NOTICE

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SPACE FABRICATION DEMONSTRATION SYSTEM

QUARTERLY PROGRESS REPORT NO. 2

May 17, 1977 - August 26, 1977

NASA/MSFC Contract NAS 8-32472
SUMMARY

The Space Fabrication Demonstration System (SFDS) program concluded its second contract quarter year with a quarterly review meeting held at NASA-MSFC on 26 August 1977. This quarterly progress report as agreed upon by NASA-MSFC is comprised of the data presented at this meeting, enclosure (1), supplemented by our previous monthly progress letters, references (a) and (b).

During discussions held with NASA-MSFC in preparation for this quarterly review it was agreed to substitute incremental critical design reviews for the one CDR which was to be held at this time in order to permit continued sequential subsystem design concurrence to occur without impacting the SFDS subsystem assembly and test schedule. These are indicated on Figure 1.

Action items resulting from these meetings still be to satisfied are:

- Grumman will study the required SFDS assembly alignment tolerances and include these on the final assembly drawing.
- NASA-MSFC will furnish Grumman with test data on a pin-ended beam test similar to that performed by Grumman for a fixed-ended beam in association with this program.
DISCUSSION

WBS 1.1 PROGRAM MANAGEMENT

Continued detailed review of tasks committed versus tasks completed to date have kept the SFDS program essentially on schedule. Figure 1 - SFDS Master Program Schedule, shows our progress as marked to reflect percent task completion, as applicable. Deviations from and changes made to the schedule are noted below.

WBS 1.2 DESIGN and DEVELOPMENT

1.2.1 Structural Member Development

Process definition includes final selection of recommended thermal coating for the structural truss. Various alternate finishes are still being examined.

Detail truss design and analysis is complete except for completion of the final memo report with conclusions and recommendations for future action.

The material for manufacture of the truss for the truss/joint tolerance tests has been received. The schedule has been updated to reflect the expected test plan and test completion dates.

Data associated with verification of the design of the basic "building block" truss for this reporting period are included in enclosure (1).

1.2.2 Fabrication Facility Design

The schedule has been revised to reflect the completion of detail, dimensioned design layouts of each subsystem. This was done to comply with the agreement reached with NASA-MSFC that Grumman would furnish these for each incremental critical design review in lieu of the design layout drawings we had originally anticipated furnishing.

The configuration layout will be completed upon finalization of each subsystem design layout.

The schedule for the roll forming subsystem has been extended to include completion of the detail design of the rolling mill drive, cap stock feed encoder mounting and cap stock supply reel design. NASA-MSFC has requested that consideration be given to have one of the supply reels include not only simple reload capability but also a self-threading feature to demonstrate how this might be accomplished on a space flight article being used to fabricate large space structure building block trusses.
The schedule for the magazine and dispensing subsystem has been extended to include design consideration of simple cross-brace reloading capabilities for one magazine/dispensing subsystem to demonstrate long range space structure fabrication application has been implemented at the request of NASA-NSFC. Though concurrence with this design is not expected until December, critical long lead items have been released for request for quote in order to expedite purchase, receipt of components, detail parts manufacture and subassembly.

The weld process subsystem detail design completion date has been extended to accommodate the inclusion of six transformers and their related cabling as requested by NASA-NSFC rather than the one transformer originally contemplated. This was done in order to provide a closer match to the SST/payload power supply capabilities. Also included in this schedule extension is the completion of the diagonal brace weld/clamp mechanism.

A mock-up of the truss cut-off has been built and tested. Detail design has been initiated. With completion in October and release to the shop at that time it is expected that detail parts fabrication will be completed on time.

Development testing remains an open item. It will remain so until all subsystem detail designs have been completed and the need for construction of subsystem mock-ups or concept verification tests have been satisfied. Determination of series spotweld electrode life continues.

It is anticipated that the above schedule changes will not impact the overall delivery schedule of the SFDS.

WBS 1.3 FABRICATION and ASSEMBLY

1.3.1 Detailed Parts

Fabrication of detail parts for the roll forming mill continues at the Yoder company. Assembly and test of these subsystem components is anticipated next month.

The magazine and dispensing subsystem components are being held-up pending completion of the detail design layout completion.

1.3.2 Assembly

Composite development forming tests have been completed within the scope of effort defined for this program. Conclusions and recommendations for further in-house development efforts have been generated and are being submitted for corporate management approval.
WBS 1.4 TEST

No tests associated with the final products, the structural member or fabrication facility, were performed during this reporting period.

WBS 1.5 FLIGHT DEMONSTRATION PLANNING

The preliminary Flight Demonstration Program Plan, Cost and Schedule were completed and submitted to NASA-MSFC during this reporting period. We are waiting for comments and/or questions from NASA-MSFC before proceeding with updating materials contained within the report in preparation for the final plan.

CONCLUSION

Satisfactory progress has been accomplished during this reporting period.

Face to face discussion with NASA-MSFC helped to understand their concept of the type and nature of documentation they desired before concurring on developmental subsystem detail design.

RECOMMENDATIONS

Continued close management surveillance by NASA-MSFC and Grumman program management personnel.

Implementation of monthly or bi-monthly meetings for face to face discussions to keep all parties knowledgeable of what is being provided and what is expected so that no further uncertainties may develop.

Should you have any questions or comments with regard to the above or the enclosed, please contact us.

Very truly yours,

GRUMMAN AEROSPACE CORPORATION

Walter K. Mueneh
SFDS Program Manager

WKM: dm
cc: Distribution NASA-MSFC
    Distribution Grumman
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## SFDS MATERIALS REQUIREMENTS

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*Note: RFQ = Request for Quotation, PO = Purchase Order, EOD = Expected Order Date.*

**Remarks/Reference:**
- Awaiting quote from vendor.
- Release of P.O. pending life tests.
- Same as above.
- Make item.
- MIN-MAX stock.
STRUCTURAL DESIGN CONDITIONS ONE METER DEEP BEAM

DESIGN CONDITION I — FABRICATION IN ORBITER PAYLOAD BAY
  — ORBIT 215 NM 28.5° INCLINATION
  — CRITICAL LOAD COND: ORBITER RCS THRUSTER FIRING
  — THERMAL CONDITION: ORBITER +Y AXIS EARTH POINTING

DESIGN CONDITION II — SATELLITE SOLAR POWER SYSTEM (SSPS)
  — ORBIT: GEOSYNCHRONOUS, SUN ORIENTED
  — CRITICAL LOAD COND: STATION KEEPING MANEUVER
  — THERMAL COND: SOLAR ARRAY — SUN POINTING
    MW ANTENNA — EARTH POINTING
DESIGN CONDITION I – BEAM FABRICATION IN ORBITER PAYLOAD BAY

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<th>$+\ddot{\phi}$</th>
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<td>1.4</td>
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<td>0.03</td>
<td>0.03</td>
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ROLL $\phi$

PITCH $\theta$

YAW $\psi$

ULTIMATE FACTOR OF SAFETY 1.40

$\ddot{\phi} = 1.5$ SEC/SEC$^2$ USED TO DESIGN BEAM
"BUILDING BLOCK" TRUSS – ONE METER DEPTH
ULTIMATE BENDING MOMENT AT POINT A VS BEAM LENGTH RCS FIRING

![Graph showing ultimate bending moment at point A vs beam length RCS firing.](image)
# Material Comparison

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<th>Materials</th>
<th>Aluminum* 2219-T6</th>
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<th>Graphite/Polyether-Sulfone ($O_2=45_2$)</th>
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<td>60</td>
<td>60</td>
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<td>36</td>
<td>-</td>
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<td>48</td>
<td>60</td>
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<td>E, KSI</td>
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<td>.065</td>
<td>.065</td>
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<td>a, in/in.$^3$/F</td>
<td>12.4 x 10$^6$</td>
<td>.1 x 10$^8$</td>
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<td>Handling Quality</td>
<td>GOOD</td>
<td>GOOD</td>
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| Thermal Coating    | Fair              | Excellent                    | Excellent                                |
|                    | Apply coating to basic material in GRO process, must be removed for joining | Excellent | Incorporated into resin material during processing ground |
|                    | Excellent         | Poor                         | Very Good                                |
|                    | Can use any of the following: ultrasonic weld, pressure weld, mechanical attachment | Poor bonding requires melt & cure | Ultrasound weld gives good simple attachment |

| Joining            | Excellent         | Excellent                    | Excellent                                |
|                    | Not known         | Good                         | Not known                                |

| UV Degradation     | Excellent         | Good                         | Good                                    |
|                    |                   |                              |                                        |

| State-of-the-Art   |                   |                              |                                        |
|                    |                   |                              |                                        |

| Application        |                   |                              |                                        |

*Properties of 2024-T3 and 6061-T6 approximately the same
CANDIDATE THERMAL COATINGS

- BLACK ANODIZE MIL A-8625
  - ELECTROLYTICALLY PRODUCED DYED OXIDE COATING
  - THICKNESS .01 TO .1 MILS
  - ABSORPTANCE TO EMITTANCE RATIO < 1.00

- SPRAY PAINTS
  - POLYURETHANE
  - FLUOROCARBON
  - THICKNESS APPROX .8 TO 1 MIL
  - $\alpha = .96, \epsilon = .91$
BEAM ORBITAL ORIENTATION

SOLAR VECTOR

$\eta = 180^\circ$

$\eta = 270^\circ$

$\eta = 0^\circ$

$\eta = 90^\circ$
ORBITAL TEMPERATURE RESPONSE

\[ \Delta T = 17.8^\circ F \]
\[ T = 110.9^\circ F \]

SUN VECTOR
180°

\[ \Delta T = 44.2^\circ F \]
\[ T = 98.12^\circ F \]

EARTH

\[ \Delta T = 49.1^\circ F \] MAX TEMP DIFFERENCE INTRIANGLE
\[ \Delta T_{aw} = 12.8^\circ F \] MAX TEMP DIFFERENCE BETWEEN TRIANGLES AREA WEIGHTED
SOLAR BLOCKAGE GEOMETRY

BLOCKAGE LASTS FOR 6.1° OF TRAVEL AND 95 SECONDS OF TIME

SOLAR RAYS END OF BLOCKAGE

SOLAR RAYS START OF BLOCKAGE

ΔT: 37° F

DIRECTION OF MOTION
W = 3.9°/MIN

45 IN.
DESIGN CONDITION 1

- THERMAL STRESSES

- FREQUENCIES AND MODE SHAPES
THERMAL STRESS IN CAP MEMBER DUE TO THERMAL GRADIENT (TEMP, DATUM ASSUMED, 0° F, UNRESTRAINED)

STRESS PSI X 10^2
TEMP OF X 10

1 METER TRUSS

CROSS SECTION WEIGHTED AVER, TEMPERATURE 79.02° F

TENSION

COMPR

STRESS

SUN
THERMAL STRESS IN CAP 1 METER TRUSS

+497 PSI (PEAK TENS)

TENSION

-493 PSI (PEAK COMPR.)

COMPRESSION

SUN
(NUOT TO SCALE)

1M
THERMAL STRESS IN CAP MEMBER (1 1/2M LENGTH) DUE TO THERMAL GRADIENT, FULLY RESTRAINED IN ROTATION ABOUT Y AND Z AXES
FUNDAMENTAL FREQUENCY VS BEAM LENGTH 1 METER BEAM

FREE-FREE

CANTILEVER

FREQUENCY HZ

10 BEAM LENGTH - M 100

0.1

0.01

10
1M X 40M BEAM SHUTTLE-MOUNTED MODES

1ST LATERAL BENDING .57 HZ (+X)

1ST LATERAL BENDING .57 HZ (+Y)

2ND LATERAL BENDING 3.5 HZ
1M X 40M BEAM FREE-FREE MODES

1ST TORSION
7.6 Hz

1ST LATERAL BENDING 3.6 Hz
Isometric View of One-Door SPS

INTERMEDIATE LATERAL MEMBERS NON-CONDUCTING

LATERAL POWER BUS

X DIRECTION

400 M

449 M

909 M

215.5 M

246 M

1 METER

SEC AA
DESIGN CONDITION II - SSPS STATIONKEEPING MANEUVER

MAXIMUM APPLIED THRUSTER FORCES INCREASED BY DYNAMIC MAGNIFICATION FACTOR = 2.0, FACTOR OF SAFETY = 1.40

2558N (575 LB)
DEFLECTED SHAPE DUE TO TIP LOAD-STRUCTURAL MODEL

PEAK MEMBER LOAD = -3630 N ULTIMATE
SOLAR REFLECTOR PRELOAD REQUIREMENTS

- REFLECTOR PRELOAD IS SIGNIFICANT DRIVER FOR BEAM DESIGN

- PRELOAD EVALUATED FOR:
  - THERMAL EXCURSIONS
  - SOLAR RADIATION PRESSURE
  - ROTATIONAL ACCELERATIONS
  - NATURAL FREQUENCY
SOLAR REFLECTOR NATURAL FREQUENCY VS PRELOAD

248M X 248M

248M X 483M

DESIGN
PRELOAD

REFLECTOR MEMBRANE PRELOAD LB/IN.

1 x 10^-2

1 x 10^-3

1 x 10^-4

1 x 10^-5

0.1

10

CPH

FREQUENCY

REFLECTOR

CPH

FREQUENCY

REFLECTOR
SSPS STEADY STATE TEMPERATURE DISTRIBUTION
FULL SUN

SOLAR VECTOR

50°F
92°F
19°F

5°F
-5°F

-12°F
1M

20M

213.5M
246.5M
100.17

246.5M

1M

2105-078W
DESIGN CONDITION II

SSPS 1M X 40M BEAM CRITICAL CAP LOAD FUNCTION OF FOLLOWING:

- AXIAL LOAD DUE TO BENDING – STATIONKEEPING
- REFLECTOR PRELOAD
- MANUFACTURING MISALIGNMENT OF 20M X 493M BEAM
- THERMAL GRADIENT/DEFLECTION OF 20M X 493M BEAM
- MANUFACTURING MISALIGNMENT OF THE 1M X 40M BEAM
- THERMAL GRADIENT/DEFLECTION OF THE 1M X 40M BEAM
BENDING MOMENT DUE TO COMBINED LOADS AND INITIAL

DEFL 20M X 493M BEAM

MOMENT

P

W = 1.21 N/M

P = 3530N

DEFL VS \( \Delta T \)

\( C_0 \) INITIAL DEFL METERS

BENDING MOMENT 10^-4 NM ULT
BENDING MOMENT DUE TO COMBINED LOADS AND INITIAL
DEFL 1M X 40M BEAM

\[ P = 412.5 \text{ LBS LIM} \]
BEAM FAILURE MODES

- 40 M EULER INSTABILITY
- CAP LOCAL CRIPLING
- 1½ M CAP TORSION/FLEXURE INSTABILITY
OVERALL STABILITY OF 1M X 40M BEAM

BUCKLING MODE $P_{cr} = 17485N$
(AXIAL PLUS LATERAL)

BUCKLING MODE $P_{cr} = 17485N$
(AXIAL LOAD ONLY)

1M X 40M STRUCTURAL MODEL
(1/2 LENGTH)
MAXIMUM BEAM CAP STRESSES
1M X 40M BEAM

- DESIGN CONDITION I:
  - COMPRESSION STRESS
  - APPLIED LOADS
  - THERMAL GRADIENT
  TOTAL
  - 2505 PSI
  - 680 PSI
  - 3185 PSI

- DESIGN CONDITION II (SSPS):
  - COMPRESSION STRESS
  - APPLIED LOADS
  - THERMAL GRADIENT
  TOTAL
  - 2272 PSI
  - 680 PSI
  - 2962 PSI

- ALLOWABLE AVERAGE COMPR STRESS
  BASED ON STATIC TEST
  4421 PSI
ALLOWABLE MANUFACTURING MISALIGNMENT
1M X 40M BEAM

DESIGN CONDITION II:
ULTIMATE CAP LOAD: -856N (-192.5 LBS)
ALLOWABLE CAP LOAD: -1868N (-420 LBS)
PERMISSIBLE MOM: 977NM (8645 IN LBS)

ALLOWABLE MISALIGNMENT C₀ = .21 METERS
EFFECT OF MANUFACTURING MISALIGNMENT ON BEAM MOMENT (APPLIES IN X-Z PLANE ONLY)*

![Graph showing effect of manufacturing misalignment on beam moment.]

- **ALLOWABLE MOMENT**
- **PERMISSIBLE MISALIGNMENT**

\[ \frac{M}{M_{Co}} = 0 \]

\[ C_o / L \times 10^{-3} \]

*MISALIGNMENT IN X-Y PLANE INDUCES TORSION*
FATIGUE

- **SSPS**
  - 30 YEAR LIFE REQUIREMENT
  - GEOSYNCHRONOUS ORBIT – ENTERS AND EXISTS ECLIPSE PHASE TWICE EACH YEAR FOR 45 DAY PERIOD
  - USE SCATTER FACTOR OF 4.0
  - NUMBER OF THERMAL STRESS CYCLES 21600
  - NUMBER OF MECHANICAL STRESS CYCLES – TBD
  - MAXIMUM STRESS (TENSION) + 6752 PSI
  - ENDURANCE LIMIT APPROX 11000 PSI
FATIGUE DATA S-N CURVE NOTCHED $K_T = 2.0; 2024 - T3$
BEAM DESIGN CONFIGURATION

BEAM BUILDER STRUCTURAL ARRANGEMENT

BEAM BUILDER INSTALLATION IN ORBITER
CONCLUSIONS

- DESIGN LOADS AND TEMPERATURES EVALUATED FOR:
  1. FABRICATION IN ORBITER PAYLOAD BAY
  2. SSPS VEHICLE

- MATERIALS AND PROCESSES SELECTED MEET REQUIREMENTS
  - 2024-T3; 2219-T6; 6061-T6
  - THERMAL COATINGS
  - ROLL FORMING
  - SPOTWELDING

- BEAM DESIGN HAS BEEN DEFINED AND SATISFIES CRITICAL CONDITIONS

- FABRICATION ACCURACY REQUIREMENT FOR BEAM DEFINED FOR FABRICATION FACILITY

- STRUCTURAL TEST ON NOV 1978 ESTABLISHES CONFIDENCE IN BASIC DESIGN
DESIGN REQUIREMENTS

- LOW COST
- COMPLY WITH SHUTTLE PAYLOAD CONSTRAINTS
- MAXIMUM USE OF COMMERCIAL “OFF-THE-SHELF” HARDWARE
- MAXIMUM USE OF EXISTING “STATE-OF-THE-ART” EXPERTISE
- COMPATIBLE WITH FUTURE FLIGHT TEST NEEDS
- FULLY AUTOMATED FABRICATION OF TRUSS
WORKING MOCKUPS

- MACHINE CONFIGURATION
- MAGAZINE MECHANISM
- CLAMP & WELD ELECTRODE MECHANISM
- CAP CUTOFF
FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY
PRINCIPAL MACHINE PROCESSES

- ROLL-FORM CAP MEMBERS
- MAGAZINE STORE PREFAB BRACES
- RESISTANCE-WELD ATTACHMENT
- COMPUTER CONTROL CAP ALIGNMENT
PRINCIPAL SUBSYSTEMS:

- Roll Forming
- Magazine/Clamp Mechanism
- Attachment
- Cutoff & Support
- Controls
PROJECTED WEIGHT DISTRIBUTION

GROUND UNIT
9070 KG
(20,000 LBS)

FLIGHT TEST
7256 KG
(16,000 LBS)
GROUND DEMONSTRATION MACHINE
PROJECTED WEIGHT DISTRIBUTION

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROLLING MILL</td>
<td>2876 KG (6255 LBS)</td>
</tr>
<tr>
<td>BRACE DISPENSERS</td>
<td>163 KG (360 LBS)</td>
</tr>
<tr>
<td>WELDING SYSTEM</td>
<td>1170 KG (2580 LBS)</td>
</tr>
<tr>
<td>CONTROL SYSTEM</td>
<td>318 KG (702 LBS)</td>
</tr>
<tr>
<td>MATERIALS</td>
<td>210 KG (462 LBS)</td>
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<tr>
<td>SUPPORT STRUCTURE</td>
<td>4081 KG (9000 LBS)</td>
</tr>
</tbody>
</table>

2105-048W
PROJECTED AVG POWER DISTRIBUTION

AVG. 2.2 KVA

ACTUATORS
ROLLING MILLS
WELD SYSTEM
COMPUTER & INTERFACE
TOTAL POWER REQUIREMENTS FOR GROUND DEMONSTRATION SYSTEM

POWER (KVA)

BAY CYCLE TIME (SECONDS)

- WELD SUBSYSTEM
- ASSEMBLY SYSTEM
- SERVO SYSTEM
- COMPUTER

AVG. 2.2 KVA
WELD POWER REQUIREMENTS

12 WELDS (TYPICAL)
EACH LASTS \approx 17 \text{MSEC}

AVGAGE POWER OVER
4 WELD SEGMENTS (2.1 KVA)

POWER (KVA)

60 40 20

BAY CYCLE TIME (SEC)

20 40 80 100

2105-060W
FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY
ROLL-FORMING CAP MEMBER

FLOWER DIAGRAM

PROGRESSIVE FORMATION OF CAP

CROSS-SECTION

60°

19.1 MM

66.8 MM

2.63 IN.

165 MM

6.5 IN.
## DEVELOPMENT TEST SUMMARY

<table>
<thead>
<tr>
<th>TASK</th>
<th>RESULTS</th>
<th>ACTION</th>
</tr>
</thead>
</table>
| ESTABLISH 2219-T62, 2024-T3 SPRING BACK | 2219-T62 (10 DEG)  
2024-T3 (2 DEG) | PRELIMINARY ROLL DESIGN                      |
| REDUCE ROLL STATIONS             | STATION REQMTS  
8 → 7 | ESTABLISH 65-IN LENGTH                      |
| PRELIMINARY CONFIGURATION EVALUATION | • RIPPLED FLANGE  
• LONGITUDINAL BOW | MODIFY ENTRY AND TRANSITION ROLLS           |
| CONFIGURATION REFINEMENT         | • IMPROVED FLANGE  
• ELIMINATE BOW | REDESIGN TRANSITION ROLLS                   |
| FLANGE EVALUATION                | • MINIMAL WAVE | • ADD CROWN TO FLANGE  
• PROCEED WITH FINAL DESIGN              |
EXTERNAL SUPPORT STRUCTURE

- MATERIAL – HOT ROLLED STEEL
- ARC WELD AND BOLTED CONSTRUCTION
- DWG. NO. RDM 447-2070
ROLLING MILL EQUIPMENT WEIGHT DISTRIBUTION

- ROLL HOUSING 857 KG (1890 LBS)
- TOOLING 1048 KG (2310 LBS)
- DRIVE 129 KG (285 LBS)
- GUIDE & STRAIGHTENER 381 KG (840 LBS)
- OTHER 422 KG (930 LBS)

TOTAL 2836 KG (6255 LBS)
SUMMARY – ROLL-FORMING SUBSYSTEM

- PRODUCED A ROLL-FORMED CAP MEMBER
- YODER ROLLING MILLS ON ORDER
- FINAL TOOL DESIGN UNDERWAY AT YODER
- EQUIPMENT CONFIGURATION CONSISTENT WITH SHUTTLE REQMT'S
- SUPPORT STRUCTURE DEFINED

UNDETERMINED

- SUPPLY REEL FINAL CONFIGURATION
FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY
BRACE MAGAZINE/DISPENSER
PRINCIPAL COMPONENTS

- MAGAZINE STOP ACTUATORS
- BRACE HANDLER ACTUATOR
- VERTICAL MAGAZINE FRAME
- DIAGONAL MAGAZINE FRAME
STEPS IN BRACE HANDLING

1. REST POSITION: BRACES IN MAGAZINE
2. TSS SEPARATES BRACE 1 FROM BRACE 2
3. BRACE DISPENSED FROM MAGAZINE
4. BRACE MOVED TO CAP
CLAMP ATTACHMENT MECHANISM

- HOUSING FOR WELD ELECTRODES
- ELECTRODE MECHANISM & ACTUATOR
- BRACE ATTACH CLAMP MECHANISM
- BRACE ATTACH ACTUATOR
- CLAMP ADVANCE ACTUATOR
CLAMP MECHANISM PRINCIPAL FORCES

WELD ELECTRODE FORCE

CLAMP FORCE

CLAMP FORCE

BRACE

CAP

CA
SUMMARY – MAGAZINE/DISPENSER SUBSYSTEM

- BRACE DISPENSER MOCKUP FUNCTION TESTED
- BRACE MAGAZINE MODIFIED AS PER PDR
- CLAMP MECHANISM MOCKUP FUNCTION TESTED

UNDETERMINED

- FINAL CONFIGURATION DIAGONAL CLAMP MECHANISM
FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY
BRACE ATTACHMENT

PRIMARY SYSTEM
* RESISTANCE SPOT-WELDING

ALTERNATES CONSIDERED
* ULTRASONICS
* HOLLOW INTEGRAL RIVET
* INTEGRAL RIVET
* STAPLING
* ELECTRON-BEAM WELDING
* ADHESIVE BONDING
WELD POWER SUPPLY GROUND DEMONSTRATION SYSTEM

- MANUFACTURER - SCIAKY
- QUANTITY - 6
- TYPE - SOLID-STATE A/C
- COOLANT - WATER
- OUTPUT - 63 KV, 4.5 V
- DUTY CYCLE - APPRX. 0.01%
- WEIGHT - 91 KG (200 LBS)
- SIZE - 25.4 x 30.5 x 50.8 CM (10 x 12 x 20 IN.)
SUMMARY – ATTACHMENT SUBSYSTEM

- SERIES ELECTRODE LIFE-TESTS PERFORMED
- ORDERING SIX TRANSFORMERS AS PER PDR
- WELD QUALITY EXCEEDS LOAD REQUIREMENTS
- ELECTRODE SWITCHING SHOWN IN MOCKUP
FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY
TRUSS CUTOFF MECHANISM & SUPPORT STRUCTURE

FUNCTIONS:
- GUIDE TRUSS AFTER ROLL-FORMING
- PROVIDE BACKUP FOR BRACE CLAMP AND WELD
- CUT OFF TRUSS TO PROPER LENGTH
INTERNAL SUPPORT STRUCTURE

- MATERIAL: HOT ROLLED STEEL
- ARC WELD AND BOLTED CONSTRUCTION
- DWG. NO: RDM 447-2069
SUMMARY – TRUSS CUTOFF AND INTERNAL SUPPORT SUBSYSTEM

- CUTOFF MOCKUP BEING EVALUATED
- TRUSS SUPPORT CONFIGURATION DEFINED UNDETERMINED
- FINAL CONFIGURATION TRUSS CUTOFF
1. BAY LENGTH – 1.5 METERS ± 0.8 MM
2. BAY FABRICATION RATE – 60 TO 300 SEC
3. MAXIMUM CAP LENGTH VARIATION (40-M BEAM) – 20 MM
4. ROLLING MILL DRIVE SPEED – 1.5 TO 3.0 METERS/MIN

PERFORMANCE REQUIREMENTS
DESIGN GUIDELINES

- MAXIMUM USE OF "OFF-THE-SHELF" COMMERCIAL COMPONENTS
- MINIMUM-COST SYSTEM
- INSURE BEAM STRAIGHTNESS
- HIGH RELIABILITY
PRINCIPAL COMPONENTS

- CENTRAL PROCESSOR
- CAP SYSTEM SERVO
- ASSEMBLY SUBSYSTEM
- OPERATOR CONTROL PANEL
- TELETYP
CONTROL SYSTEM FUNCTIONS

- Coordinate motion of rolling mills
- Sequence events for assembly and fastening
- Execute operator input commands
CAP POSITION CONTROLS

RAMP GEN

ON/OFF

FROM CPU

TO CPU

75%
25%
0%

TO CPU

INTERUPT

CLK

VCO

SERVO TRANSLATOR ST-JOJ-3

MOTOR TACH/RESOLVER (SM709)

UP/DN CNTR

2

3

SLOT DETECTOR

ENCODER (11 DEX)
## PERFORMANCE SUMMARY

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>REQUIREMENTS</th>
<th>GOAL</th>
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<tbody>
<tr>
<td>BAY LENGTH (1.5 METERS)</td>
<td>± 0.8 MM</td>
<td>± 0.15 MM</td>
</tr>
<tr>
<td>BAY FABRICATION RATE</td>
<td>60 - 300 SEC</td>
<td>100 - 300 SEC</td>
</tr>
<tr>
<td>MAXIMUM CAP LENGTH VARIATION (40-METER BEAM)</td>
<td>± 20 MM</td>
<td>± 0.15 MM</td>
</tr>
<tr>
<td>ROLLING MILL DRIVE SPEED</td>
<td>1.5 - 3.0 M/MIN</td>
<td>1.5 - 3.3 M/MIN</td>
</tr>
</tbody>
</table>
SELECTION OF CENTRAL PROCESSOR (PDP8/A)

- COMMERCIALY AVAILABLE
- KNOWN HIGH RELIABILITY
- LOW COST
- ROOM FOR EXPANSION
- EXTENSIVE SOFTWARE SUPPORT
- EASE OF INTERFACING
ASSEMBLY SUBSYSTEM SEQUENCE

- Select V
- Move V to Cap
- Position V Electrode Blocks to 'A'
- Position Electrodes for Weld 1
- Weld 1
- Open Scissors
- Move Electrode Block to 'B'
- Weld 2
- Open Scissors
- Close Scissors
- Do Weld 13-24
- Retract Electrode Blocks
- Select 'D'

Tasks and Time
SOFTWARE HIERARCHY

EXECUTIVE CONTROLLER

ASSEMBLY SOFTWARE
- TASK ACTIVATOR
- COMPLETION DETERMINATION
- STATUS MONITOR

CONTROL STATION MONITOR AND COMMAND STATUS

CAP ROLLING SOFTWARE
- END POSITION ON FLY CONTROL
- INTERPOLATION
- RECALIBRATION

SOFTWARE CLOCKS

INTERRUPTS
- CLOCKS
- FIFO
- SLOTS
- POWER FAIL

INTERRUPT HANDLER
- UPDATE CLOCKS
- PT. D POSITION
- EMERGENCY
- STOP SHUT DOWN

1 2 3 4
n - n - n - n
ASSEMBLY SUBSYSTEM SOFTWARE

- Task Residency
- Task Selector
  - Get Next Task and All Parallel Tasks
- Set Up Pointer to Next Task
- Wait Queue
  - Wait for Any Interlocking Tasks to Complete
- Completion Monitor and Control
- Active Tasks
  - Que: Holds Tasks to Be Made Active
- Task Activator
  - Turns Actuators On or Off
SUMMARY

- OVERALL ARCHITECTURE OF CONTROL SYSTEM DEFINED
- MAJOR CONTROL ELEMENTS SELECTED
- EQUIPMENT ORDERED:
  - COMPUTER SYSTEM
  - ROLLING MILL DRIVES
- SOFTWARE DEFINED
- PROCEEDING WITH DETAIL DESIGN, SOFTWARE GENERATION
  AND COMPONENT PROCUREMENT
- UNDEFINED:
  - CONTROL CIRCUITRY FOR ACTUATORS
  - CABLING AND PACKAGING DETAILS
FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS

- SUMMARY
<table>
<thead>
<tr>
<th></th>
<th>Working Mockup</th>
<th>Preliminary Testing Performed</th>
<th>Proven Commercial Process Equipment</th>
<th>Commercial Expertise Utilized</th>
<th>For Coring</th>
<th>Compatible with Shuttle Power Rec/M</th>
<th>Compatible with Shuttle Power Rec/M</th>
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<tbody>
<tr>
<td>Controls</td>
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<td>Truss Cutoff</td>
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<td>Brace Dimensions Roll Forming</td>
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<td>Overall Configuration</td>
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SUMMARY - FACILITY DESIGN
FACILITY DESIGN PLAN

- OBTAIN CONCURRENCE WITH MSFC ON DESIGN FOR ALL SUBSYSTEMS

- START FABRICATION AND PROCUREMENT OF DETAIL PARTS

- CONTINUE WITH CONSTRUCTION TO MEET EXISTING PROGRAM SCHEDULE REQUIREMENTS
SFDS QUALITY ASSURANCE

OBJECTIVE: DELIVERY OF A FACILITY FUNCTIONING AT REQUIRED OPERATING CONDITIONS AND RATES THAT REPEATEDLY PRODUCES BEAMS TO ENGINEERING DRAWING REQUIREMENTS

MAJOR QUALITY ASSURANCE TASKS
• FABRICATION OF FACILITY
• EVALUATION OF FABRICATED BEAMS
BEAM EVALUATION

- CONVENTIONAL INSPECTION AND N.D.T. DURING GROUND PHASE
- INVESTIGATE ADVANCED AUTOMATED SYSTEMS FOR FLIGHT APPLICATION
- PRIMARY INSPECTION AREAS
  - ROLL FORMED CAP MEMBERS
  - SPOT WELD ATTACHMENTS
  - BRACE POSITIONING
  - ASSEMBLY ALIGNMENT
BRACE POSITIONING

- Evaluate test beams to verify
- Brace location on cap member
- Brace alignment
- Spot weld location
- Utilize conventional dimensional inspection
SPOT WELD ATTACHMENTS

- Fabricate test samples to verify welding parameters
- Prepare process control test specimens before and after beam fabrication
- Visual and radiographic evaluation of attachments at intervals along test beams
ASSEMBLY ALIGNMENT

- Optical Technique to Measure Bow and Torsional Displacement
- In Process Evaluation During De-Bugging Phase
- Overall Measurement of Test Beams
- Evaluate Advanced Techniques for Flight Monitoring
SUMMARY

- STRUCTURAL TRUSS DESIGN
- FABRICATION FACILITY DESIGN
- PRODUCT ASSURANCE TESTS
- NEXT PROJECT MILESTONE
- QUARTERLY REVIEW ACTION ITEMS