when it is already built.

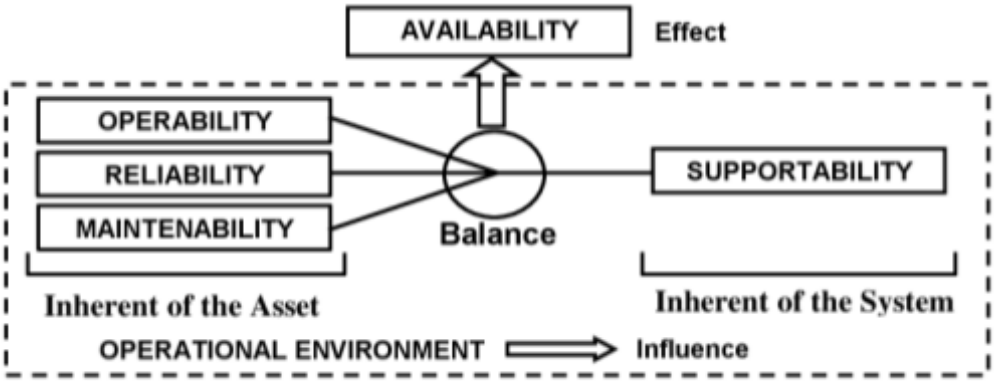

Figure 2

Over time, RAM has evolved to RAMS, where S stands for safety, which can be viewed from two points of view, the first from the asset, where it is an intrinsic attribute of it, and the second from the system, where operational safety and operators' safety and health, etc. are involved. Support must ensure that the intrinsic safety of the equipment does not decrease during its lifetime and that the system operates safely.

Regarding the operation and support stage of the assets' life cycle, the Guide indicates that it must be ensured that the necessary levels of RAM are kept during the useful life

of the system, since the costs of this stage usually represent around 80% of the total life cycle cost, and although it points out that reliability and maintainability are those which determine the supportability and its cost, the operability and the operational context in which they will have to work will also condition them. When referring to supportability, it includes maintenance at all levels; personnel to operate and support the system; supply support; support equipment and tools; technical data; training and training support; IT resources support; facilities; and packaging, handling, storage and transportation, so all these

[3] Department of Defense. (1997). MIL-HDBK-502 Department of Defense Handbook Acquisition Logistics. http://everyspec.com/MIL-HDBK/MIL-HDBK-0500-0599/MIL_HDBK_502_235/.
[4] Vittorangeli, A.E. (2020). Incorporando un sistema, cuando lo barato sale caro. visión práctica de un proceso de análisis de ciclo de vida. https://www.researchgate.net/publication/344961953

elements will condition the ability of the system to fulfill its mission/function at the time it is required.

It can be said as a conclusion that:

1. RAM is a tool for assets or system design. Can a "RAM analysis" be used once the equipment is operational? Yes, but as a control function to preserve the design reliability and in that sense, I find it difficult to improve the reliability, maintainability and original operability of the assets, unless redesign actions are carried out. As for availability, it is not an attribute of the assets; it is a consequence of the other factors, operational context and supportability. System reliability" can be improved by working on personnel, procedures, physical (basically maintaining their intrinsic reliability) and supportability.
2. To keep the design reliability working at the systemic level, I would prefer to use an ILS (Integrated Logistic Support) scheme, such as the one in Figure 3[5] or directly apply RCM.

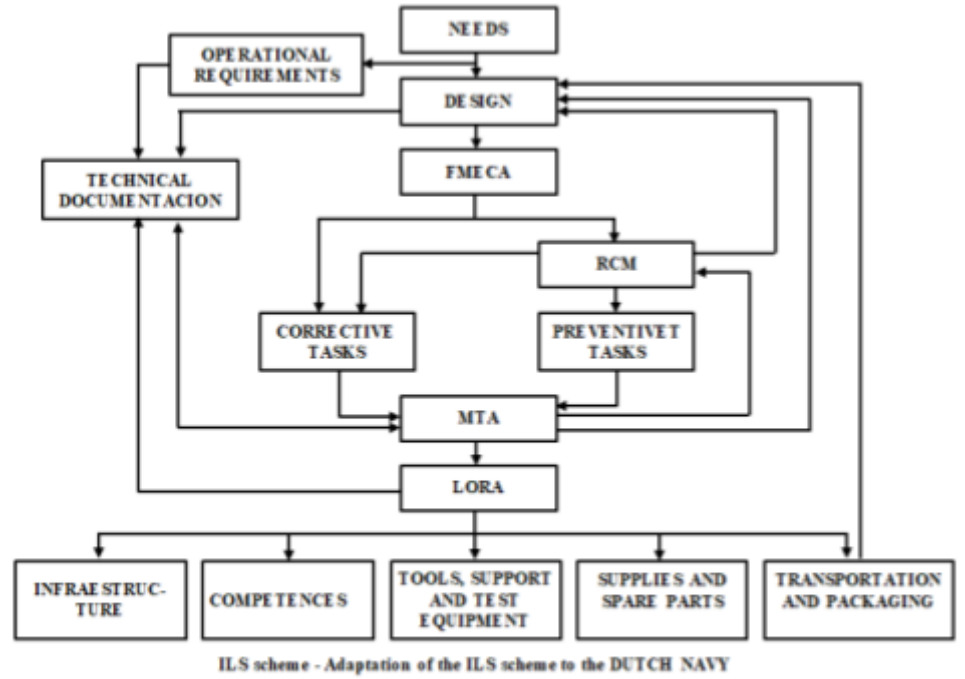

Figure 3

3. Reliability, maintainability and operability must be designed and built; the Guide to achieve the RAM indicates the steps to follow to achieve it.
4. Supportability is defined as "A key component of availability. It includes design, technical support data, and maintenance procedures to facilitate detection, isolation, and timely repair and/or replacement of system anomalies. This includes factors such as diagnostics, prognostics, real time maintenance data collection, and Human System

[5] Yolton, J.(2008). Integrated Logistics Support (I LS). SKF Aptitud Exchange. https://www.skf.com/binaries/pub12/Images/0901d196802370e6-04014_Integrated_Logistics_Support_2017_tcm_12-110996.pdf

integration (HSI) considerations."[6] and implies that:

- The asset or system must be designed to be supportable.
- In parallel with the design and construction of the asset, the support system must be designed and procured to ensure that the assets can be operated and maintained throughout its useful life.
- Once the equipment is operational, support must be exercised to sustain the reliability of the equipment.

5. I believe that analyzed from a systemic point of view and from the perspective of the life cycle of an asset, RAMS could become RAMS+S, where the final S stands for Supportability, a system attribute whose function is to sustain reliability and safety at the design levels of the equipment, ensuring its availability.
6. In short, to speak properly about RAM, the whole life cycle of the assets plus the system's supportability should be considered, within the operational context in which it will have to operate, and this is closer to Asset Management than to maintenance.

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Figures:

1. Figure 1-3 from the Guide for achieving Reliability, Availability, and Maintainability
2. Author's own.
3. Author's adaptation of a Dutch Navy ILS scheme.

[6] Defense Acquisition University. (2020). Glossary of Defense Acquisition Acronyms and Terms – Supportability. https://www.dau.edu/glossary/Pages/Glossary.aspx#!both|S|28579