# THE ROLE OF THE SHUTTLE REMOTE MANIPULATOR SYSTEM IN SATELLITE SERVICING

A PRESENTATION BY SPAR AEROSPACE

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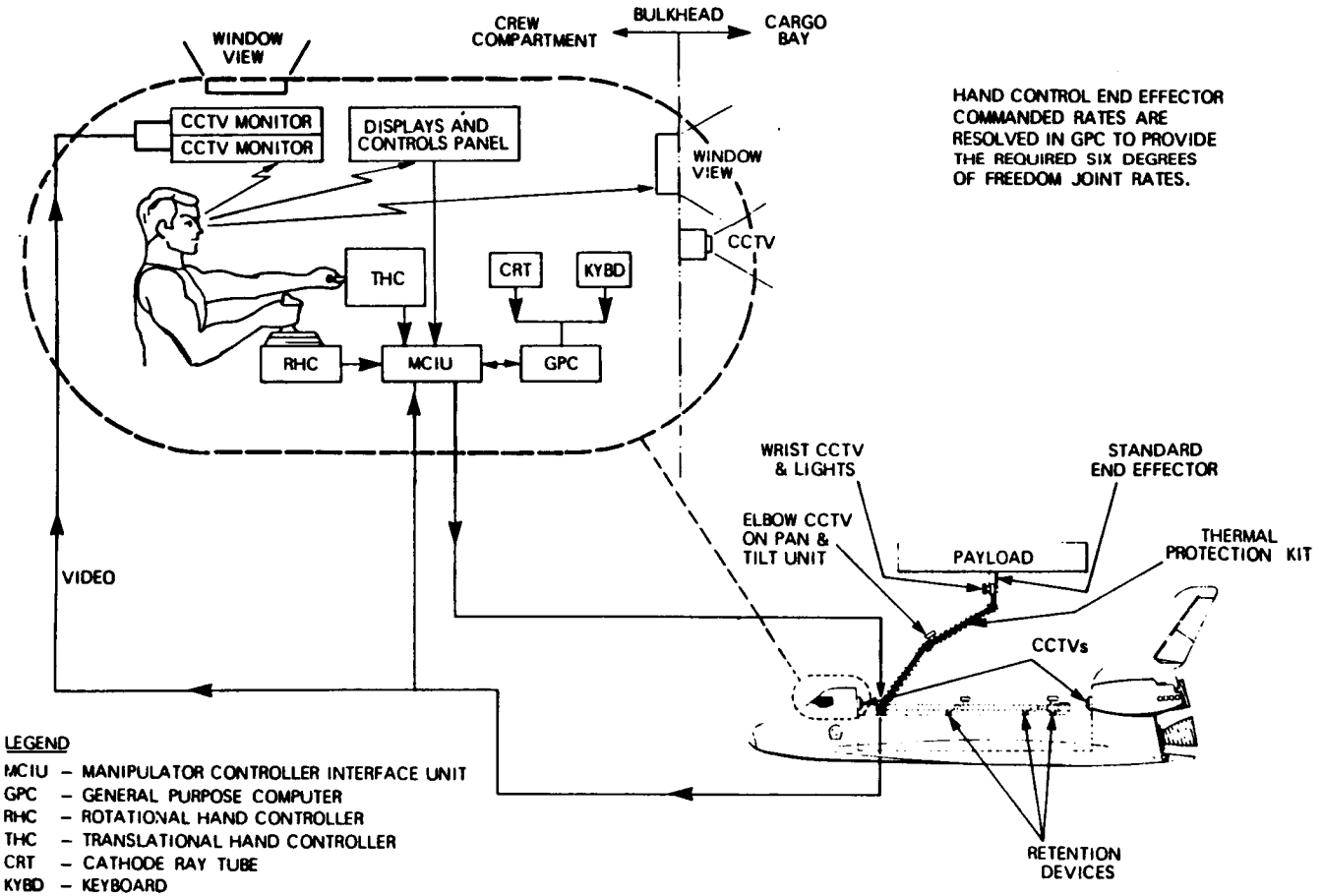
**SRMS BASIC DESCRIPTION**

SRMS SERVICING ROLE

SRMS POTENTIAL GROWTH

UNIVERSAL SERVICE TOOL CONCEPT

## SHUTTLE RMS



## SRMS SYSTEM

THE SHUTTLE REMOTE MANIPULATOR SYSTEM (SRMS) COMPRISES:

STANDARD CONFIGURATION:

- MANIPULATOR ARM INSTALLED ON PORT LONGERON
- WRIST CCTV CAMERA AND LIGHT
- STANDARD END EFFECTOR (SEE) WITH ELECTRICAL CONNECTOR & EVA HAND HOLD

OPTIONS

- SECOND ARM INSTALLED ON STARBOARD LONGERON
- ELBOW CCTV CAMERA WITH PAN & TILT UNIT
- SPECIAL PURPOSE END EFFECTORS
- SPECIAL PURPOSE GRAPPLE FIXTURES

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# THE ROLE OF SRMS IN SATELLITE SERVICING

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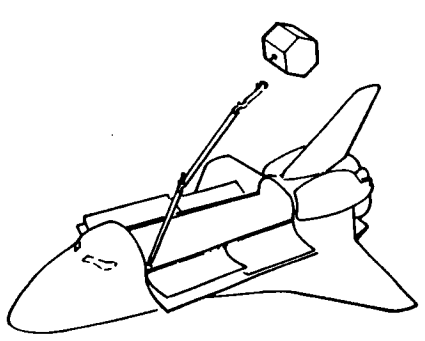
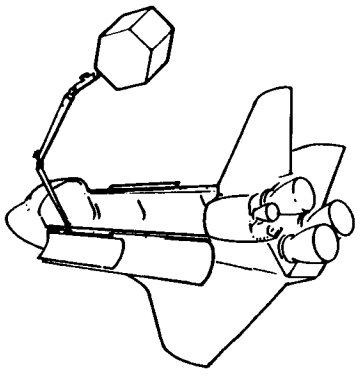
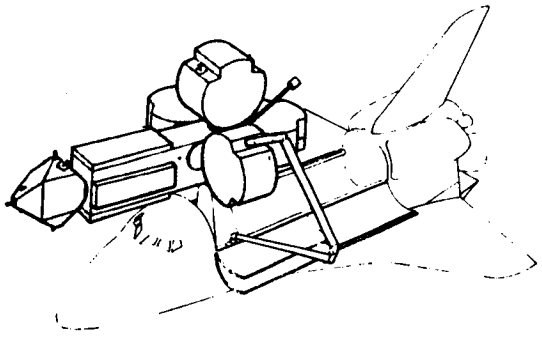
## SRMS TASKS







DEPLOYMENT → RETRIEVAL /BERTHING → LARGE SPACECRAFT ASSEMBLY/MODULE EXCHANGE

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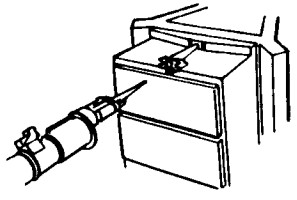
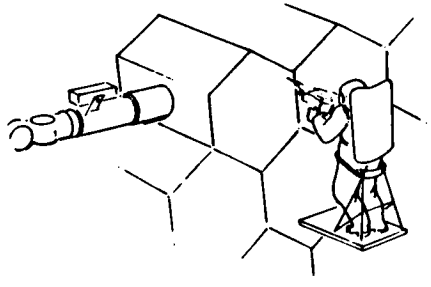
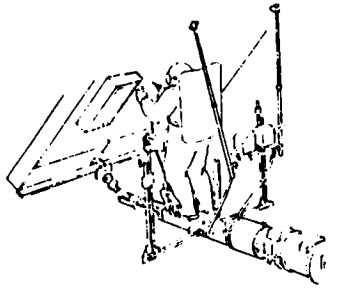
REMOTE SERVICING ← ASSIST EVA SERVICING ← SUPPORT OCP SERVICING







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## SRMS TASKS

- DEPLOYMENT – 65,000 LB. PAYLOAD BASELINE
- RETRIEVAL – 32,000 LB. PAYLOAD BASELINE
  – 65,000 LB. CONTINGENCY CAPABILITY
- SPACECRAFT ASSEMBLY/MODULE EXCHANGE
  (Under Evaluation for 25 kW Power System/Power Utilization Package and Space Operations Center)
- SUPPORT ASTRONAUT SERVICING (Baseline for OCP)
- REMOTE SERVICING – USING SRMS SUPPORTED TOOLING

## DEPLOYMENT

- THE SRMS IS DESIGNED TO DEPLOY AND RELEASE PAYLOADS WITH AN ATTITUDE ACCURACY OF ±5° AND A TIP-OFF RATE < 0.015°/SEC. WRT ORBITER.
- A CAPABILITY TO DEPLOY SPINNING PAYLOADS E.G. UNIVERSITY OF IOWA PDP.
- A CAPABILITY TO DEPLOY SATELLITES WITH AN INITIAL VELOCITY UP TO 1 FT/SEC. THIS REQUIRES FURTHER EVALUATION. PRESENT OPERATING CONSTRAINTS NECESSARY TO ENSURE A 2 FT. MAXIMUM STOPPING DISTANCE WOULD ALLOW RELEASE AT TYPICALLY 0.1 FT/SEC. FOR A 32,000 LB. PAYLOAD.

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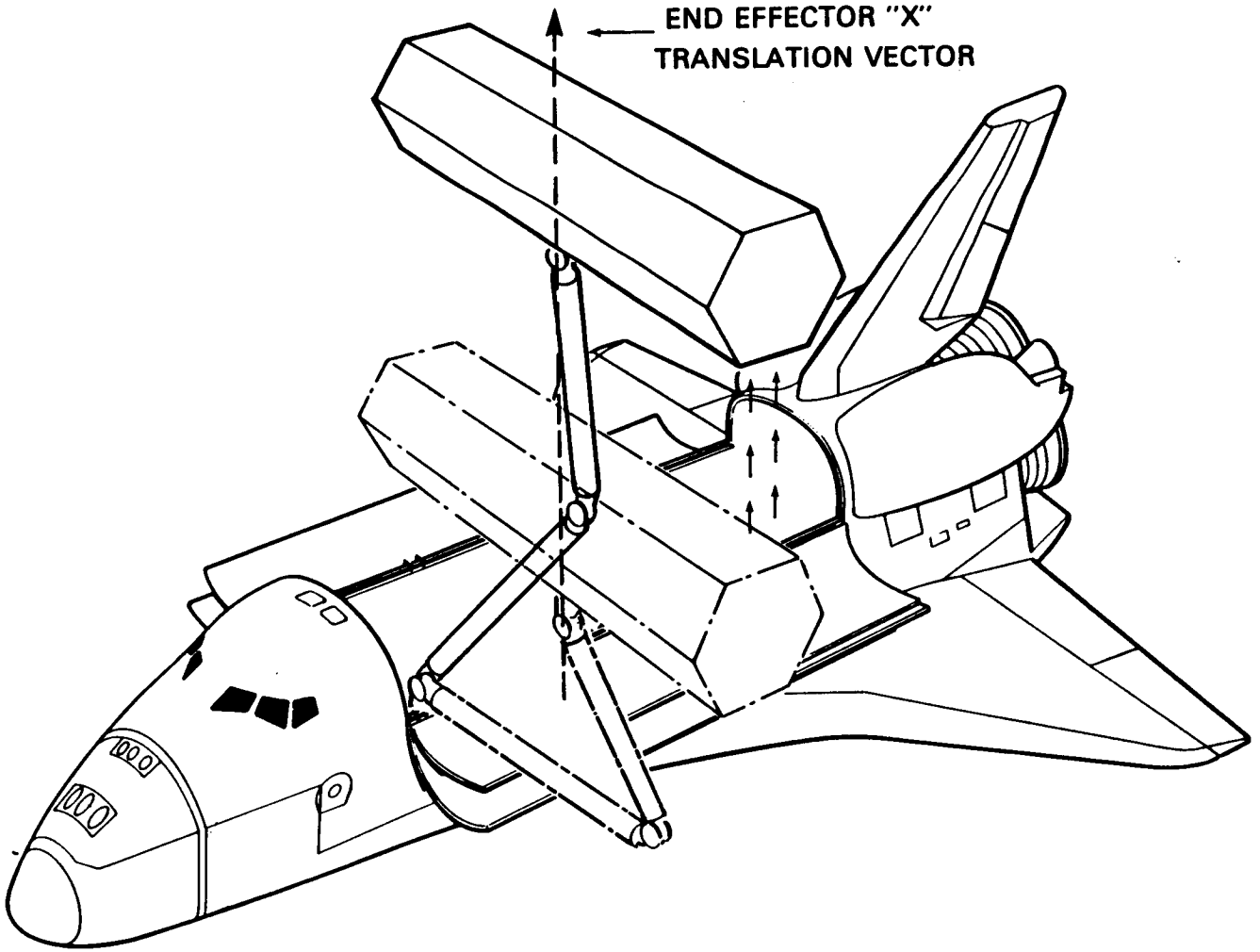
## TYPICAL ARM CONFIGURATION FOR PAYLOAD RELEASE WITH A ΔV



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## RETRIEVAL/BERTHING

SRMS WITH THE STANDARD END EFFECTOR CAN INTERFACE MECHANICALLY WITH ANY NON-SPINNING SATELLITE WHICH HAS A COMPATIBLE GRAPPLE FIXTURE. PRESENT CAPTURE CONSTRAINTS FOR RELATIVE TRANSLATIONAL AND ROTATIONAL VELOCITY BETWEEN ORBITER AND SATELLITE ARE 0.1 FT/SEC. AND ±1°/SEC. IN ANY AXIS.

- PRESENT GRAPPLE FIXTURES AVAILABLE ARE:

  STANDARD GRAPPLE FIXTURE – SUITABLE FOR CAPTURE OF A PAYLOAD UP TO 65,000 LB.

  ELECTRICAL GRAPPLE FIXTURE – CAPABLE OF HANDLING SMALL PAYLOADS.

- GRAPPLE FIXTURES OPTIMIZED FOR SPECIFIC PAYLOADS CAN BE SUPPLIED BY SPAR.

- A SPINNING END EFFECTOR CAPABLE OF DEPLOYING RETRIEVING AND DESPINNING SATELLITES UP TO 16,000 LBS. MASS IS IN THE FEASIBILITY STUDY STAGE AT SPAR.

- BERTHING IS ASSISTED WITH PAYLOAD MARKINGS AND TRUNNION GUIDE MARKINGS. USING GOOD VISUAL CUES ±1 INCH ±1° POSITIONING ACCURACIES CAN BE ACHIEVED.

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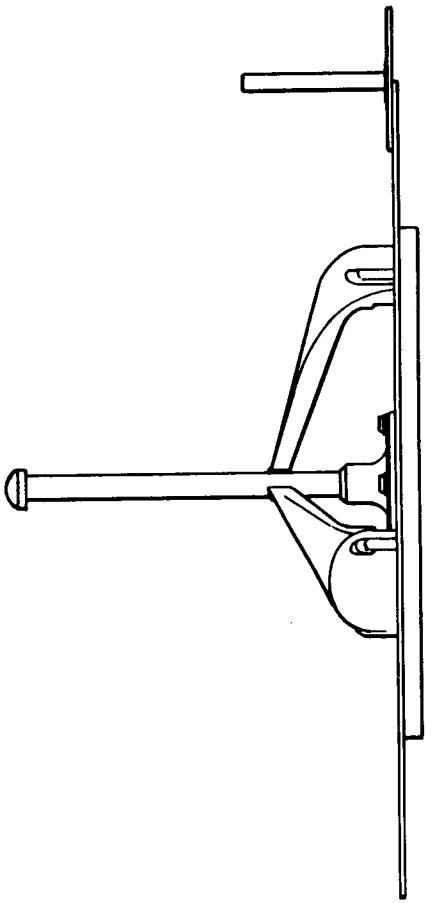
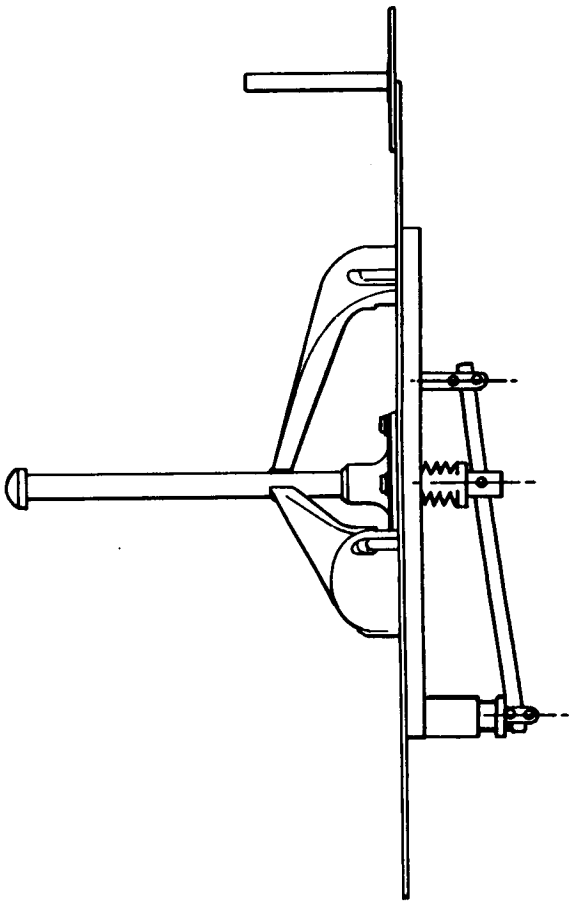
## STANDARD GRAPPLE FIXTURE



## ELECTRICAL GRAPPLE FIXTURE



## SUPPORT ASTRONAUT SERVICING

- INSPECTION TO ASSESS EVA REQUIREMENTS (TOOLS & EQUIPMENT).
- DEPLOY, MANOEUVRE AND POSITION A WORK STATION
- DEPLOY, MANOEUVRE AND POSITION MODULES FOR FURTHER SERVICING TASKS BY THE ASTRONAUT

## REMOTE SERVICING

- INSPECTION.
- REPLACEMENT OF EXPENDED AND FAULTY MODULES.
- REMOVAL AND ATTACHMENT TO REPLENISHMENT EQUIPMENT.
- THE SRMS CAN HANDLE MODULES UNSUITABLE FOR ASTRONAUT HANDLING (SIZE, INERTIA, RADIOACTIVE, ETC.)
- FACILITATED BY SPECIAL END EFFECTOR – PICKED UP BY STANDARD END EFFECTOR ON ORBIT
  – ATTACHED TO SRMS PRIOR TO LAUNCH

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## SRMS POTENTIAL GROWTH - INCREASE IN UTILIZATION

| | |
|---|---|
| DUAL ARM OPERATION (SRMS is designed to operate 2 arms in series) | - MAXIMIZE UTILIZATION OF EXISTING HARDWARE |
| REMOTE MOUNTED SRMS | - SPACE OPERATIONS CENTRE APPLICATIONS |
| ΔV PAYLOAD DEPLOYMENT | - MEET VOL XIV SATELLITE DEPLOYMENT REQUIREMENTS WITHOUT USING SPACECRAFT OR ORBITER CONSUMABLES |
| SPIN/DESPIN RETRIEVAL/DEPLOYMENT (Currently under study at SPAR) | - PROVIDE STANDARD END EFFECTOR WITH A "SPIN" JOINT OR A SPECIAL PURPOSE END EFFECTOR |
| UNIVERSAL SERVICE TOOL | - PROVIDE A BASIC REMOTE SERVICING CAPABILITY |

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## POTENTIAL SRMS GROWTH – PERFORMANCE IMPROVEMENTS

| | |
|---|---|
| IMPROVED POSITIONING ACCURACY | – INCORPORATE SOFTWARE FOR INTERFACE WITH PHOTOGRAMMETRY HARDWARE WHICH USES WRIST OR ORBITER CAMERAS TO PROVIDE OPERATOR WITH RELATIVE POSITION AND RATE DATA. |
| IMPROVE SRMS/PAYLOAD ELECTRICAL INTERFACE | – MODIFY STANDARD END EFFECTOR WITH AN "ACTIVE" ELECTRICAL CONNECTOR TO INCREASE NUMBER OF SIGNALS ACCOMMODATED ON PAYLOAD/SRMS ELECTRICAL INTERFACE. |
| ADDITION OF AN UPPER ARM ROLL JOINT | – ELIMINATE PRESENT SINGULARITIES IMPROVE OBSTACLE CLEARANCE CAPABILITY INCREASE/IMPROVE REACH. |
| END POINT FORCE SENSING/ FEEDBACK (Currently under investigation at SPAR) | – IMPROVE HANDLING PRECISION |

## SPECIAL PURPOSE END EFFECTOR APPLICATIONS

- DEPLOYMENT AND RETRIEVAL
  - STABLE NON-SPINNERS
  - STABLE SPINNERS
  - UNSTABLE/UNCO-OPERATIVE
  - DEBRIS COLLECTORS

- SPECIAL HANDLING
  - SPECIFIC SHAPES OR STRUCTURE
  - IRREGULAR, HOLLOW, CONVEX, CONCAVE

- PAYLOAD SERVICING
  - LATCHING/DELATCHING
  - TORQUING (WRENCH, SCREW DRIVER)
  - ROTARY/POWER TOOLS (CUTTER, DRILL)
  - REPLENISHMENT OPERATIONS

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## UNIVERSAL SERVICE TOOL SYSTEM (USTS) FOR ON-ORBIT SPACE SYSTEM SERVICING

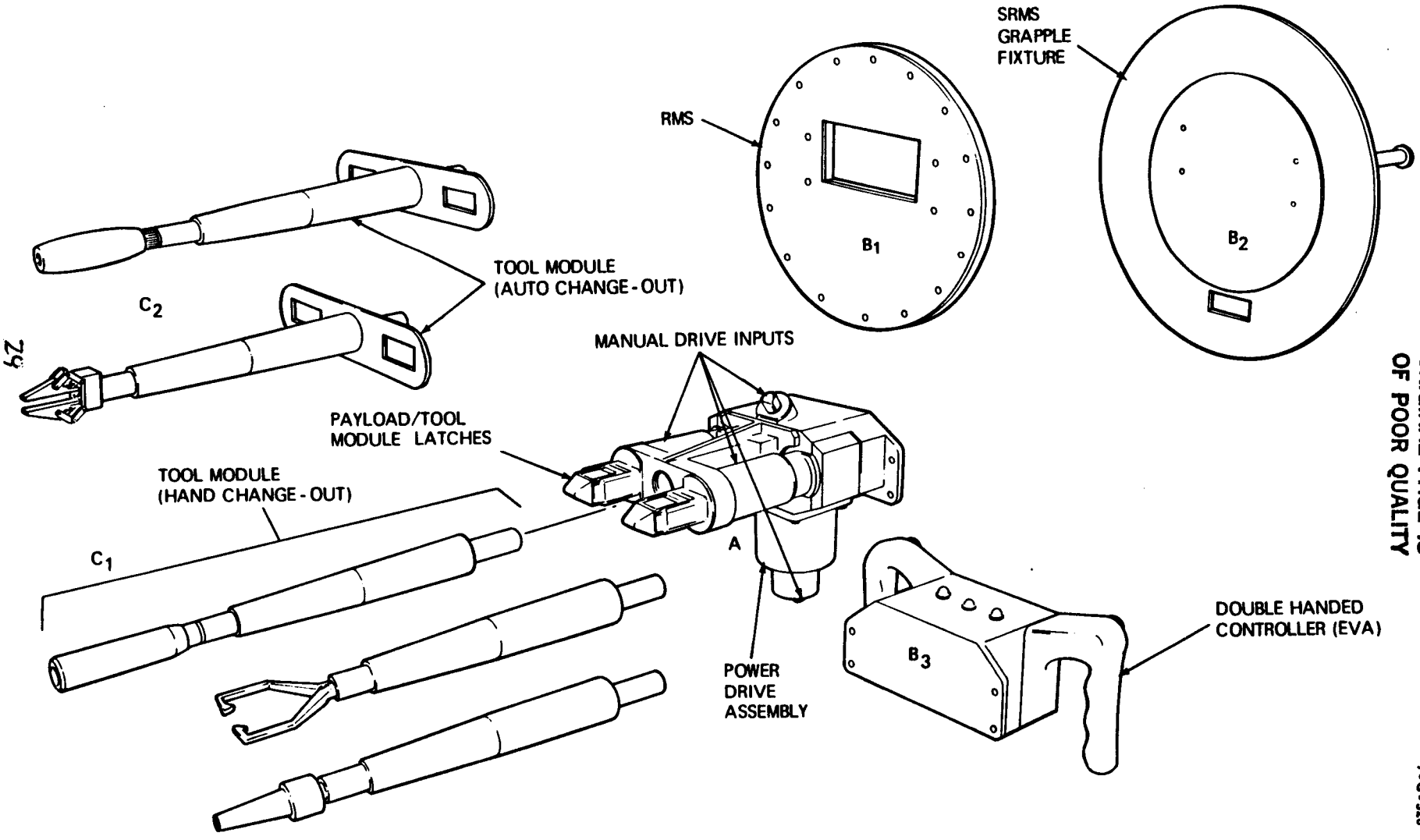
- A VERSATILE SERVICE TOOL SYSTEM:

  MODULAR DESIGN ACCOMMODATING SIMPLE CHANGE-OUT TOOLS, MANIPULATOR AND OPERATOR INTERFACES

  VARIABLE TORQUE CAPABILITY

- A MODE OF OPERATION FOR SRMS REMOTE SERVICING (USING SPEE CONNECTOR FOR ELECTRICAL POWER AND CONTROL INTERFACING).
- A MODE OF OPERATION FOR ASTRONAUT EVA (MANUAL OPERATION OF TOOL AND LATCH DRIVES AND TOOL INTERCHANGE).
- MINIMUM PAYLOAD INTERFACE ENVELOPE
- WEIGHT EFFECTIVE DESIGN.

## UNIVERSAL SERVICE TOOL SYSTEM





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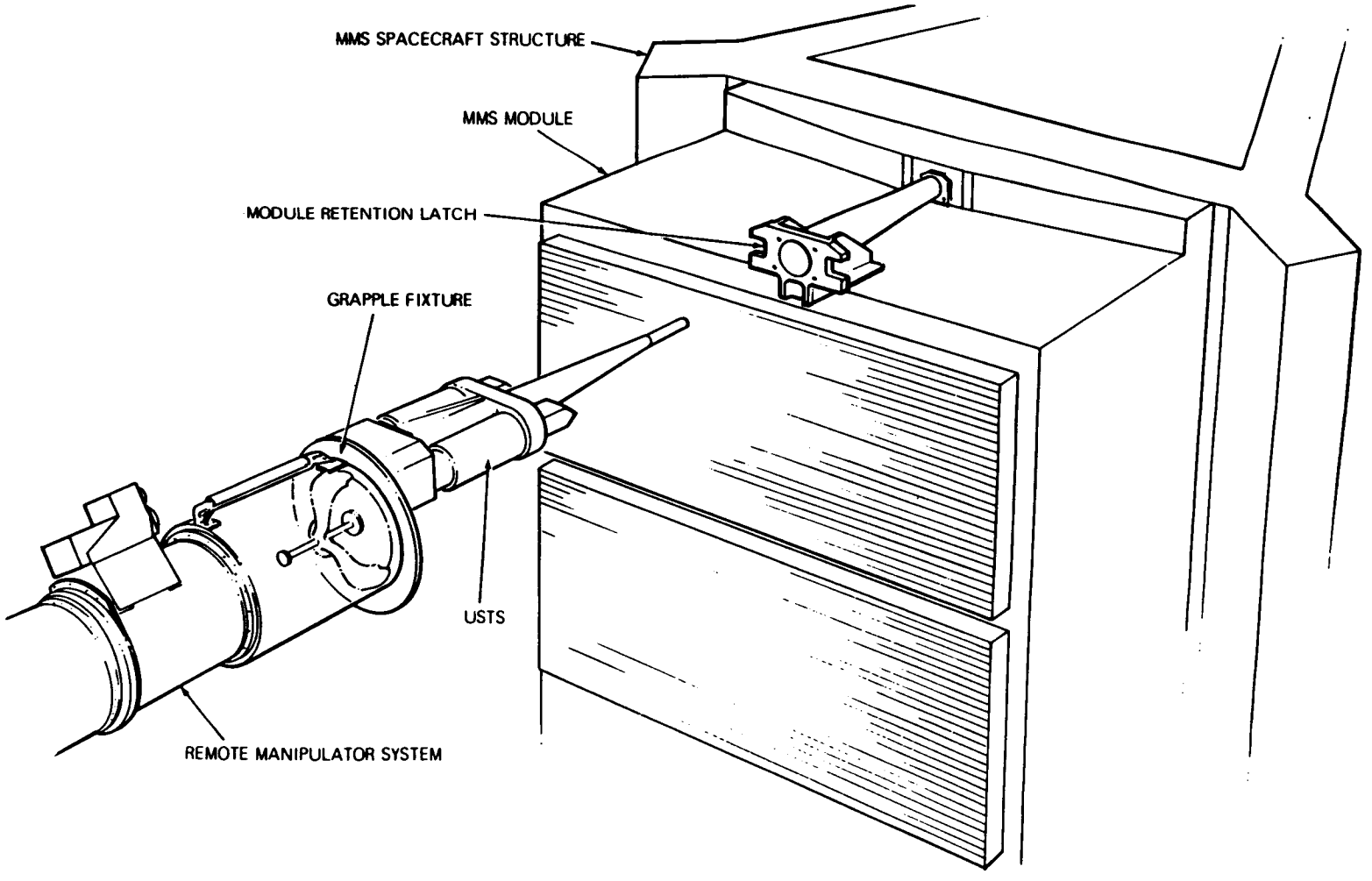
## UNIVERSAL SERVICE TOOL SYSTEM (USTS) CONCEPT

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## CONCLUDING REMARKS

- SRMS IS THE BASELINE ORBITER PAYLOAD DEPLOYMENT AND RETRIEVAL SYSTEM.
- SRMS HAS A GROWTH POTENTIAL TO SUPPORT SERVICING TASKS AS REQUIREMENTS EVOLVE.
- SRMS GROWTH FOR SATELLITE SERVICING IS GENERALLY BY ADD-ON KIT (E.G. SPECIAL END EFFECTORS).