TECHNICAL BRIEF

DESIGN REFERENCE MISSION PROFILE

Development Guidelines

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Foreword

A primary goal of the ASN (RD&A) Strategic Plan is to acquire, interpret and share technical information and provide expert consultation to continuously improve acquisition practices. To implement this goal, the ASN (RD&A) Acquisition and Business Management Directorate periodically issues technical briefs.

The intent of this technical brief is to assist our Navy managers, designers and testers with the best possible information regarding the concept of the Design Reference Mission Profile. This technical brief is a joint effort between senior technical experts within the Navy and industry. The Navy would like to recognize Mr. Scott Woods of Svredrup Technology for his contributions to this technical brief.

I solicit your inputs for technical issues that you, the user, would like to see addressed in future technical briefs. This guide is posted on the ABM homepage at www.abm.rda.hq.navy.mil and comments may be posted there as well.

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PURPOSE

The purpose of this technical brief is to clarify the concept of the Design Reference Mission Profile (DRMP) and provide guidance for its development and usage.

DESCRIPTION

The DRMP provides a time history or profile of events, functions (often referred to as use or operations) and environmental conditions that a system is expected to encounter during its life cycle, from manufacturing to removal from service use. The DRMP may be simplified to provide a hypothetical composite profile for a system with multiple or variable missions or life cycle profiles. The composite DRMP reflects a sequence of system operations/events and associated environments in which the various stresses occur in approximately the same proportions as in the individual multiple mission profiles, weighted according to their relative frequencies. Proper definition of the DRMP includes not only the expected nominal climatic conditions, but also worst-case, rate of change, synergistic conditions, and conditions of assembly, packaging, handling, shipping, storage, maintenance and transportation. The significance of induced environments (i.e., environmental conditions that are predominantly man-made or generated by the materiel platform) is often overlooked. Therefore, it is essential that conditions such as repetitive shock or transient vibration caused by gunfire, fluctuating pressure loadings caused by acoustic noise, aerodynamic turbulence, pyrotechnic shock, near miss shock and electromagnetic environments be considered during development of the DRMP. The DRMP is a living document that should be reviewed and updated periodically with changes in the functional and environmental profiles.

DEVELOPMENT

A system level DRMP is prepared by the Government and included in the system performance specification. The DRMP or elements of a DRMP are normally addressed in the following planning and contract documents:

- Mission Need Statement (MNS) - The MNS identifies environments that may constrain the operation or survivability of materiel, including natural, induced (e.g., temperature and vibration during transportation), and special operational threat environments (e.g., electronic countermeasures) in which the mission is to be accomplished. The MNS defines the desired levels of mission capability in these environments.
- Operational Requirements Document (ORD) - The ORD identifies materiel performance parameters that will meet the need described in the MNS. In identifying required capabilities and critical system characteristics, the ORD describes mission, maintenance, storage, handling, and transportation scenarios that the system will experience throughout its service life.
  - The system performance portion of the ORD is required to “describe mission scenarios … in terms of mission profiles, … and environmental conditions (all-inclusive: natural and man-made; e.g., weather, ocean acoustics, information warfare).”
  - The other system characteristics portion of the ORD is required to address “natural environmental factors (such as climatic, terrain and oceanographic factors).” The natural and man-made environments and expected mission capabilities in those environments defined in the ORD should be derived with development of the DRMP.
- Concept of Operations (CONOPS) - The CONOPS includes a description of scenarios intended to characterize how the system will be used in its operating environment. The

details should be adequate to support acquisition, testing, subsystem integration and logistics decisions.

- Acquisition Plan (AP) - The AP includes a description of the system's capability/ performance and the environmental effects on performance.
- Systems Engineering Management Plan (SEMP) - Program managers integrate the DRMP functional and environmental considerations (e.g., effects of various environments on system performance and reliability) into the SEMP for implementing functional and environmental engineering tasks.
- Test and Evaluation Master Plan (TEMP) - The TEMP includes plans for testing in natural (field/fleet) environments, simulated (laboratory) environments and virtual (synthetic) proving ground environments.
- Analyses of Alternatives (AoA) - Operational and environmental evaluations are an integral part of AoAs. Natural and induced environmental factors are critical in evaluating how well materiel will operate in regions of expected deployment. Therefore, it is important to identify appropriate values for materiel design and test related criteria by preparing a DRMP to identify realistic environmental parameters and materiel-specific parameter levels associated with environment-related issues and criteria.
- Performance specifications – Performance specifications should include the DRMP as a part of the description of the system's performance requirements, including associated environmental requirements.

The DRMP should be described in a documented, organized fashion as a part of the systems engineering process. It is typically developed by constructing a time profile of system functions/uses and their associated environmental conditions from manufacturing to removal from service use. A common method used is a series of charts/matrixes that, as a composite, identify and describe, in sequence, the pertinent functions and environments and their parameter ranges.

The length and degree of detail of the DRMP increase as the system evolution proceeds from the Concept & Technology Development phase through the System Development & Demonstration phase. The detailed DRMP should be updated as appropriate with changes in the design and/or system usage.

The DRMP is typically developed in two related parts; first being development of the system functional profile and the second being the environmental conditions associated with that profile.

Functional Profile

A profile is developed identifying on a time scale all events/functions that must be performed by or to the system throughout is life cycle. These profiles are typically divided into the various phases the system will encounter during its life (and further refined/detailed as the system design progresses into subsystem and sub-tier functions), such as:

- Packaging, handling, shipping and storage prior to use.
- Mission profiles while in use.
- Phases between missions such as stand-by or storage.
- Transfer to and from repair sites and alternate locations.

Environmental Profile
The environmental profile is added or related to the functional profile to identify on a time scale the associated environments and their magnitudes that are likely to have an effect on the system during its lifetime. The environmental profile is refined during system and subsystem level design based on the expected:

- Natural environmental profiles (e.g., temperature, pressure, other climatic conditions).
- Induced environmental profiles from:
  - Other external sources (e.g., electronic countermeasures, gunfire vibration, acoustic noise, aerodynamic turbulence, pyrotechnic shock, transportation, storage).
  - Internally generated sources (e.g., subsystems generating heat loads, vibration, shock).
  - Self generated with contact/interface with the environment (e.g., system external surface temperature as a function of speed).

Table 1 provides a simplified and abbreviated illustration (timelines and quantification of the environments are not shown) of a DRMP. The relative frequency and duration of storage, shipping and mission events must be included in defining life cycle environmental parameters.

Table 2 expands Table 1in the handling and road and air transportation portions of the shipping/transportation phase to illustrate quantification of the environments and their durations. The combination of Tables 1 and 2 illustrates the concept of a DRMP.

Table 1. Sample Abbreviated DRMP

	Shipping/Transportation Phase				**Storage/Logistic Supply Phase**		
	Handling & Rail Transportation	**Handling & Road Transportation**	**Handling & Air Transportation**	**Handling & Ship Transportation**	**Logistics Transportation (Worst Route)**	**Storage, Sheltered (Tent, Shed, Igloo)**	**Storage, Open**
Environmental stress generation mechanisms (induced)	Lifting acceleration Handling shock Rail shock (humping) Rail vibration	Lifting acceleration Handling shock Road shock (large bumps/ potholes) Road vibration (random)	Lifting acceleration Handling shock Take-off acceleration In-flight vibration (engine/turbine induced) Landing acceleration	Lifting acceleration Handling shock Wave-induced vibration (sinusoidal) Wave shock Mine/blast shock	Lifting acceleration Handling shock Road shock (large bumps/ potholes) Road vibration (random) Thermal shock (air drop)	None	None
Environmental stress generation mechanisms (natural) *(Table 1 continued on next page)*	Temperature Rain/hail Sand/dust	Temperature Pressure	Temperature Reduced pressure Thermal shock (air drop only)	Temperature Rain/hail Temporary immersion Salt fog	Temperature Rain/hail	Temperature Salt fog	Temperature Rain/hail Sand/dust

Table 1. Sample Abbreviated DRMP - Continued

	Mission/Use Phase					
	Deployment & use on Land Vehicles	**Deployment & use Aboard Ships**	**Deployment & Use on Aircraft Including Captive stores (Fixed/ Rotary Wing)**	**Delivery to Target, Projectile**	**Delivery to Target Torpedo/Underwater Launched Missile**	**Delivery to Target, Missile/Rocket**
Environmental stress generation mechanisms (induced)	Road/off-road vibration (surface irregularities/tread laying) Handling shock (including bench) Engine-induced vibration Road/off-road shock (large bumps/holes) Land mine/blast shock Weapon firing shock/vibration Explosive atmosphere Electromagnetic interference	Wave induced vibration (sinusoidal) Engine-induced vibration Acoustic noise Wave-slam shock Mine/blast shock Weapon firing shock Explosive atmosphere Electromagnetic interference Increased pressure (submarine)	Runway-induced vibration Aerodynamic turbulence Maneuver buffet vibration Gunfire vibration Engine-induced vibration Acoustic noise Take-off/ landing/ maneuver acceleration Air blast shock Catapult launch Arrested landing shock Handling shock (including bench) Aerodynamic heating Explosive atmosphere Electromagnetic interference	Handling/loading shock Firing shock Firing acceleration Acoustic noise Aerodynamic heating Explosive atmosphere Electromagnetic interference	Launch acceleration Handling/launch shock Engine-induced vibration Acoustic noise Pyrotechnic shock (booster separation) Explosive atmosphere Electromagnetic interference	Handling/launch shock Launch/maneuver acceleration Engine-induced vibration Aerodynamic turbulence (random vibration) Acoustic noise Aerodynamic heating Explosive atmosphere Electromagnetic interference
Environmental stress generation mechanisms (natural)	Temperature Thermal shock (storage to use) Rain/hail Sand/dust/mud Salt fog Solar radiation Fungus growth Chemical attack	Temperature Thermal shock (storage to use) Rain Salt fog Solar radiation Fungus growth Chemical attack	Temperature Thermal shock (storage to use) Rain Salt fog Solar radiation Rain impingement Sand/dust impingement Fungus growth Chemical attack	Thermal shock (storage to use) Rain Impingement Sand/dust impingement	Immersion Thermal shock	Rain impingement Sand/dust impingement

MIL-STD-810F, "*Department Of Defense Test Method Standard For Environmental Engineering Considerations And Laboratory Tests.*"

Table 2. Detailed Environmental Profile Illustration for Handling & Road Transportation Phase and Handling & Air Transportation Phase

Shipping/Transportation Phase			
Handling & Rail Transportation	**Handling & Road Transportation**	**Handling & Air Transportation**	**Handling & Ship Transportation**
Lifting acceleration Handling shock Rail shock (humping) Rail vibration	Lifting acceleration Handling shock Road shock (large bumps/potholes) Road vibration (random)	Lifting acceleration Handling shock Take-off acceleration In-flight vibration (Engine/turbine induced) Landing acceleration	Lifting acceleration Handling shock Wave-induced vibration (sinusoidal) Wave shock Mine/blast shock
Temperature Rain/hail Sand/dust	Temperature Pressure	Temperature Reduced pressure Thermal shock (air drop only)	Temperature Rain/hail Temporary immersion Salt fog

The level of detail shown is illustrative of an actual DRMP. Handling and road transportation phases illustrate transportation both to and from the airbase.

Event (Subsystem in shipping container)	**Equipment Required**	**Environmental Factors** (Environmental conditions are input to container. Environmental factors have been simplified for illustrative purposes.)			**Duration Nom/Max**
		Condition	**Expected**	**Worst**	
Handling and Road Transportation (to Airbase)					
Lift container from dock to flatbed trailer (6 containers/ flatbed).	Overhead crane, sling, flatbed trailer, tiedowns, grounding strap	Lifting acceleration Handling shock Temp Pressure	1.5 g 3.0 g, 11 ms 65-85°F 970 – 1030 mb	Same 20 g, 11 ms 29-111°F Same	15 minutes per container 60 minutes total 1-1/2 hour max
Deliver to Air Station - 100 miles. *(Table 2 continued on next page)*	Flatbed trailer, tractor	Road Shock Road vibration Temp Pressure	0.5g, 15ms 0.3Gpk 4-100 Hz 65-85°F 970 – 1030 mb	3.0g, 15ms 3.0 Gpk 4-100 Hz 29-111°F Same	2-1/2 – 3-1/2 hours

Event (Subsystem in shipping container)	**Equipment Required**	**Environmental Factors** (Environmental conditions are input to container. Environmental factors have been simplified for illustrative purposes.)			**Duration Nom/Max**
		Condition	**Expected**	**Worst**	
Off-load trailer onto cargo truck platform.	Flatbed trailer, tractor, forklift, platform, cargo truck, pallets (4), pallet spacers	Lifting acceleration Handling shock Temp Pressure	1.5 g 3.0 g, 11 ms 65-85°F 970 – 1030 mb	Same 20g, 11 ms 29-111°F Same	20 minutes per container 30 minutes max
Handling and Air Transportation					
Place loaded platform into C-5A or C- 141.	C-5A, C-141, tie downs, ground straps, platforms (2)	Lifting acceleration Handling shock Temp Pressure	1.5 g 3.0 g, 11 ms 65-85°F 970 – 1030 mb	Same 20g, 11 ms 29-111°F Same	20 minutes per container 30 minutes max
Taxi and takeoff.	C-5A, C-141	Acceleration	.15 g	1 g	15 minutes
Fly to destination.	C-5A, C-141	Vibration Temp Pressure	<0.8 Grms below 100 Hz <3 Grms 100-4000 Hz 40-55°F Sea Level to 20,000 ft	Same Same 30-70°F Same	5 hours 4 hours 5 hours 5 hours
Landing and taxi.	C-5A, C-141	Acceleration	.15 g	1 g	15 minutes
Remove loaded platform from C-5A or C- 141. *(Table 2 continued on next page)*	C-5A, C-141, tie downs, ground straps, platforms (2)	Lifting acceleration. Handling shock Temp Pressure	1.5 g 3.0 g, 11 ms 65-85°F 970 – 1030 mb	Same 20 g, 11 ms 29-111°F Same	20 minutes per container 30 minutes max

Event (Subsystem in shipping container)	Equipment Required	Environmental Factors (Environmental conditions are input to container. Environmental factors have been simplified for illustrative purposes.)			Duration Nom/Max
		Condition	**Expected**	**Worst**	
Handling and Road Transportation (from Airbase)					
Off-load cargo truck platform onto trailer.	Forklift, platform, cargo truck, pallets (4), pallet spacers, flatbed trailer, tractor	Lifting acceleration. Handling shock Temp Pressure	1.5 g 3.0 g, 11 ms 65-85^{o}F 970 – 1030 mb	Same 20 g, 11 ms 29-111^{o}F Same	20 minutes per container 30 minutes max
Deliver to storage warehouse - 100 miles.	Flatbed trailer, tractor	Road Shock Road vibration Temp Pressure	0.5g, 15ms 0.3Gpk 4-100 Hz 65-85^{o}F 970 – 1030 mb	3.0g, 15ms 3.0 Gpk 4-100 Hz 29-111^{o}F Same	2-1/2 – 3-1/2 hours
Off-load trailer into warehouse.	Flatbed trailer, tractor, forklift, platform, pallets (4), pallet spacers	Lifting acceleration Handling shock Temp Pressure	1.5g 3.0g, 11ms 65-85^{o}F 970 - 1030 mb	Same 20g, 11ms 29 – 111^{o}F Same	20 minutes per container 30 minutes max

The DRMP may be converted into a graphical display or shown in a timeline type format for a clearer understanding of the functional and environmental profile interactions. Table 3 illustrates a timeline type format. The duration and frequency of occurrence of the various environmental factors listed has been simplified and would be provided by performance specifications and engineering analyses/tests.

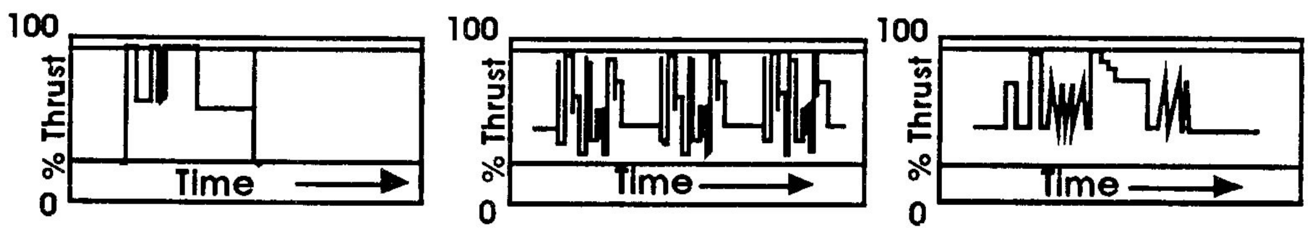
Table 3. Time Phased Environmental Profile Illustration, Handling and Road/Air Transport, Shipping/Transportation Phase

Mission Phase / Environmental Stresses	Handling and Road Transportation (to Airbase)			Handling and Air Transportation					Handling and Road Transportation (from Airbase)		
(For duration and frequency of occurrence of Handling, and Road/Air Transportation Events and Environmental Stresses, see performance specifications and engineering analyses/test documentation.)	Lift container from dock to flatbed trailer (6 containers/ flatbed).	Deliver to Air Station - 100 miles.	Off-load trailer onto cargo truck platform.	Place loaded platform into C-5A or C-141.	Taxi and takeoff.	Fly to destination.	Landing and taxi.	Remove loaded platform from C-5A or C-141.	Off-load cargo truck platform onto trailer.	Deliver to storage warehouse - 100 miles.	Lift container from flatbed trailer to warehouse (6 containers/ flatbed).
Mission Time Event Starts	0 time	+1 hour	+4 hours	+5 hours	+5.25 hours	+10.25 hours	+10.5 hours	+11.5 hours	+12.5 hours	+15.5 hours	+16.5 hours
Lifting acceleration	1.5g		1.5g	1.5g				1.5g	1.5g		1.5g
Handling shock	3g, 11ms 20g, 11ms		3g, 11ms 20g, 11ms	3g, 11ms 20g, 11ms				3g, 11ms 20g, 11ms	3g, 11ms 20g, 11ms		3g, 11ms 20g, 11ms
Road Shock		.5g, 15ms 3g, 15ms								.5g, 15ms 3g, 15ms	
Road vibration		.3gpk 4-100hz 3gpk 4-100hz								.3gpk 4-100hz 3gpk 4-100hz	
Acceleration					.15g		.15g				
Vibration						<.8grms below 100hz <3grms 100 – 400 hz					
Temp	65–85°F 29–111°F	65–85°F 29–111°F	65–85°F 29–111°F	65–85°F 29–111°F	65–85°F 29–111°F	40–55°F 30–70°F	40–55°F 30–70°F	65–85°F 29–111°F	65–85°F 29–111°F	65–85°F 29–111°F	65–85°F 29–111°F

Subsystem Design
The system level DRMP must be used by the contractor to develop design requirements for items that make up the system. At the subsystem and parts level, consideration must be given to changes in the DRMP environmental profiles because of stresses induced by the system itself (e.g., mounting provisions, heat transfer, shock and vibration amplification/attenuation).

DRMP Requirements May Change
The DRMP should accurately describe real-world operational and environmental conditions that are relevant to the materiel being developed. It provides a consistent baseline for design and test decisions regarding materiel performance and survival under realistic operational and environmental conditions. The DRMP is a living document that should be reviewed and updated periodically as new information regarding operational and environmental conditions becomes available. Significant differences can often be found between initially specified profiles and actual profiles determined during testing or operational use. For example, the thrust requirements shown below were found to vary significantly from those initially specified. DRMP requirements should include "worst case" conditions, which are not always the combat mission. In the case of the aircraft engine example shown below, the training mission placed the greatest amount of stress on the engine. This resulted in the composite profile shown, that was integrated into the overall DRMP.

Design Requirement | Usage | Composite Profile



Fighter Mission | Training Mission | Composite Mission (Fighter, Attack & Training)

Figure 4. Aircraft Engine Example

APPLICATIONS
The prime contractor should establish an Integrated Product Team (IPT) with all major subcontractors, including environmental engineering specialist, to refine and further detail the DRMP based on the contractor's design concept. This should be completed prior to start of detail system design (e.g., by systems requirements review) and updated as the detail system design progresses down, as appropriate, to the part level.

The DRMP establishes the technical foundation and reduces program risk by providing the systems engineering framework for performance of the following fundamental design and test processes:
- Trade studies.
- Parts and material selection.
- Parts derating.

- Stress/fatigue analysis.
- Corrosion analysis.
- Thermal analysis.
- Worst case analysis.
- Failure modes, effects and criticality analysis.
- Fault tree analysis.
- Sneak circuit analysis.
- Vulnerability analysis.
- Life/Reliability predictions.
- Qualification tests.
- Reliability tests.
- Supportability analyses.

High program risk results from designing a system without understanding the worst-case DRMP. Designing to nominal conditions may result in system failure under worst-case missions. However, designing only to worst-case profiles may result in excessive and unnecessary program cost. The DRMP should include both the nominal as well as worst-case.

ENVIRONMENTAL PROFILE RESOURCES

Basic sources of information for tailored development of the DRMP includes:

- MIL-HDBK-310 provides worldwide and regional ambient climatic data, useful as inputs for developing the DRMP natural environmental profile.
  - Climatic data are presented in terms of their values and frequency of occurrence during the most severe month. The selection or tailoring of the applicable frequency of occurrence for a specific system must be determined by the procuring activity.
  - Long-term climatic extremes presented are values that are expected to occur at least once, for a short ($\leq$ 3 hours) duration, during 10, 30, or 60 years of exposure.
- MIL-STD-810F provides guidance for developing a system's life cycle environmental profile, including:
  - Definition of environmental stress sequences, durations, and levels.
  - Development of analysis criteria tailored to the system and its life cycle.