UNITED KINGDOM CHAPTER

The Mystique[1] of Availability

Availability is the outcome that equipment logistic support must deliver – *the ability to use a system when required*. In the simplest terms, availability is the proportion of time that a system can be used. While very commonly used, availability is generally poorly understood and frequently ill-defined based on precedents rather than careful thought about the specific demand

Many factors contribute to the extremely complex subject of actual availability including system design, component reliability, operating scenario, usage pattern, Support arrangements, and cost compared with available budget. Simplistic definitions are frequently misleading and lead to inadequate requirements. Multiple definitions to cover all aspects of Support increases the capture burden without necessarily improving understanding of interrelated cause and effect. In practice, many in-service systems fail to meet expectations, stretch logistic support arrangements, cost more than budgeted, limit operational output and undermine capability. Worse, the impacts are then usually experienced through-life. These weaknesses have long been recognised without finding a solution.

Increased but still affordable availability is a universal objective. Experience in many fields, and common sense, has shown that it is easier and more cost-effective to identify and remove the causes of failure than to enhance success by further enhancing what is already good. In a similar vein, measuring positive success is a natural approach but direct metrication and management of availability is very hard. And it cannot be directly adjusted by Support engineers. It is the outcome of many complex interacting contributors that are difficult to separate and independently quantify. Improvement only comes from identifying, removing or reducing the causes of unavailability.

The common perception that availability is the sole appropriate key to delivering Support needs is misleading because availability is an outcome. Measures to improve it must focus on the input causes of unavailability which manifest as Downtime.. Downtime should be the preferred means to identify, prioritise and direct management actions and to measure their success. The outcomes will be improved outcomes of availability and cost.

Operating Scenarios and Availability Requirements

Operational Availability is often seen as the ultimate, simple system-level metric. But many alternative measures are used to reflect the needs of different operating scenarios. For example:

- Continuous on-state requirement. The Continuous At Sea Deterrent (CASD) must be operationally available at all times. If only a single platform is used, that implies a need for significant system and sub-system redundancy.
- Ground-based radar systems should always be operating to ensure continuous coverage. As planned and some corrective maintenance activity is inevitable, the overall capability must have redundancy using multiple channels or systems.
- Immediate Readiness such as Quick Reaction Alert fighters, search and rescue helicopters or SAM batteries need not be operating continuously but must be available for use within very short timescales. Planned maintenance should be managed through platform redundancy with not every system down at the same time or for limited periods of accepted risk.

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[1] Mystique can be defined as having *a reputation of mystery, glamour, and power that is impressive or baffling to those without specialized knowledge*. Many non-specialists have not studied the subject of availability sufficiently but believe and trust in it.

- Continuous Patrol such as Airborne Early Warning surveillance barriers, maritime patrol aircraft search patterns and combat aircraft patrols (CAPs) all require equipment operating often some distance from their base. On-station failures, replacement scramble and transit times all cause downtime. The failure frequencies and recovery rates are critical which draws in reliability, testability and diagnosis, maintainability and logistic resource availability.
- Civilian airlines place heavy emphasis in contracts for On-Time Dispatch Rate to exploit system redundancy backed by OEM permissible faults.

Similar very different definitions apply at formation level and can vary significantly over time:

- Squadron Availability. Historically, squadrons were required to maintain in excess of 70% aircraft availability for immediate operations. The training task was usually expressed as achieving a minimum number of flying hours or mission completed flights in a specified period at a minimum confidence level. But these metrics are not directly related since, for example, Typhoon achieves only about 40% availability while deliverings 108% of the annual task.
- Fighting Formations. Aircraft mission packages must have minimum numbers of each element to succeed. On land, formations such as battle groups require a minimum number of systems to be operational to remain as a combat effective unit. For example, if the number of tanks falls below 5 out of 8, the unit cannot fight effectively and must withdraw. Different numbers will be required depending on the specific task. For example, operations and collective training will demand very high system availability across a large fleet while individual training may only need low system availability.
- System of Systems. Ships are systems of systems requiring a mix of continuous and occasional needs to Fight, Move or Float as required. The roles can vary at any time including ASW, ASUW, AAW, helicopter operations, replenishment, shore-based presence etc.

These examples illustrate that **simple system-level availability metrics using standard rules-of-thumb required levels are very frequently inappropriate**. Each case of peace and contingency demand must be evaluated as a distinct requirement based on the defined usage pattern and metricated accordingly. To cope with the inevitable complexities, many specific definitions have evolved. Recent work by the DE&S Defence Availability Centre revealed more than 35 different definitions in use such as Equipment Available Days but many are convenient management inventions that do not indicate more than derivations of the basic parameters.

Availability Definitions

Availability is usually expressed in terms of Mean Time Between Failure (MTBF) as the measure of Uptime with Mean Time to Repair (MTTR) to reflect Downtime. Unfortunately, MTBF does not always describe the 'average' usage between failures. Without getting too mathematical, that only applies if items fail in a Normal Distribution. Most systems fail randomly (exponentially) which means that 62.8% fail by the MTBF not half.

Common availability definitions fall within 3 principal categories:

- Inherent Availability (A_i) reflects the reliability and repairability of the equipment. Availability is usually expressed in terms of MTBF as a proportion of the total time comprising MTBF plus the Downtime of MTTR for Corrective maintenance ($MTTR_C$).
- Achieved Availability (A_a) adds preventive maintenance time ($MTTR_P$) to the definition of Downtime. This is also sometimes referred to as Maintenance Availability (A_m).
- Lastly, Operational Availability (A_o) adds the contribution of the Support chain expressed as Administrative & Logistic Delay Time (ALDT) to total Downtime. Spares availability (A_S) is just one component of ALDT that also incorporates the contribution of manpower, support equipment, facilities, information etc all set in specific contractual contexts.

Reliability is an intrinsic system design characteristic for the specified physical environment. FMECA and RCM techniques informs maintenance and Support policies largely through preventive maintenance activities. Support engineers cannot directly control actual reliability although improved feedback using sustaining engineering processes such as S5000F will help design teams to address emergent issues.

Planned combined maintenance and upgrade is a sensible management approach as access, component replacement and functional testing activities can be combined to minimise downtime. These activities are usually excluded from availability definitions and separately identified.

Too little attention is also paid to Durability arising from non-attributable failures such as bird strikes, weather, damage caused that is operator or maintainer induced, and Battle Damage. These cause downtime but are always excluded from system design requirements largely for contractual reasons.

Software reliability is also an unclear area especially for large complex systems that are becoming increasingly common. Software does not fail in the traditional sense but always has bugs. Apparent failures can be caused by lack of operator training, data errors and incompatibilities, system timing discrepancies, hardware faults detectable by Built In Test, hardware faults not detectable by Built In Test and others. Corrective action is by software update that can be either in-phase or separate from planned upgrades, or as temporary work-arounds. All cause system Downtime.

In short, **classic availability definitions do not include all causes of Downtime**. The multiple and often inter-connected causes of non-availability including the availability of Support resources are not captured directly. Management action is needed to combine and integrate the contributors to obtain a holistic view.

Setting Availability Requirements

While usually operational experts in their role, Capability Managers across MOD very rarely have any experience in setting availability requirements. The need to set availability levels in Operational Analysis to inform fleet sizing is recognised and usually understood from experience. Force Elements @ Readiness may be specified but they rely on simple rules-of-thumb such as 70% operational availability based on typical precedent. However, there is rarely sufficient clarity of the operating environments or the varying usage pattern demands in operations, contingencies and peacetime training. The complexity in defining availability reinforces the attractiveness of using inappropriate and incorrect simplifications.

The presumption, shared by industry suppliers, is that Support arrangements will be shaped and sized to meet the operational demand. But there is little understanding of the connection between task achievement and required availability. Because both governments and suppliers largely separate funding for equipment procurement and support services, acquisition of sufficient platforms is the primary driver with downstream Support consequences typically addressed later. **Support affordability is only roughly estimated, often inaccurately using optimistic 'entry-ism' understatements to ensure project survival.** As a result, poor Support definition often leads to early in-service disappointment and severe through-life cost growth. F35 is the classic example. Supportability Modelling is largely overlooked.

There is no reason why the simplifying air gap between classic OA and Support modelling should exist. Current conflicts and geostrategic tension have increased recent focus on incorporating resilience into wargaming although the aim has been to evaluate supply chain reactivity using stockpiles and transportation rather than addressing holistic system Support.

In the early stages of equipment design, benchmark data can be used for the small set of logistically significant components that will predominate availability and life cycle affordability. Later, actual data feedback will refine any assumptions to refresh planning decisions. This is not a new concept. In the mid 1990's, the MOD's Logistics Analysis & Research Organisation (LARO) modelled all RAF fixed and rotary platforms including all marks and sub-fleets around the world against 7 operational scenarios each year. The scenarios ranged from normal peacetime usage at Main Operating Bases, through exercise and deployments up to and including full contingency and wartime operations. The different results were invaluable in deciding the size and disposition of contingency stocks using risk-based evidence. Regrettably, the capability was disbanded 10 years later in favour of reliance upon prime contractors who are not necessarily experienced and competent in designing Support solutions. Moreover, misalignment of motivations are common. The capability and practice of continuing through-life modelling must be revived.

Capability Managers, and those who assure business cases, need greater awareness, education and have ready access to similar modelling & analysis capabilities as essential advice to set informed Support requirements.

Summary

Availability is the most commonly used measure of Support. Better, affordable availability is a universal objective but it is not generally well understood, frequently inappropriately specified, complex to measure and hard to forecast. Simple system-level availability metrics with standard rules-of-thumb required levels are very often inappropriate. Classic availability definitions do not include all causes of Downtime. In-service availability is often worse than demanded and at greater cost than anticipated.

The common perception that availability is the sole appropriate key to Support needs is misleading because it is an outcome. Measuring positive success is a natural approach but direct metrication and management of availability is very hard because it is the outcome of many complex interacting contributors that are difficult to separate and independently quantify. Improvement only comes from removing or reducing the causes of unavailability. **Measures to improve availability must focus on the causes of unavailability which manifest as Downtime. Downtime should be the preferred means to identify, prioritise and direct management actions and to measure their success. The outcomes will be improved availability and cost.**

Capability Managers across MOD use extensive operational analysis and wargaming to inform fleet sizing but very rarely have any experience in setting availability requirements which are often set using standard rules-of-thumb. The presumption is that Support arrangements will be developed to deliver. Support affordability is only roughly estimated, frequently inaccurately using optimistic understatements. As a result, poor Support definition has often led to early in-service difficulty and severe through-life cost growth. **Capability Managers need awareness, education and ready access to Support modelling & analysis capabilities to set informed Support requirements.** These capabilities existed but were lost to reliance upon prime contractors with different motivations.