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ENGINEERING OPERATIONS REPORT

INTERFACE CONTROL & MRL

PHASEDOWN REPORT

Nerva

DRA

PROJECT 110 - WORK STATEMENT
PARAGRAPHS f6a & f6b

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PROJECT REPORT

ENGINE SYSTEM INTERFACE CONTROL & MRL

1. **INTRODUCTION**

    a. **Purpose**

    Perform engine interface control activities to coordinate engine and component design activities in conformance with the 1137400E flight engine baseline. Specific activities will include:

    (1) Maintain interface control drawings (IDS's) and publish a flight engine Data Item E-106 consistent with the level of flight engine, flight engine component, stage, facilities and aerospace ground equipment design maturity available eight weeks prior to data item submittal to SNSO-C. The data item will be assembled in a loose-leaf binder to facilitate revision. The following drawings will be maintained and will constitute the flight engine Data Item E-106:

    1136393 - NERVA Flight Engine Nuclear/Non-Nuclear ICD

    1136403 - NERVA Flight Engine Module/Stage ICD

    1136408 - NERVA Flight Engine Non-Nuclear Components ICD

    1137460 - Propellant Shutoff Valve/Stage ICD

    1137461 - Cooldown Supply Module/Stage ICD

    1137462 - NERVA Digital Instrumentation and Control Electronics (NDICE)/Stage ICD

    (2) Maintain the preliminary Operational Flight Engine Measurement Requirements List (MRL) consistent with design requirements, the flight engine configuration and an allocated minimum measurement channel quantity. Work will be performed and documented in accordance with Data Item Description C-101.

b. **Gross Content of Material Preserved**

  (1) ICD's

  The status of ICD preparation is documented by the
following drawings of the issue listed and available from the ANSC NERVA
Drawing Microfische File (prints are included in Section 7.a):

> 1136393C - NERVA Flight Engine Nuclear/Non-Nuclear ICD
>
> 1136403C - NERVA Flight Engine Module/Stage ICD
>
> 1136408D - NERVA Flight Engine Non-Nuclear Components ICD
>
> 1137460C - Propellant Shutoff Valve/Stage ICD
>
> 1137461C - Cooldown Supply Module/Stage ICD
>
> 1137462C - NERVA Digital Instrumentation and Control
> Electronics (NDICE)/Stage ICD

  Potential revisions to ICD 1136393C are documented in the
following unreleased layout drawings included in this report (prints of these
unreleased drawings are included in Section 7.b):

> (a) Forward Reactor Support Design Concepts
>
> (b) Revised Reflector Support Cylinder/Pressure Vessel
> Interface Concept #2
>
> (c) Drawing No. 1139697 - Turbine Lines/Nuclear Subsystem/
> Closure Interface Concept
>
> (d) Interface Design Proposals for Interface #10 of
> of ICD 1136393

  WANL input to ICD 1136393C was received at ANSC in August 1971,
and was evaluated by ANSC for inclusion in the ICD. Some of these data are
included in ICD issue 1136393C released in November 1971, while others were
deferred for further evaluation and possible inclusion in ICD 1136393D.
Section 7.o presents the status of WANL input to ICD 1136393.

(2)   Operational Flight Engine MRL

Data Item C-101-CP090290A-F1, Preliminary Measurement

Requirements List for the NERVA Operational Flight Engine is attached

herein in Section 7.c. Proposed changes are described in Sections 7.d,

7.e and 7.f.

c.   Degree of Completion and Major Missing Items

(1)   ICD's and Data Item E-106

(a)   Degree of Completion

The magnitude of work required to convert the ICD's

listed in Section 1.b.(1) for consistency with the 1137400F Baseline NERVA

Flight Engine cannot be estimated at this time; thus, the degree of

completion cannot be predicted.

Rather than describing degree of completion, the current

ICD status will be presented.

The drawings listed in Section 1.b.(1) represent ICD's

consistent with the 1137400E Baseline NERVA Flight Engine.

NERVA engine and component design activity in CY 1972

was directed toward updating the Baseline NERVA Flight Engine. The ICD updating

activity in CY 1972 has been limited because of the emphasis on evaluation of

proposed configuration changes to the Baseline Engine. The emphasis was placed

on preparation of Interface Design Proposals for ICD 1136393, since no Baseline

Engine configuration changes were proposed that affected these nuclear/non-

nuclear hardware interfaces.

NERVA Program Planning performed early in CY 1972 resulted in scheduling an issuance of updated ICD's in May 1972 and transmittal of an updated E-106 data item to SNSO-C by 31 August 1972. Preparation of Interface Design Proposals for all ICD's was scheduled from October 1971 through 15 April 1972. Preparation of revised ICD's was scheduled from 15 April 1972 through 31 May 1972.

Interface Design Proposals were prepared for the following interfaces of ICD 1136393C:

Interface No.	Interface Name
1 & 2	Pressure Vessel (PV)/Nuclear Subsystem (NSS) Internal Shield Interface
3	PV/Nozzle/NSS Reflector Interface
4	Turbine Inlet Line (TIL) & Turbine Discharge Line (TDL)/NSS/Pressure Vessel Closure (PVC) Interface
6 & 7	Structural Support Coolant Line (SSCL) & Structural Support Bypass Line (SSBL)/NSS/PVC Interface
10	NSS Instrumentation (NSSI)/PVC Interface

An Interface Design Proposal was initiated for ICD 1136393 Interface No. 11, Control Drum Actuator (CDA)/PVC/Wiring Harness (WH) Interface.

These Interface Design Proposals have not been previously documented, and are included in Section 3 of this report.

(b)   Major Missing Items

The major missing item from the CY 1972 work scope is that effort required for conversion of the ICD's supporting the 1137400E Baseline NERVA Flight Engine to updated ICD's supporting the 1137400F Baseline NERVA Flight Engine.

Additional missing items, considering a complete ICD package beyond the CY 1972 work scope are the following ICD's updated for consistency with the 1137400F Baseline NERVA Flight Engine:

1137463 - NERVA Engine/AGC ICD

1137464 - NERVA Engine/Facility ICD

1137465 - NERVA Engine/Propellant Depot ICD

1137466 - NERVA Engine/Space Station ICD

1138619 - Destruct System/Stage ICD

All ICD's will require maturation beyond CY 1972, leading to completion of these drawings at the time that the NERVA Flight Engine is operational.

(2)   MRL

(a)   Degree of Completion

The degree of completion cannot be estimated at this time. Data Item C-101 presented in Section 7.c shows the current status of the MRL, which supports the 1137400E Baseline NERVA Flight Engine.

The current MRL must be updated to support the 1137400F Baseline NERVA Flight Engine. This update will also reflect the CY 1972 accomplishments in engine control system design, trend data analysis, reliability analysis, safety analysis, malfunction analysis and engine component design.

(b) Major Missing Items

The major missing items regarding the CY 1972 work scope are:

<u>1</u>   Changes consistent with the 1137400F Baseline NERVA Flight Engine.

<u>2</u>   Changes consistent with CY 1972 efforts in engine design, control system design, trend data analysis, reliability analysis, malfunction analysis and safety analysis.

Beyond the CY 1972 work scope, MRL's will be required for each engine and reactor test in the development and qualification phases of the NERVA Program.

d.   External Factors Influencing the Results

(1)   ICD's

The design maturities of the NERVA engine, engine components and stage imposed a distinct limitation on the completeness of the ICD's.

(2)   MRL

The MRL maturity was severely hampered by the maturity of the NERVA engine, engine component and stage design; as well as by the maturity of trend data, reliability, safety and malfunction analyses of the NERVA engine.

e.   Identification Numbers for Related Activities Recorded Last Year

(1)   ICD's

This work is a continuation of the work described in the CY 1971 Work Statement for Project 117-f-2.

(2)   MRL

This work is a continuation of the work described in the CY 1971 Work Statement for Project 117-f-6.

f.   Names of Personnel Performing Work

   (1)   ICD's

      (a)   Section N8640 (Requirements and Interfaces) -

         J. L. Smith

      (b)   Section N8150 (Engineering Services [Drafting]) -

         L. J. Booth

         D. K. Darmstead

         A. L. DeHann

         R. F. Gostage

         W. R. Harrington

         V. H. Romani

         A. R. Rowley

         A. W. Schifini

         K. R. Wills

         J. Zalte

      (c)   Section N8610 (Engine Design) -

         W. E. Stephens

      (d)   Section N8630 (Instrumentation) -

         R. D. Huffman

         E. A. Sheridan

      (e)   Department N8300 (Turbopump) -

         N. A. Edlebeck

         P. R. Pare

(f) Department N8400 (Valves) -

L. D. Johnson

E. A. Shearer

(g) Department N8500 (Nozzle, Pressure Vessel and Skirt) -

L. A. Shurley

D. W. Tracy

J. L. Watkins

(2) MRL

(a) Department N8500 (Reliability and Safety) -

D. Syrek

(b) Section N8620 (Analysis and Hybrid Computer) -

G. G. Strucel

(c) Section N8630 - W. P. Gilles

(d) Section N8640 - J. L. Smith

2. SUMMARY

a. Interface Control

(1) ICD Status

The status of interface control drawings in March 1971 is documented in the Phasedown Report for Project 117 presented in Section 7.g.

The interface control drawing status in February 1972 was as follows:

(a) ICD's 1136393C, 1136403C, 1136408D, 1137460C, 1137461C and 1137462C were released. These ICD's were consistent with the Baseline NERVA Flight Engine drawing 1137400E and the component, stage and engine design maturity of this baseline.

(b) Interface Design Proposals were prepared for Interfaces 1, 2, 3, 4, 6, 7 and 10 of ICD 1136393C.

(c) An Interface Design Proposal for Interface 11 of ICD 1136393C was being prepared.

(2) ICD Plans and Recommendations

The CY 1972 plans for the 75K Engine ICD's were to update the ICD's previously listed for consistency with the 1136400F Baseline Engine and to issue an updated E-106 Data Item of ICD's also consistent with 1136400F.

Planning related to program conversion to a Low Thrust NERVA Engine should include:

(a) Data Item Description E-106 compliance.

(b) Use of applicable interface description extracted from existing ICD's.

(c) Improvements in ICD preparation and control as described in Section 3.a.(1).

b. Measurement Requirements List (MRL)

(1) MRL Status

The status of the Preliminary MRL for the NERVA Operational Flight Engine in February 1972 was:

(a) Data Item C-101-CP090290A-F1 was released in September 1971. This MRL was consistent with the 1136400E Baseline NERVA Flight Engine and the maturity of engine control system design, trend data analysis, safety analysis, reliability analysis, malfunction analysis and engine component design.

(b) MRL change requests were received from the turbopump, controls system, and engine system designers. These change requests have not been evaluated,nor has any disposition been made.

(2) MRL Plans and Recommendations

The CY 1972 MRL plans were to update the C-101A Data Item per the 1137400F Baseline Engine and the maturity of engine control system design, trend data analysis, malfunction analysis and engine component design in June 1972 and submit this C-101B Data Item to SNSO-C in August 1972.

Planning related to program conversion to a Low Thrust NERVA Engine should include:

(a) Data Item C-101 compliance.

(b) Compliance with the general approach to MRL preparation described in Section 7.h.

3. TECHNICAL DISCUSSION

    a. Interface Control

        (1) Interface Control Method Study

A. D. Cornell, Manager of Department N8600, requested (i) a study of the interface control methods currently employed on the NERVA Program as defined in Data Item Description (DID) E-106E (see Section 7.i) and Data Item C-018 (see Section 7.j); and (ii) an evaluation of alternate interface control methods to ensure that the most beneficial method was selected.

A very thorough study was conducted with the aid of ANSC NERVA engine and component design section managers, or their appointed alternates.

A complete report of the details of this study is given in Section 7.k. The results of the study can be summarized as follows:

Section N8640, Requirements and Interfaces, and all cognizant engine and component section managers recommend the following Interface Control Method:

Use the Interface Control Method defined in DID E-106 and Data Item C-018, with the following minor improvements that are in consonance with these reference documents:

(a) Revise all component specifications to refer to specific ICD sheet numbers rather than to refer only to ICD drawing numbers.

(b) Devise approval methods for ICD's and Data Item E-106 to provide a means for rapid processing of changes.

(c) Issue an Engineering Operations Procedure to define the method and organizational responsibilities for preparation, maintenance, use and approval of ICD's. This shall clearly define the differences between flight engine, ground test engine and component development hardware interface definition and control methods and responsibilities.

(2)   ICD Preparation

Preparation of ICD's during CY 1972 was limited to the work scope described in Section 1.a.

DID E-106E (see Section 7.i) describes the overall ICD scope and requirements for the total NERVA Program.

A more detailed description of the preparation of ICD's is provided in Section 7.1.

Section 7.j describes the Interface Control Procedures for the NERVA Program.

(3)   Interface Design Proposals

The purpose of interface design proposals is to evaluate existing interface definitions in more detail and to either propose a new design concept or propose some change in interface design detail.

Section 7.m presents all the Interface Design Proposals prepared in CY 1972.

b.   Measurement Requirements List (MRL)

Preparation of MRL's in CY 1972 was limited to two updates of a preliminary C-101 for the Operational NERVA Flight Engine, as described in Section 1.a.

Sections 7.n and 7.h provide a detailed description of the MRL work required for the entire NERVA Program and also a discussion of the recommended method and organizational responsibilities for MRL preparation.

4.   CONCLUSIONS

a.   Gross Conclusions

(1)   The status of ICD's is compatible with the 1137400E Baseline NERVA Flight Engine and component design configuration and maturity.

Interface Design Proposals for interfaces 1, 2, 3, 4, 6, 7, and 10 are adequate to warrant inclusion in the next ICD update.

(2)   The MRL status is consistent with the 1137400E Baseline NERVA Flight Engine and component design maturity and also maturity of trend data analysis, reliability analysis, safety analysis and malfunction analysis.

b. Interpretation

The ICD and MRL status reflects that ICD and MRL work was on schedule and thus that these activities had been conducted in an efficient and timely manner to provide the desired definition of design requirements for use by the engine and component designers in the continuing design activities.

5. RECOMMENDATIONS

a. Interface Control

If the 75K NERVA Program is reactivated, the following recommendations are applicable:

(1) Resume ICD and E-106 preparation using the contents of this Phasedown Report and the report listed in Section 6.a as a baseline.

(2) Use the interface control method and procedures of DID E-106 and DI C-018 as direction for all continuing interface control work, with the following minor improvements:

(a) Revise all component specifications to refer to specific ICD sheet numbers rather than to refer to only ICD drawing numbers.

(b) Devise ICD and DI E-106 approval methods to expedite change approvals.

(c) Issue instructions to define the procedure and organizational responsibilities for preparation, maintenance, use and approval of ICD's. Differences between flight engine, ground test engine and component development hardware interface definition and control procedures and responsibilities shall be clearly defined.

(3)   Complete the Interface Design Proposal for Interface No. 11 of ICD 1136393C.

(4)   Prepare Interface Design Proposals for all other ICD interfaces.

If the NERVA Program is redirected to a Low Thrust Engine Program, the same recommendations apply, except that the contents of this Phasedown Report must be revised based on the Low Thrust Engine Baseline configuration.

b.   MRL

The following recommendations apply in the case of reactivation of the 75K NERVA Program:

(1)   Resume MRL preparation using the contents of this Phasedown Report and the report listed as Section 6.a as a baseline.

(2)   Use the DID C101 format and follow the preparation procedures described in Section 7.i.

The same recommendations apply in the case of program redirection to a Low Thrust Engine, except that the contents of this Phasedown Report must be revised in accordance with the Low Thrust Engine Baseline and configuration.

6.   REFERENCES

None.

7.   DATA INDEX

a.   Current ICD's 1136393C, 1136403C, 1136408D, 1137460C, 1137461C and 1137462C.

b.   ICD 1136393 Interface Design Proposal Prints.

c.   C-101-CP909290A-F1, Preliminary Measurement Requirements List (MRL) for the NERVA Operational Flight Engine, dated October 1971.

d. Memo N8300:M0803 from N. A. Edlebeck to A. D. Cornell, dated 12/29/71, Subject: NERVA Flight Instrumentation.

e. Memo N8630:5141M from C. R. Dippel to J. R. DaVolio, dated 11/3/71, subject: Control Measurement Parameters

f. Memo N8610:087M from K. R. Conn to W. J. Houghton, dated 11/1/71, Subject: Review of Draft Copy of C-101-CP090290-F1, Flight Engine MRL.

g. PD-1291 – Phasedown Report for Project 117 dated March 1971

h. Memo N8640:061M from J. R. DaVolio to Distribution, dated 1/11/72, Subject: Preparation of MRL C101B.

i. Data Item Description (DID) E-106E, Engineering Data for Interface Control (MIL-D-1000) (Category B).

j. Data Item C-018-SS090205-CF1, NERVA Configuration Management Plan – Sections 3.6 through 3.6.2 on pages 14.b through 17.a.

k. Interface Control Method Study

l. ICD Preparation

m. Interface Design Proposals for ICD 1136393C.

n. Data Item Description (DID) C-101A, Measurement Requirements List (MRL)