RADAR CREDIBLE TARGET – 1 (RCT-1) FLIGHT TEST : AN INNOVATIVE SOLUTION FOR GROUND BASED RADAR - PROTOTYPE (GBR-P) TESTING

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ABSTRACT (U)

This paper provides an overview of the innovative solutions developed to meet the requirements of the target set designed for the Ground Based Radar - Prototype (GBR-P) Radar Credible Target (RCT-1) flight test. The methodology used to design and plan this Target Of Opportunity (TOO) mission as a Minuteman III Associated Operation mission is presented. Solutions developed for the fundamental target designs and their truth data instrumentation are presented in context with the deployment schema developed for RCT-1. In addition, an innovative and cost-effective chaff target concept to be tested on RCT-1 is presented with respect to possible out-year Integrated Flight Test requirements. Emphasis is placed on the lessons learned to date from this process, and applicability to further NMD flight testing.

1. INTRODUCTION (U)

(U) The Radar Credible Target – 1 (RCT-1) mission is a Ground Based Radar (GBR) dedicated flight test mission. This mission is being conducted to satisfy test needs associated with the GBR program in general, and the Ground Based Radar – Prototype (GBR-P) in particular. The GBR-P is a National Missile Defense (NMD) testbed radar located on Kwajalein Island in the Marshall Islands. The GBR-P is a large (105 square meter aperture), X-Band, phased array radar with a 2000 km single pulse detection range and simultaneous electrical/mechanical scan and tracking capability.

(U) While the RCT-1 mission is GBR-dedicated, various NMD Weapon System elements or others may choose to participate on a non-interference basis. One known RCT-1 participant is the USAF Reentry Vehicle Applications Program, which will conduct a reentry plasma effects experiment using the RCT-1 Reentry Vehicle (RV).

(U) The RCT-1 mission will be conducted as an Associated Operation on the Minuteman III Operational Test (OT) Mission GT-170GM, which is scheduled to fly on 10 February 1999. The RCT-1 mission will use the MM III as a delivery system; RCT-1 targets will occupy one of the three RV seats on the MM III bus. The GT-170GM OT will fly a normal MM III OT trajectory that originates in California at Vandenburg Air Force Base and terminates in the Marshall Islands at the Kwajalein Missile Range. In order to avoid interfering with normal conduct of the MM III OT, the RCT-1 target set will be deployed from the MM III bus as a single unit, or target stack. Individual targets will be deployed from the RCT-1 target stack after release from the MM III bus. The RV used on RCT-1 is expected to survive reentry; no other RCT-1 targets will survive to impact.

(U) The U.S. Army Space and Missile Defense Command, Ballistic Missile Targets - Joint Project Office, Strategic Targets Product Office, SMDC-TJ-S, is the executing agent for NMD strategic targets for the Ballistic Missile Defense Organization (BMDO), and as such directs Sandia National Laboratories (SNL) in the development of the targets payload systems required for the RCT-1 flight test.

1.1 RCT-1 TEST OBJECTIVES (U)

(U) The planned GBR-P test program uses a combination of testing and analysis to verify the ability of the NMD-GBR to meet requirements dictated by NMD Weapon System requirements documentation and the NMD-GBR Technical Requirements Document (TRD). The planned GBR test program provides for assessment and validation of radar requirements pertaining to the following:

- **Basic radar parametric performance confirmation, to include:**
  Radar Cross Section (RCS) measurement accuracy, angle measurement accuracy, range change accuracy, absolute range measurement accuracy, range sidelobes, dynamic range, range resolution, system sensitivity, angle sidelobes, and Checkout/Alignment/Calibration.
- **Basic radar NMD Weapon System support functions, to include:**
  Search, acquisition, track, discrimination, and kill assessment.
- **Inter-operability with the NMD Weapon System BMC3, to include:**
  Functionality of the BMC3/GBR hardware and software interface; appropriate response to BMC3 radar tasking; generation/transmission of In-Flight Target Update reports; generation/transmission of Target Object Map reports; real-time kill assessment reports; and radar status reports.
- **Verification and validation of GBR analysis tools, to include:**
  The GBR Hardware In The Loop simulation tool and other models and simulations.

(U) The RCT-1 mission is designed to contribute to examination of the above areas within the framework of a progressively stressing, long-term test program. These areas are pertinent to the GBR program in general and to the GBR-P in particular. Mission objectives for the RCT-1, therefore, fall into two categories: General Mission Objectives and Specific GBR-P Mission Objectives. General Mission Objectives assist in the development of the GBR and other radars used in the NMD Weapon System, and contribute to the conduct of a progressively stressing NMD test program; Specific GBR-P mission objectives test GBR-P capabilities.

(U) In addition to the mission objectives discussed above, there is an associated experiment on RCT-1 known as the Reentry Plasma Experiment (RPE) which has the following mission objectives:

- Assessment of GPS antenna performance on reentry vehicles, including signal loss due to plasma during reentry and signal reacquisition after emerging from plasma blackout prior to impact
- Assessment of 50 watt C-Band transponder effectiveness for RV acquisition and lock-in by small Kwajalein radars without use of KREMS

1.2 <u>General RCT-1 Mission Objectives (U)</u>

(U) General RCT-1 Flight Test Mission Objectives are stated below in prioritized form. Priority 1 represents the highest priority and Level 2 a lower priority. No attempt is made to prioritize objectives within each level. Priorities shown are subject to change depending upon radar maturity and success of testing prior to the RCT-1 mission. General RCT-1 Flight Test Mission Objectives are:

<u>LEVEL 1 (U)</u>

- Mitigate NMD Weapon System Integrated Flight Test Mission Risks
- Support an FY00 deployment decision
- Validate Radar Models, Simulations, and the GBR Hardware In The Loop (HWIL) testbed tool
- Stress the GBR-P performance envelope to assist in development of the Objective System
- Support the development of discrimination algorithms

<u>LEVEL 2 (U)</u>

- Provide threat traceable objects not previously viewed by the GBR-P
- Support evaluation of the FY99 Critical Test Objectives
- Verify Capability against the NMD Weapon System threat
- Stress the GBR-P performance envelope to assist in development of the Objective System
- Support the development of discrimination algorithms

1.3 <u>GBR-P Specific RCT-1 Mission Objectives (U)</u>

(U) RCT-1 Flight Test Mission Objectives specific to testing the GBR-P are stated below; Priority 1 represents the highest priority and Level 2 a lower priority. No attempt is made to prioritize objectives within each level. GBR-P Specific RCT-1 Flight Test Mission Objectives are:

LEVEL 1 (U)

- Non-realtime discrimination evaluation against performance stressing targets
- Evaluate capability against closely spaced objects
- Validate Radar Models, Simulations, and the GBR Hardware In The Loop testbed tool
- Stress the GBR-P performance envelope to assist in development of the Objective System
- Evaluate feasibility of using endoatmospheric chaff in the exoatmosphere; collect data on endoatmospheric chaff deployed in the exoatmosphere

LEVEL 2 (U)

- Perform real-time discrimination
- Evaluate performance against multiple target clusters
- Evaluate GBR-P data recording capability
- Verify Capability against the NMD Weapon System threat
- Obtain external sensor truth data

2. RCT-1 TARGET OBJECTS (U)

(U) In order to meet the requirements established for the RCT-1 mission in the GBR-P RCT-1 Target Requirements Letter (TRL), dated November 1997, and to comply with the challenges of being an Associated Operation payload on the Minuteman III missile system, four deployable target objects were selected. Namely, one Reentry Vehicle (RV), two Rigid Lightweight Replicas (RLRs), and one chaff package. Sandia National Laboratories (SNL) is responsible for the fabrication of the RV, RLRs and chaff ejector, while Tracor Aerospace manufactured the RCT-1 chaff target. An unclassified discussion of these targets follows.

- **Small Reentry Vehicle (SRV)** – The SRV is required in order to evaluate the ability of the NMD-GBR to fulfill crucial functions such as discrimination. The SRV is "SHiP-derived" (where the SHiP RV is a part of the Baseline Target Set), and is the only available RV that will meet the delivery system's payload mass and volume constraints. For RCT-1, this target object is designated as SRV-301. Specific details of this target with respect to signatures, dimensions, etc. are classified. These details may be found within the "RCT-1 Target Support Plan", or the "RCT-1 Target Design Reference Handbook", available through the U.S. Army Space and Missile Defense Command, Ballistic Missile Targets - Joint Project Office, Strategic Targets Product Office, SMDC-TJ-S.

- **Small Rigid Lightweight Replicas (SRLR)** – Among available penetration aids, this type of target object provides the most predictable flight dynamics. These target objects are lightweight, and their construction allows them to be stacked atop the RV (dixie-cup style), thereby conserving payload space. These features make the SRLR attractive for use on the RCT-1 mission due to payload mass and volume constraints and the desire to explore certain aspects of radar performance. The SRLRs flown on the RCT-1 mission (designated as SRLR-301 and SRLR-302) are also elements of the Baseline Target Set (BTS). However, these target objects have been X-Band signature matched to the SRV-301 by new techniques versus previous methods implemented on elements of the BTS. As with the SRV, specifics regarding signatures, dimensions, etc. are classified and may be found within the RCT-1 Target Support Plan.

- **CHAFF** – Chaff used on the RCT-1 mission is a standard aircraft package chaff (RR-170/AL cannister with BBU-35B impulse cartridge as propellent) in a slightly modified form. The chaff package contains in excess of 3 million pieces of chaff cut to L, C, and X-Band dipole length, and is the only package available for use on the RCT-1 mission. The chaff package will be ejected from the rear of the SRV-301, with chaff release occurring after a considerable time delay to allow the package to obtain the desired separation distances from the other target objects.

- USAF OBJECTS – The USAF also has two payload objects to be deployed on this mission. A description of these targets may be found within USAF documentation for the GT-170GM mission.

2.1 Target Object On-Board Instrumentation (U)

(U) Several instrumentation systems are used on the RCT-1 mission. Data from the instrumentation will be telemetered to ground receiving stations in real-time. No video will be used on the mission, and telemetry encryption will not be used. Specific on-board instrumentation is discussed below.

- SRV-301 – on-board instrumentation includes a C-Band transponder, GPS, body dynamics measurements (3-axis measurement of angular rates, accelerations and magnetic flux), RV substructure temperatures, and diagnostics. The GPS translator is a Model IEC BMT-40; 2 watt output; and a calculated 0dB margin path length of 7,399 km. The C-Band transponder model and characteristics are: Aydin Vector AV50CM or Vega 366C-2; 50 watt minimum output; and a calculated 0dB margin path length of 2868 Km for uplink and 20,735 Km for downlink. The telemetry transmitter is an Aydin Vector T105S; 5 watt minimum output; with a calculated 0dB margin path length of 3,537 Km.
- SRLR-301 and SRLR-302 – on board instrumentation consists of a modified Lightweight Instrumentation System (LWIS) for collecting body dynamics and inertial orientation data (3 single-axis magnetometers, 3-axis angular rates, 1-axis acceleration), substructure temperatures, and diagnostic data. The LWIS uses a low-power Microcom S-Band telemetry transmitter.
- USAF OBJECTS – The GBR program has no plans to receive or use any data from instrumentation located on-board USAF objects flown on the GT-170GM mission.

3. DEPLOYMENT SCHEME (U)

(U) Due to the fact that the RCT-1 mission is an Associated Operation of the GT-170GM mission, trajectories are classified. The entire RCT-1 payload stack is deployed from the MM-III bus after which the stack is spin stabilized from the control system on SRV-301. Given the constraints of the MM-III deployment system and the performance parameters to be tested on the GBR-P system, a nominal mission event timeline was developed to optimize the "system of systems." The RCT-1 Mission Event Timeline is shown in Table 1.

Table 1: RCT-1 Mission Event Timeline (U)

TALO (Seconds)	EVENT
1	Turn On RV TM System (~2 g)
410	Deploy RCT-1 Target Set (Bus Back-Away)
416	Begin Spin-Up Of RCT-1 Target Stack
430	Spin-Up Complete
950	Down Range Horizon Break (GBR-P : 0 deg elevation)
1050	Deploy SRLR-301 From RCT-1 Target Stack (~1.7 m/s)
1200	Deploy Chaff Package From SRV-301 (~4.0 m/s)
1250	Deploy SRLR-302 From SRV-301 (~1.7 m/s)
1450	340 meter separation between targets
1550	Initiate Chaff Release (centroid at 1400 m from SRV-301)
1700	Nominal SRV-301 Impact

4. SUMMARY AND IMPLICATIONS (U)

(U) The GBR-P RCT-1 flight test has been developed to satisfy test needs associated with the GBR program in general, and the Ground Based Radar – Prototype (GBR-P) in particular. Concurrent engineering methods have been applied to the entire process of developing target requirements, satisfying the constraints and guidelines of being a payload on a MM-III Associated Operation, designing a deployment schema to meet the needs of the GBR-P system, fabricating radar signature matched target payloads, developing a low-cost evaluation chaff target for data collection purposes and planning the data products to be produced. The current implications of the RCT-1 flight test to future NMD system testing is that a viable data collection experiment can be designed but not without significant cost trades on fundamental mission design parameters. These implications and lessons learned will best be addressed in a post mission forum.