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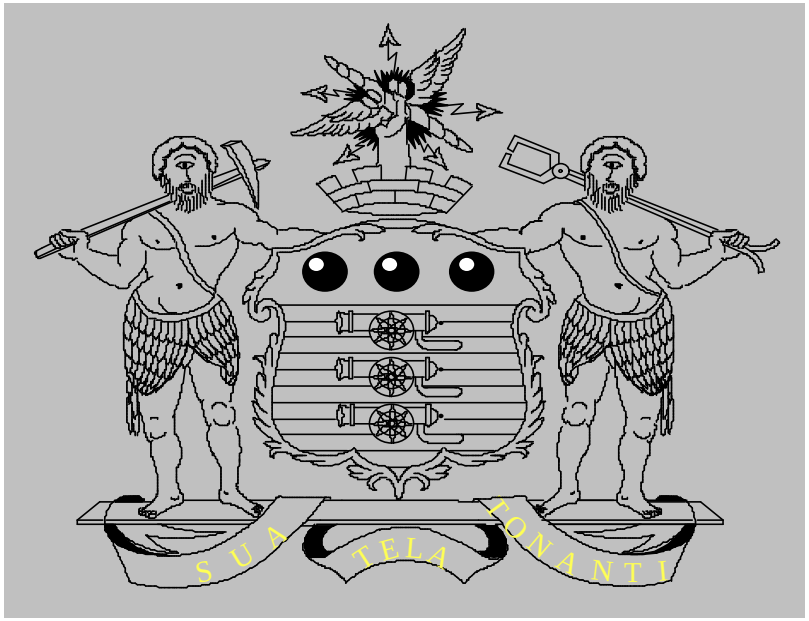

UK ORDNANCE BOARD PROCEEDING 124(1)

SMALL ARMS, CANNON AND GRENADE LAUNCHER MOUNTING SYSTEMS

SCOPE

The following categories of mount are considered:

- **Ground mounts.**
- **Special terrain mounts (such as a snow sled).**
- **Vehicle mounts.**
- **Interface mounts (such as soft mounts, cradles or yokes).**
- **Helicopter door mounts.**
- **Ship or small craft mounts.**

Detailed Information Provided

- Design Safety Principles and Requirements.
-
- Suitability for Service Requirements.
-
- Safety Test Requirements for Weapon Mounts.
-

Design Safety Requirements

- Mounting System Strength of Design
- Stability
- Locking Mechanisms
- Arc and Depression Stops
- Feed System
- Mechanical Triggers and Electronic GCU
- Ejection System
-

Design Safety Requirements

continued

- Applied Safety
- Human Factors
- Sights
- Toxicity
- Noise/Blast

Suitability Requirements

- Accuracy
- Consistency
- Firing Arcs
- Ejection
- Functioning
- Mechanical Reliability
- Functional Reliability

Suitability Requirements

Continued

- Durability
- Operational Factors
- Human/Handling Factors
- Maintenance
- Ammunition Supply

Safety Matrix

- Evidence Needed
- Service Environment Agreed By The User
- Technical Details of Mount
- Design safety Principles and Requirements
- Safety and Sequential Trials and Tests
- Variations From Normal Testing and Standards

Design Safety Assessment Aim

- To ensure the design safety principles have been met
- Identify:
  - Failure Modes
  - Interface Problems
  - Hazards to Personnel
  - Technical Risk

Strength of Design

- Firing Test
- Trundling Test
- Special testing for Airborne and Shipborne mountings
- User Testing representing the most severe in-service usage

Safety Assessment Phases

- Phase 1. Design Safety Assessment
-
- Phase 2. Manned Firing Clearance Assessment
-
- Phase 3. Safety and Suitability for Service Trials and Assessment

Phase 1 - Design Safety Assessment

Conduct initial design safety assessment

Consider Evidence from:

- Fault Tree Analysis (FTA)
- Failure Modes, Effects and Criticality Analysis (FMECA)

Assess results from development and other trials

Phase 2 - Manned Firing Clearance Assessment

Conduct Safety trial programme

Recommendation for:

- Manned firing clearance (MFC)
- Certificate of Clearance for Use (CCU) for Naval applications
- Service Deviation for air applications

Initial User Trials

Phase 3 - Safety and Suitability for Service Trials and Assessment

A trials programme compiled to demonstrate both safety and suitability for service in the specified environment and to address any areas of concern identified in Phases 1 or 2

Typical Test Sequence

- Development Tests
- Initial Safety Tests
- Trundling Trial (if applicable)
- Initial User Trial
- Main Safety and Technical Tests (including sequential and environmental)
- Main User Trial

Safety Trial - Initial Test Machine Gun

- One box at maximum depression.
- One box at maximum elevation.
- Two boxes at different angles of depression, elevation and traverse selected to cover the required arcs
- Two boxes at selected traverse, elevation and depression positions at which firing arc and depression stops are applied.

Main Safety Firing Test
Machine Guns

- Ten boxes at different angles of depression, elevation and traverse selected to cover the required arcs (to be fired in bursts at the specified rate of fire)

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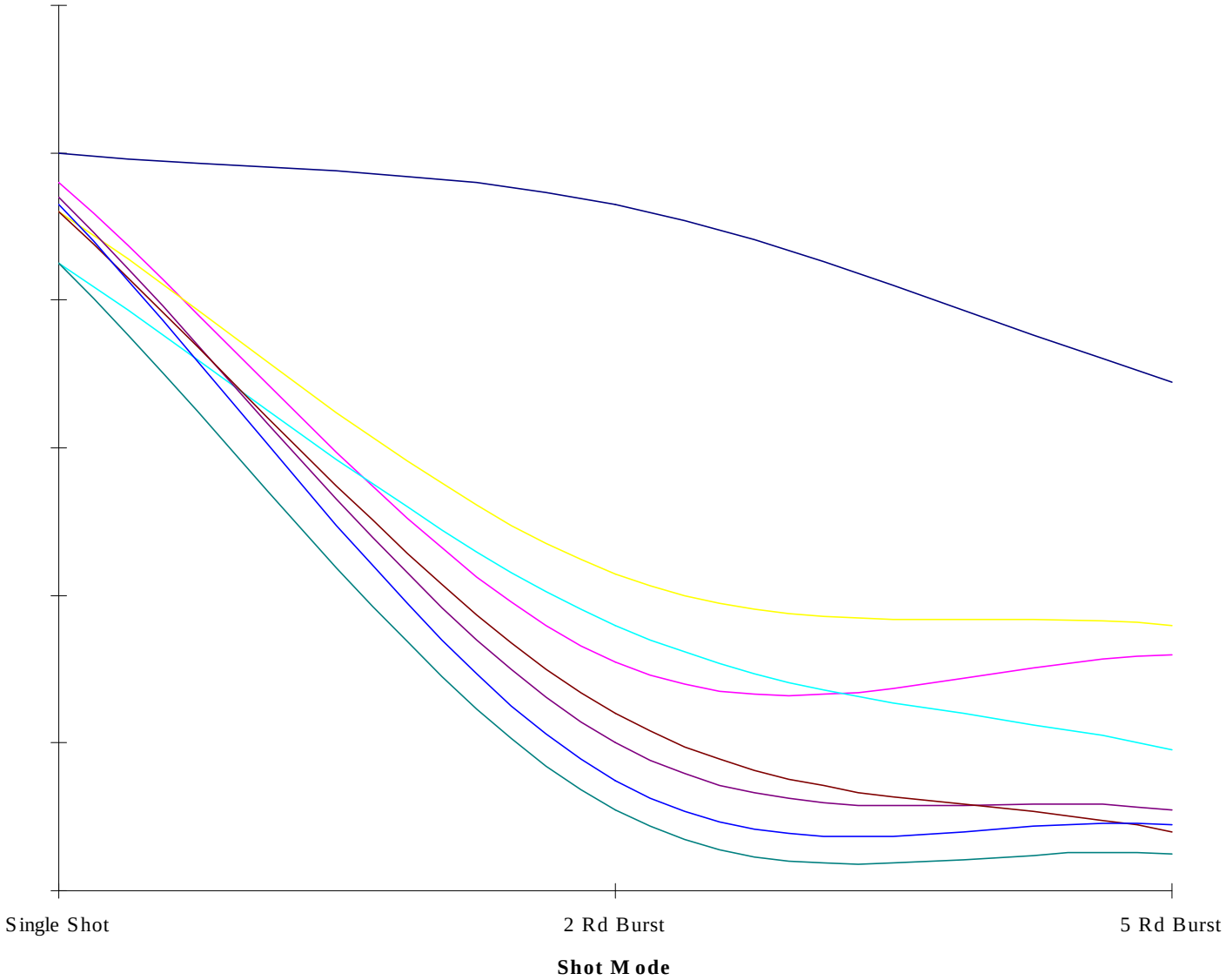
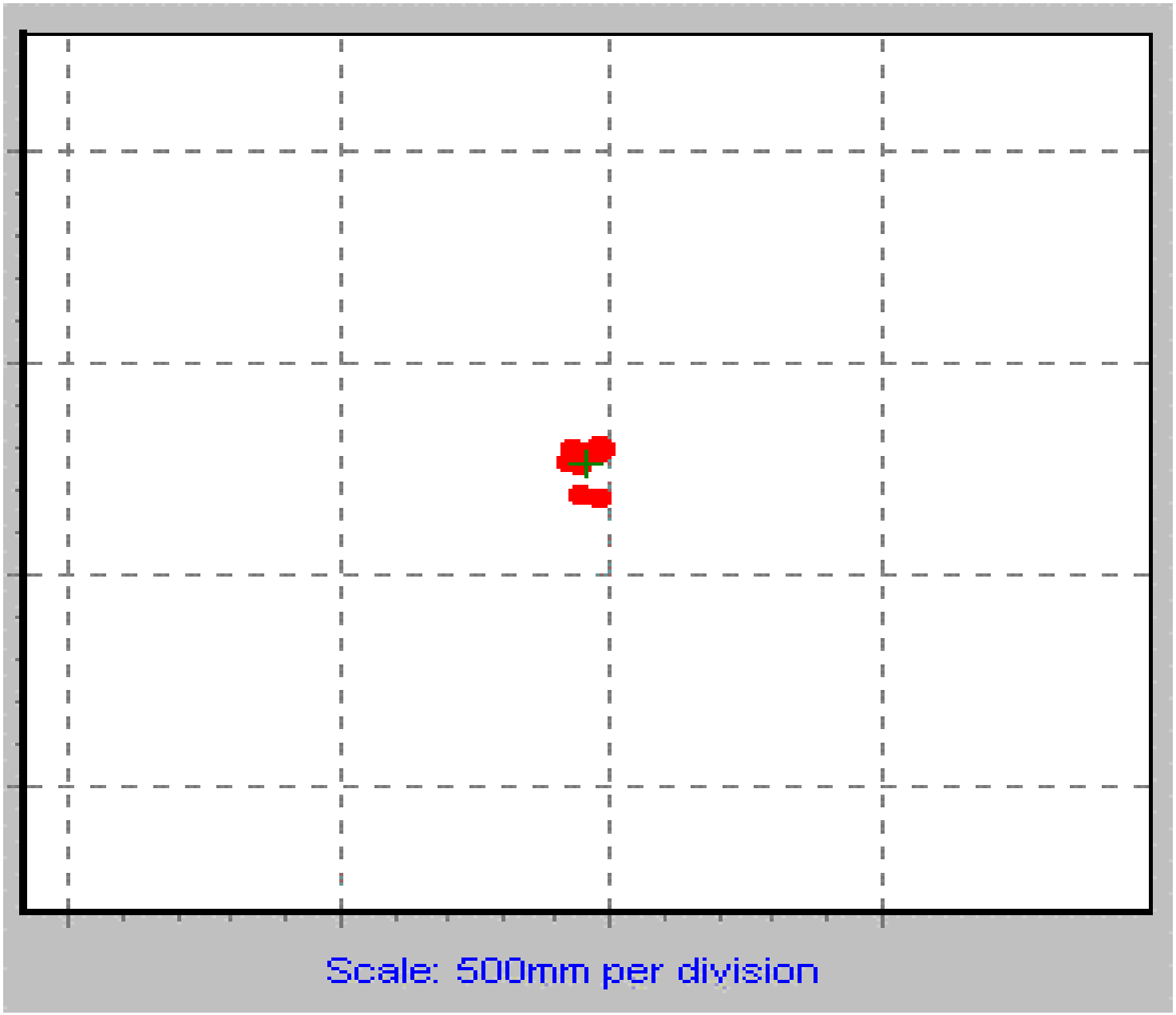
Technical Tests

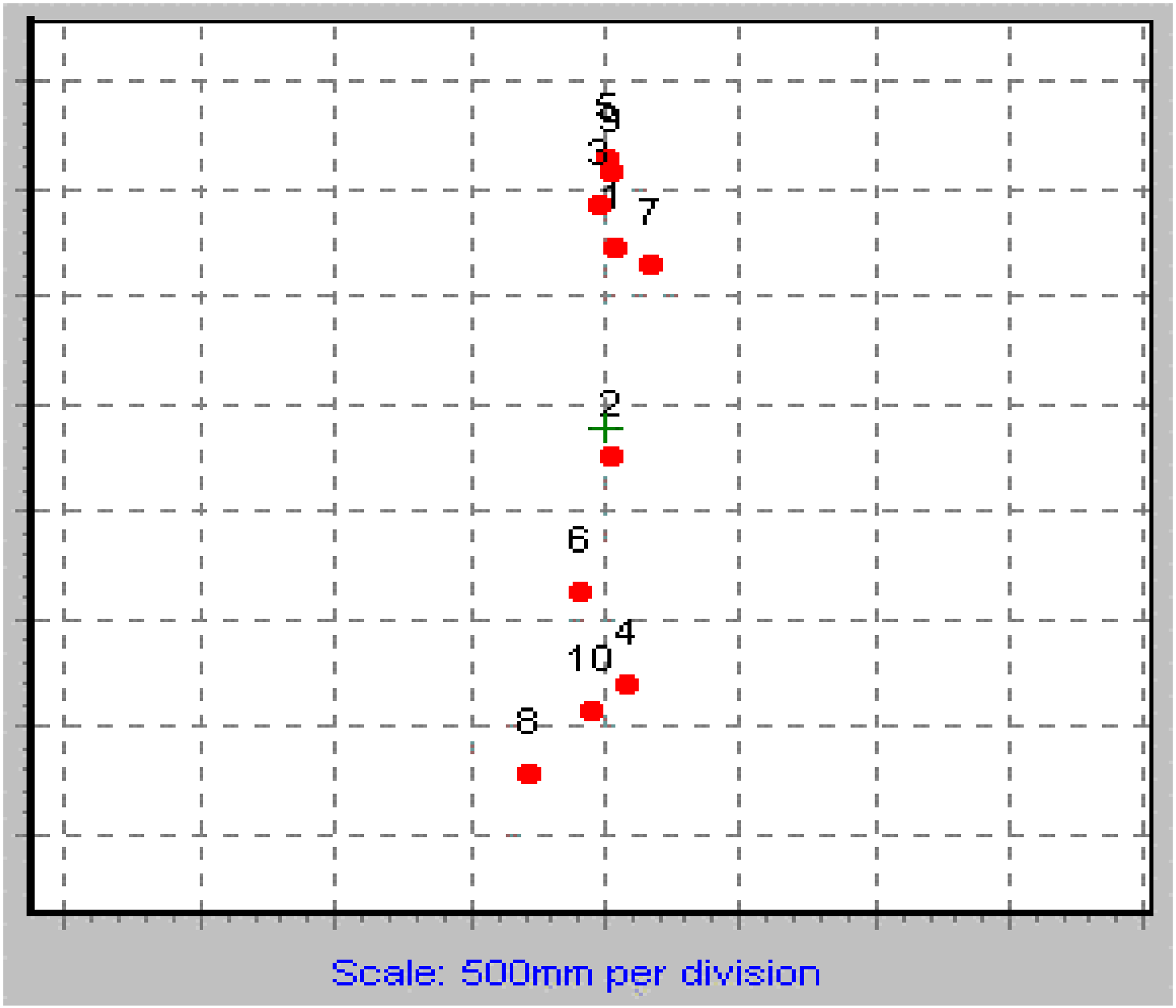
- Environmental
- Consistency
  - All natures
  - Different modes of fire
  - Different Mount Orientations
- Accuracy
- Functional and Mechanical Reliability
- Preliminary Man Machine Interface (MMI)

ERROR BUDGET - Probability of a Hit

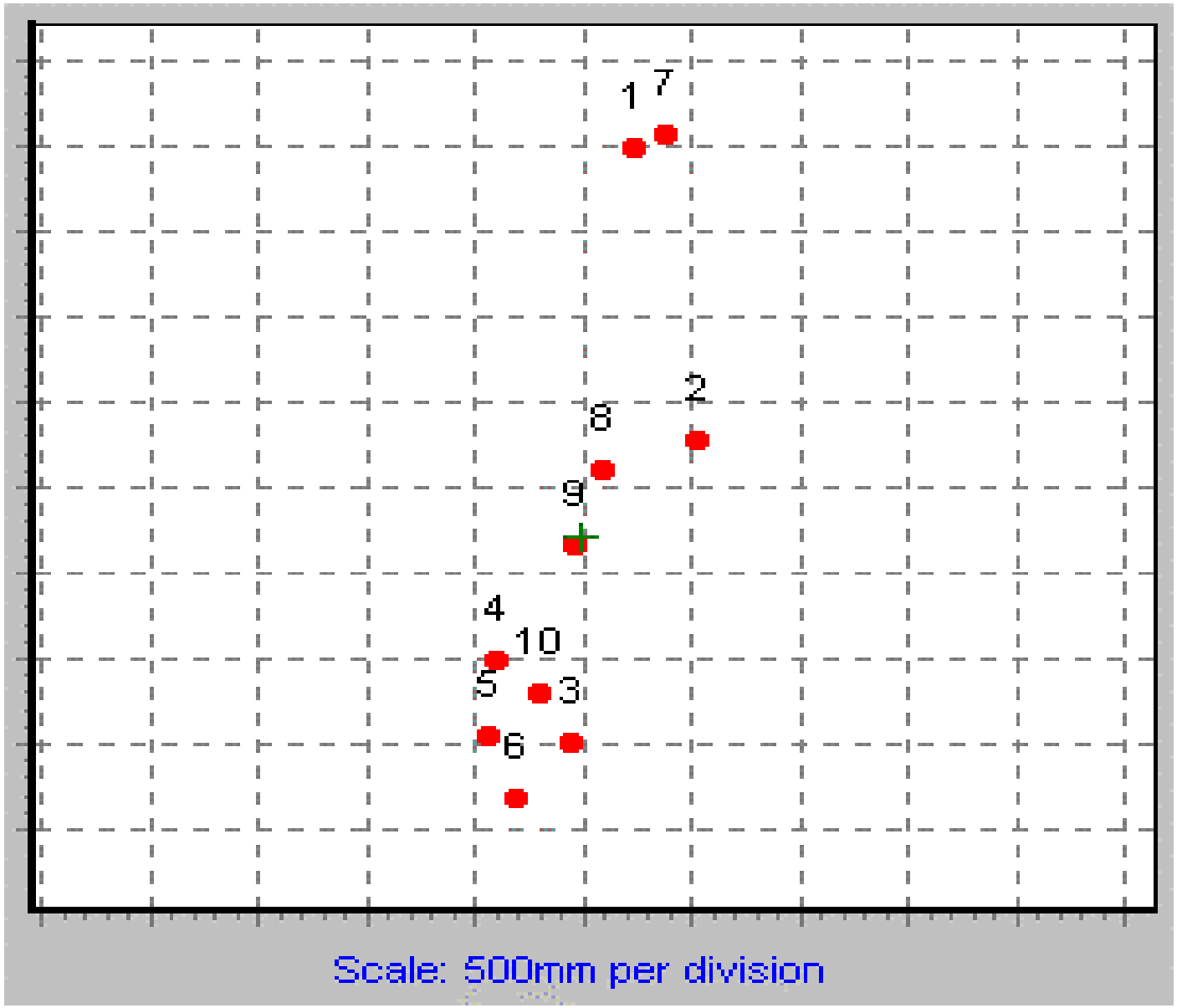




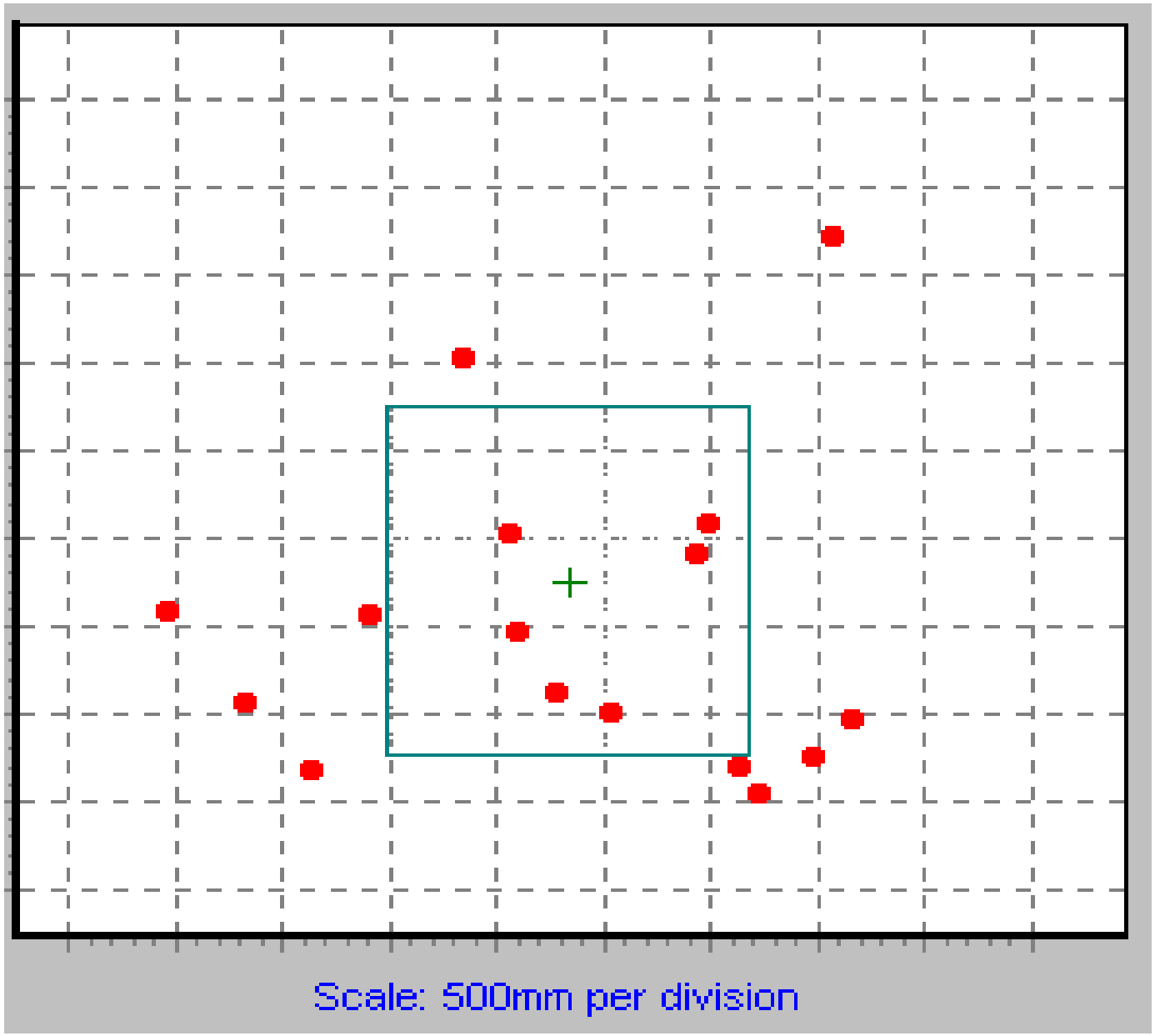
Single Shot



2 Round Bursts

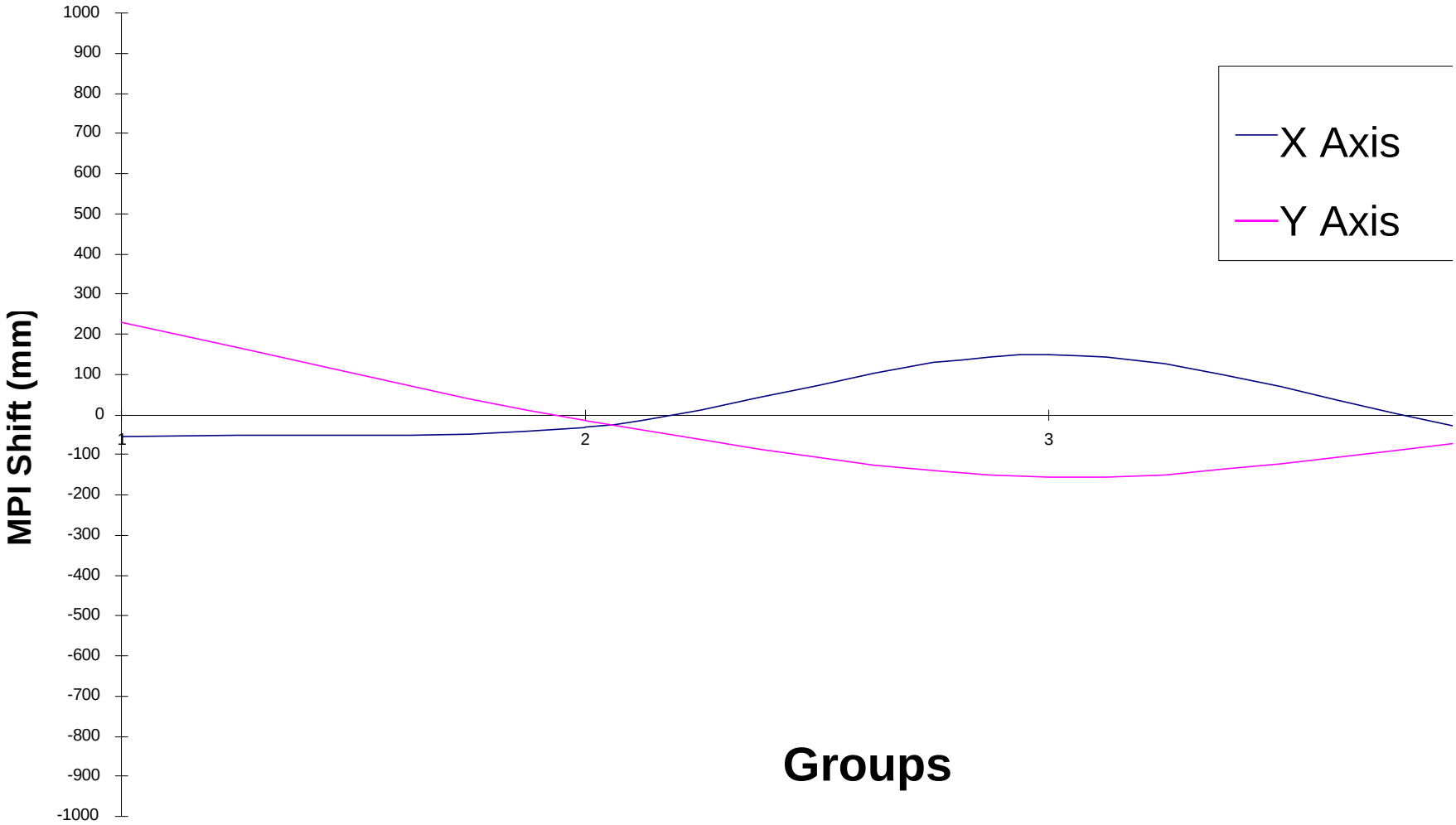


5 Round Bursts

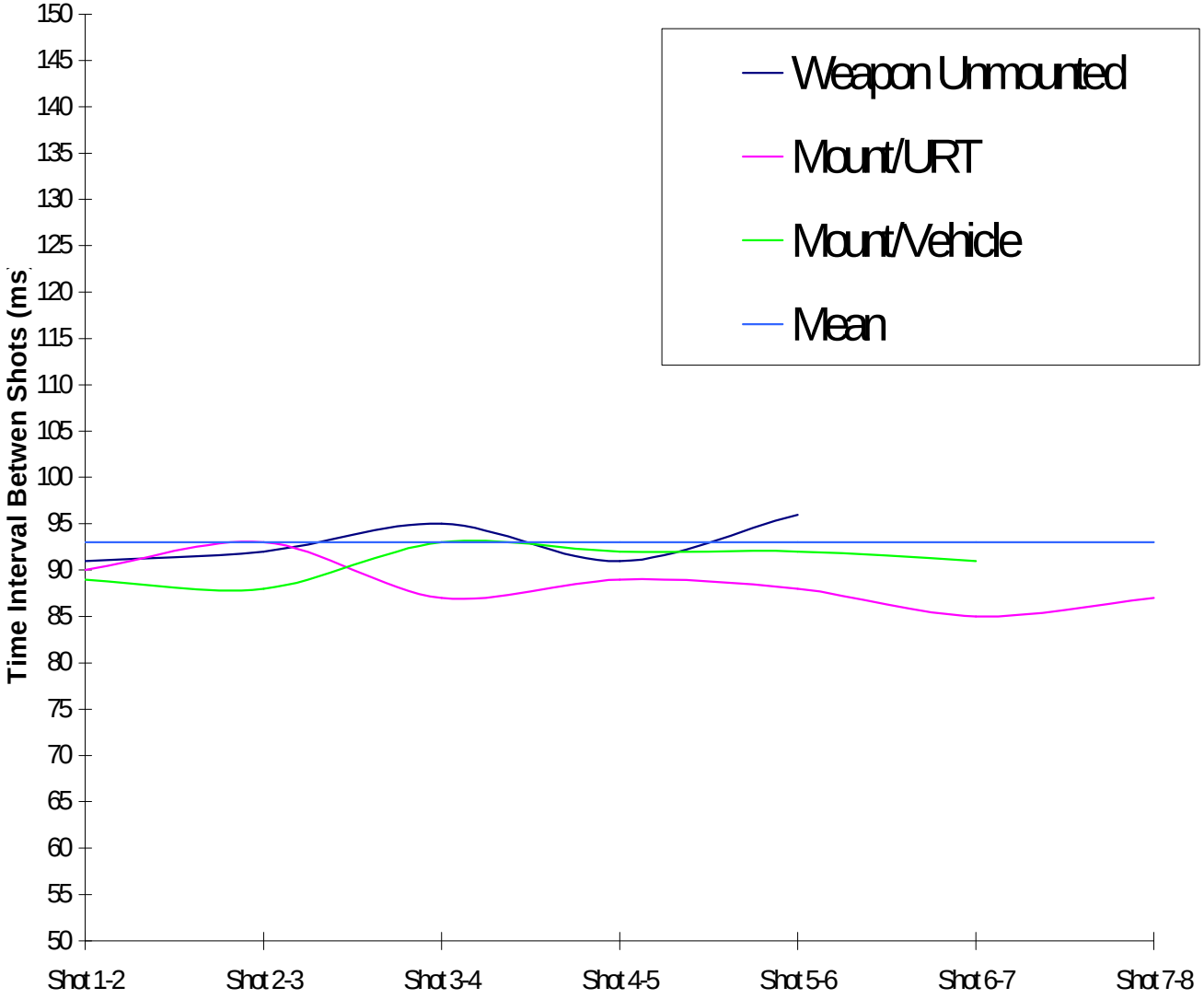


Firer Effect – 5 Round Bursts

MG Mount - MPI Shift @ 500 m



Comparison of Time Intervals Between Shots



NDIA INTERNATIONAL SMALL ARM SYMPOSIUM 1999

WEAPON MOUNTING SYSTEMS –ASSESSMENT OF SAFETY AND SUITABILITY FOR SERVICE.

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1. Good afternoon gentlemen my name is Keith Cook and I am the Director, Project Development of System Design Evaluation Limited. My co-presenter is Major John Conway who is from the Infantry Weapons Division of the United Kingdom Ordnance Board.

2. Two years ago in Reno Nevada we made a presentation to you covering the assessment of safety and suitability for service of small arms and small arms ammunition. In the intervening period we have not been idle. My firm, which provides technical support to the UK MOD, was tasked to provide a draft Pillar Proceeding covering the assessment of safety and suitability for service of mounting systems. John and I are the co-authors of this latest Ordnance Board Proceeding. Some of you will be aware that a Pillar Proceeding is a document in which the Ordnance Board publishes the principles and guidance for the safety and suitability for service of weapon systems.

3. Until recently the only such proceeding covering mounting systems was Pillar Proc P114. This proceeding deals with the safety and suitability for service of land service weapon installations, excluding rocket systems and guided weapons. As such, it deals primarily with large weapon systems such as tanks and self-propelled guns. However, the world we now live in is far removed from armoured juggernauts manoeuvring on the plains of central Europe. Today's flavour is light, airportable, rapid reaction forces. The equipment needs of such forces are different and we are seeing a proliferation of light vehicles mounting cannon and support weapons as well a resurgence of interest in ground mounted support weapons. Hence the need for a Pillar Proceeding which dealt in detail with such systems and took account of the latest safety philosophy and techniques.

4. Perhaps before getting into the meat of this new document it would be worthwhile to remind ourselves what the purpose of such a document is. It sets out the methodology for the assessment of risk by identifying, through design safety and suitability assessments, trials and other information, all the significant risks, which might be presented by operating the weapon on the mount in the defined service environment.

Health and safety legislation within the United Kingdom now requires the services to follow the ALARP principle. That is the reduction of risk to As Low As Reasonably Practical. We also have to ensure that any residual risk is defined and is acceptable in relation to the intended use of the system as a whole.

5. However, back to the case in point, mounting systems. Pillar Proceeding P124 deals with mounting systems for the following weapon types; small arms, cannon and grenade launchers. It covers ground mounts, special terrain mounts, such as a snow sled, vehicle mounts, interface mounts such as soft mounts, cradles or yokes, helicopter door mounts and finally, but not least, ship or small craft mounts. For the United Kingdom this document applies to sea, land and air service weapon mounts.

6. The document not only sets out the methodology of assessment but also provides very specific advice to both designers and manufacturers. This advice is contained in the annexes to the document. These annexes cover the design safety principles, safety and suitability for service requirements and the safety test requirements. I do not intend within the short scope of the presentation to cover these annexes in detail, but merely to highlight some of their contents.

7. First the design safety requirements. On the Vu foil you can see the headings of this section of the document. It is of course a primary concern that the mounting system strength of design is such that it can withstand the maximum firing loads of the weapon at all orientations of the mount. Equally, it must be able to deal with the stresses generated by either vehicle trundling or platform movement if applicable to the mount being assessed. Evidently it is important that the system shall remain safe to operate under all specified climatic, mechanical and electrical environmental conditions with no single fault or failure resulting in either unintentional firing of the weapon or it becoming unsafe. It is equally important that any mount fitted to a platform, when correctly set and adjusted, shall be incapable of allowing the weapon to be brought to bear on either crew members, in their allocated operating positions, or the platform. Ejected cases or links must not pose a hazard to the crew or platform.

8. Moving on to the suitability requirements. Accuracy and consistency head the list since the whole purpose of the mounting system must be to allow the weapon to fire both consistently and accurately. Touching on functional reliability it is important that the weapon and mount be able to function satisfactorily in the anticipated operational environment. Such an environment may well include high and low temperatures, blown sand and dust, freezing and driven rain. With regard to maintenance it would, of course, be nice if a mounting system could survive on benign neglect, or to put it more formally, the mounting system should require the minimum of maintenance.

9. I apologise for skipping through these requirements and principles. Time does not allow us to deal with it in any more detail.

10. Testing costs both time and money and uses often scarce resources. Therefore, if we can avoid unnecessary testing we should do so. Therefore the applicability of each of the requirements to a particular mounting system must be considered to avoid unnecessary testing. Such an assessment of applicability leads to the generation of the safety matrix. This is a document that will be issued by the Ordnance Board. To a degree, it is a living document and will continually be updated throughout the life of the project. Initially it will cite the evidence that is needed for the assessment of safety. It will define the service environment agreed by the user. It will include the technical details of the mount and will set out the applicable design safety principles and requirements. It will also detail the safety and sequential trials and tests as well as setting down any variations from normal testing and standards. When mature, it will provide an audit trail for the identification and containment of risk.

11. The assessment of safety will be based on the service environment. The User will define the operating environment in his service requirement document and cardinal point specification. This will then be amplified and further specified in an OB form 41. This document, which covers both training and operations, defines the life of the mount. That is; its manufacture to target to disposal sequence.

12. Moving on to the design safety assessment. The purpose of the assessment is to ensure that the design safety principles have been met. It will also identify failure modes, interface problems, hazards to personnel and technical risk. It is important that the design safety assessment is conducted as early as possible on a mount representative of production standard and, in any case, before the technical, environmental and User trials.

13. There are a number of general considerations for this assessment. First, any small arm ground mount will be used world wide. It will be used on surfaces that may well affect its stability. It is also a certainty that mounts will be exposed to the worst combinations of climate and rough handling. Mountings may also expose ammunition to solar radiation and for vehicle mounts the inclination of the platform may affect a firer's ability to control the mount.

14. The strength of design of the mount will be demonstrated by a firing test and either a trundling test or, if they are airborne and shipborne mounts, by testing simulating those platforms. The final strength of design demonstration will be User testing which should represent the most severe in service usage. The initial safety firing test should be conducted with ammunition generating the highest recoil load. For the trundling test the mount should be configured in such a way that it will be exposed to the greatest dynamic loads generated by the platform.

15. The safety assessment will be conducted in three phases. The first is the initial design safety assessment. This will lead on to the second phase, which is the manned firing clearance assessment, and once this is completed to the third and final phase which is the safety and suitability for service trials and assessment.

16. In phase one the initial design safety assessment would be conducted. This would consider evidence from the Fault Tree Analysis (FTA) and the Failure Modes, Effects and Criticality (FMECA) analysis to ensure that no single fault or failure could result in either unintentional firing of the weapon or it becoming unsafe. The results from development and other trials would also be assessed at this stage.

17. Phase two, the manned firing clearance assessment. A successful outcome to the initial safety tests combined with a satisfactory initial design safety assessment would lead to recommendations for man firing clearance for land service or a certificate of clearance for use for naval applications or a service deviation for air applications. This clearance would allow initial user trials to commence with the risks associated with that testing clearly defined together with any provisos on usage where significant risk had been identified in the initial safety assessment.

18. The third and final phase is the safety and suitability for service trials and assessment. This trials programme would be compiled to demonstrate both safety and suitability for service in the specified environment and address any areas of concern identified in phases 1 or 2.

19. The typical trial sequence for a mount would begin with development tests carried out by the manufacturer. If these are to be taken into account by the Board it is important that they are well documented and supported by credible data. Ideally the Board should be associated with such testing as it may allow the burden of technical testing to be reduced in later phases.

20. Initial firing safety tests would be followed by a trundling trial, if it were applicable, of at least 1600 km (1000 miles) over terrain and at speeds representative of operational usage. This in turn would be followed by the initial user trial, which would then lead to the main safety and technical tests, including the sequential and environmental trials. Finally, the main user trial which in addition to fully rehearsing all the intended operational scenarios might well include testing at the specified climatic extremes.

21. I intend to illustrate the safety test sequence using a machine gun as the example. However, the document lays down both the initial safety test and main safety tests for machine guns, cannon and grenade launchers.

22. The initial machine gun safety test, as you can see, is not an excessive test. The box referred to is the normal ammunition container for that weapon system. For example the M2 .50” heavy machine gun ammunition box contains 100 rounds.

23. So for this initial test 100 rounds would be fired at maximum depression, 100 rounds at maximum elevation and 200 rounds at different angles of depression elevation and traverse selected to cover the required arcs. A total of only 400 rounds.

24. Of interest, the main safety test which would be incorporated in the technical trials is 10 boxes or in the case of the .50” HMG 1000 rounds

25. Once the initial safety test and trundle trial are completed and provided Manned Firing Clearance is recommended an initial User test will take place. Such testing will identify any man machine interface problems and will lead on to the more detailed technical testing and the final User testing. This sequence of testing is designed to minimise both safety and technical risk.

26. I will illustrate this section on testing with a specific example. Shortly, we are to introduce into service a weapon mount installation kit for a Land Rover. This kit comprises of a frame system, fitted to the rear of the vehicle, supporting a ring mount, a folding interface mount (FIM), a buffered soft mount, and a heavy machine gun. For crew protection a buffered general purpose machine gun mount on a swinging arm is fitted forward of the commanders position in the front of the vehicle. Of interest the Folding Interface Mount allows the vehicle to be deployed as an internal load by the CH47 helicopter.

27. After the initial safety test and User assessment this mounting system was subjected to technical testing. The technical tests sought to establish the accuracy and consistency of the systems with all natures of ammunition, in different modes of fire and in different mount and vehicle orientations.

28. Throughout the tests the functional and mechanical reliability of both the weapons and the mounts was closely examined. In particular the combined effect of the mount and platform on the weapon cadence and rate of fire was monitored.

29. Although the examination of the man machine interface falls within the remit of User testing a preliminary examination was conducted during the technical testing to ensure that the design safety and suitability principles covering handling and human factors had been met.

30. The firing tests were conducted using standard measuring equipment for rate of fire and velocity. However, the shot position data was gathered using radio controlled acoustic shot position indicators. The advantage of using such a system is that it has a very large detection area, which for a .50” round is 30m x 30m, and has the ability to record the sequence of shot arrival. This is something you cannot possibly do with a physical target. Using this type of equipment it is possible to fire and record shot position data for several thousand rounds in one day, whereas with a physical target the number of rounds might be as low as 200.

31. From the data gathered by the SPIs shot distribution patterns, particularly in automatic fire can be analysed and these provide vital clues to mount behaviour.

32. The firing test methodology used to assess this mounting system was geared to produce an error budget which would clearly identify any degradation in performance and the component of the system responsible for that degradation. The rationale being that if performance enhancements are subsequently sought this methodology allows resources to be concentrated on areas most likely to yield significant improvement. Even if improvement is not sought such an error budget clearly indicates to the User the likely performance of the system under a variety of circumstances.

33. To compile this error budget first the weapon alone was fired from a universal range table in order to establish its base performance. Then the weapon and soft mount were fired from a URT and then the weapon, soft mount, FIM and ring mount were fired from a URT.

34. Then the mounts and weapon were fitted to the platform and fired with the platform in various orientations. Over the front of the vehicle, flank, rear and also with the vehicle inclined so the weapon was firing at maximum elevation and maximum depression.
35. Finally, the handling of the system was assessed both by day and night in terms of the time and rounds needed to successfully engage a target.

36. The data generated by this testing resulted in an error budget, which is illustrated in this graph. The comparison of performance is based on the probability of hitting the NATO, head on, light truck target. You will note that the graph has no values and I have carefully not mentioned the target range for which probability has been calculated. The X axis of the chart covers the different modes of fire; on the left single shot, central – short bursts and the right long bursts. The top line you can see is the weapon fired from the URT. You can see that there is some deterioration, but not a great deal, as you move from single shot to automatic fire.

37. The concentration of lines that you can see, below the weapon base line, reflect the differing performance of the mounts and system under a variety of conditions. Each line tells a story. One of the most obvious being that if you wish to engage a point target use single shot mode. The reasons for this become quite evident when you view the shot distribution patterns. Here we can see a single shot group. As you can see it's a nice tight group. However, when you move on to short bursts, not surprisingly, you get a split group.

38. The rounds at the top are the initial rounds from each burst. From this data you can see the advantage of using the type of shot data gathering equipment that we were using. We were able to tag each shot with a number so we know when it arrived. You can see that in this case , 2 round bursts, the first shot is on the point of aim and the second shot invariably goes low. This particular data was gathered at 500m.

39. Moving on to the longer bursts you can see a similar pattern emerge. However, as with the shorter bursts the first round is on the point of aim. In this particular serial

they are rounds 1 and 7 at the top of target. The remainder of the rounds form a group low and slightly left of the POA. This shot distribution poses an interesting question as to what the Correct Zero Position should be.

40. These serials, the single shot, the two round and the five round bursts were all fired with a locked mount. With the locks released and the mount shoulder controlled the results are far less predictable and here you will see the firer effect on the system. There is no clear distribution pattern and there is a fairly significant lateral spread. The lesson to be drawn is that where possible fire with a locked mount as the results are far more predictable.

41. A major concern with mounting systems, which can be locked, is the effectiveness of those locks. This can be monitored by firing a series of groups with the mount locked. Subsequent examination of the MPI shift between groups will indicate the effectiveness of the locks. This vu-foil shows the shift in MPI from group to group for a machine gun mount firing at 500m.

42. The red line is the elevation axis and the blue line, the azimuth axis. As you can see the mount is remarkably stable with only a very minor shift from the mean position. Indeed the maximum shift in any direction is some 200 mm or 8" with the mean shift in azimuth being 75 mm (3”) and in elevation 115 mm (4.5”). I think you will agree that at 500 m these are not significant figures.

43. Earlier I mentioned monitoring the effect of the mounting system on weapon cadence. This next vu foil illustrates the comparison of time intervals between shots. Here we have the weapon unmounted, the weapon and mount fired from a universal range table and the mount on the vehicle.

44. This data would indicate that the mounting has had no significant effect on weapon cadence. Indeed the most stable appears to be when the weapon is on its mount on the vehicle.

45. Regrettably time will not allow me to go into testing in greater detail. If anyone would like to discuss our test methodology please come and see me after the presentation.

46. Hopefully, within the context of a short presentation we have been able to give you a flavour of the way in which the United Kingdom will assess and test mounts. We would like to think that is a step forward in the management of both safety and technical risk. Our ultimate purpose is to ensure that the soldier, sailor or airmen is provided with mounting systems which are safe and suitable for service.

47. Finally, I think it is important to emphasise that, for mounting systems which are to be procured for the United Kingdom, the very early involvement of the Ordnance Board, even at the development stage, can be helpful. It ensures that some major stumbling

block is not placed in the way of procurement later and that by shaping the nature of development testing the overall burden of technical testing can be significantly reduced, saving time, money and resources.

48. I thank you for your attention and would mention that the Pillar Proceeding is an unclassified document and is freely available to anyone that wants it.

49. Are there any questions?