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Ground Operations

Space Transportation Technology
Workshop
October 11, 2000

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“ST Day 2000: Reducing Risk for the Next Generations”

- ◆ **Integrated Space Transportation Program (ISTP)**
 - **Shuttle Upgrades (1st Generation)**
 - **Space Launch Initiative (2nd Generation)**
 - **Advanced Space Transportation Program (3rd Generation)**
 - Support 2nd Generation RLV
 - Spaceliner 100 Investment Area
 - Propulsion
 - Airframe
 - Launch Technologies
 - IVHM
 - Operations and Range Technology Project
 - Range
 - Launch Assist
 - Ground Operations Element
 - Spaceport Operations
 - In-Space
 - Space Transportation Research
- **4th Generation RLV Research**

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Ground Operations

- ◆ **Ground Operations**
- **Technologies that could reduce ground operations costs**
- **What are the systems issues driving ground ops costs as we know them today?**
 - Example: Labor intensive manual mating of umbilicals
- **What new technologies could reduce ground ops costs?**
 - Example: Automated umbilical mating
- **Other benefits**
 - Reduced processing time
 - Increased safety and reliability

- ◆ **Ground Ops Technologies**
- **Sensors**
- **Umbilicals**
- **Payload handling & checkout**
- **Propellant production, handling & storage**
- **Cryogenic systems**
- **Weight & CG measurement**
- **Hold down posts & vehicle positioning**
- **Etc.**

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Ground Operations

◆ **Sensors**

- **Smart Instrumentation and Electronics development**
 - Near-term objectives
 - Multi-array Pressure Transducer demo and begin work on Miniature Universal Signal-Conditioning Amplifier
 - Demo robust MEMS miniature sensor work in H2, O2, P and T
 - Begin Non-Invasive Sensor work
 - Begin Self-Healing Electronics, Advanced Power Management, Advanced Software work
 - Advanced Software Algorithms
 - Long-term objectives
 - Testing of candidate instruments for miniaturized robust mass spectrometer
 - Continue Non-Invasive Sensor work
 - Continue Self-Healing Electronics, Advanced Power Management, Advanced Software work at simulation level

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Sensors

◆ Umbilicals

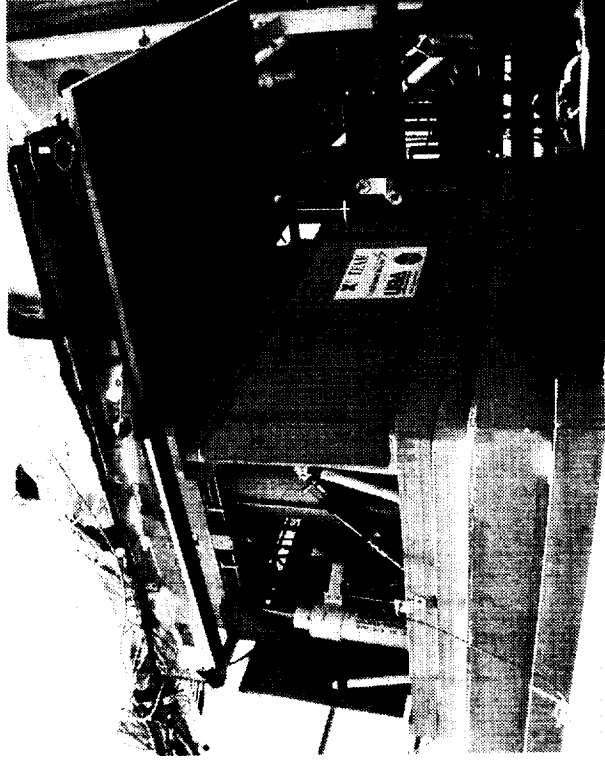
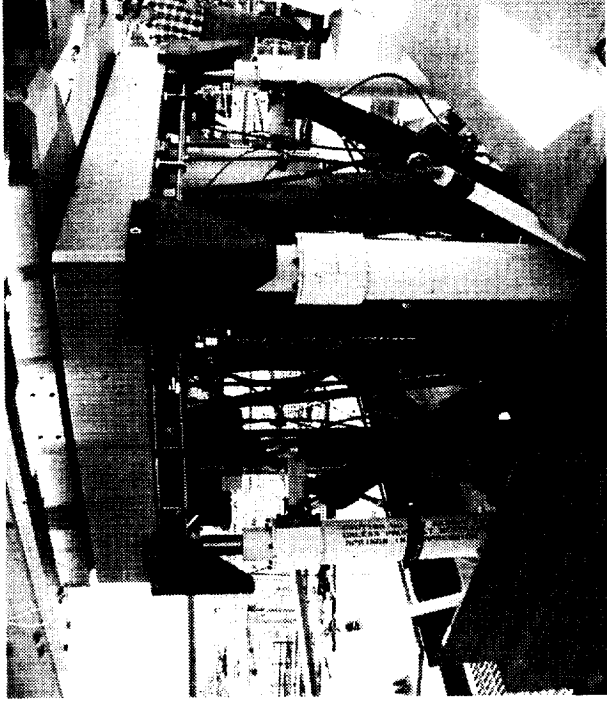
- Provide fuel fill, drain, & vent capabilities as well as power, communications, and data to vehicle prior to “T-0”
- Overall goal: “Smart” umbilicals
 - Develop enabling technologies
 - Q.D.’s
 - Fluids & fiber optics
 - Self-checking (leaks, cleanliness, etc.)
 - Self-correcting (ultimate goal)
 - Smart seals, shape-changing alloys
 - Develop with industry partners
 - - Developed spec, currently reviewing proposals
 - Automated mating
 - Vision systems
 - Advanced actuators
 - Latching systems
 - Control systems
 - Ice/frost prevention/removal systems
 - Integrate advanced sensors
 - Acoustic leak detection

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Umbilicals

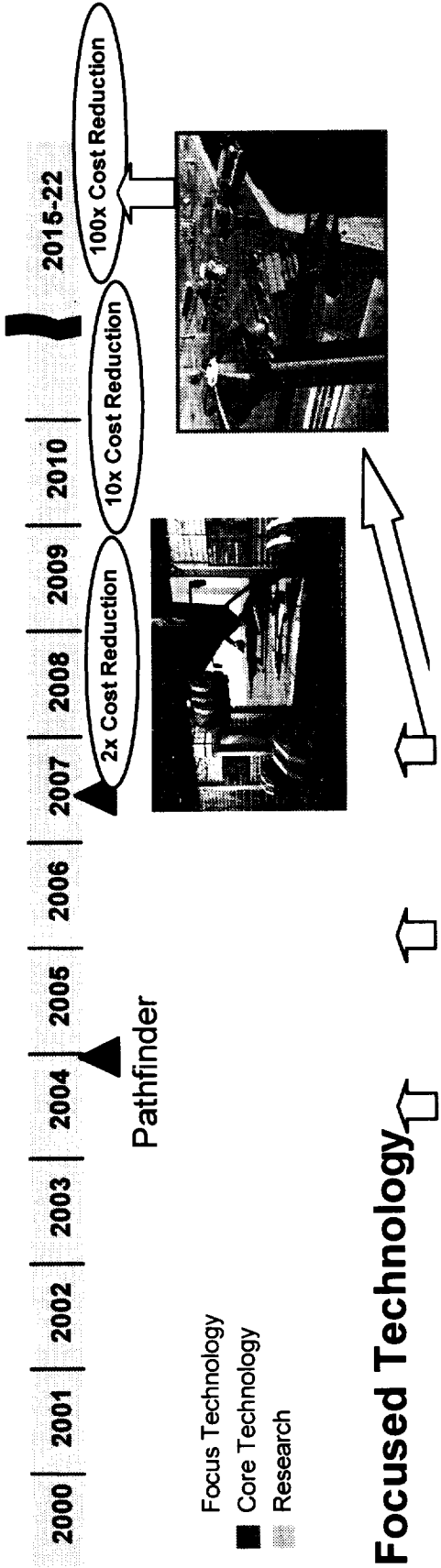
◆ 30+ years experience in umbilical design, testing & operation At KSC

- Apollo
- Shuttle
- X-33
 - Rise-off umbilical
 - Joint NASA/USA design
 - Ground and flight side plates
 - Tested at LETF



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Umbilicals

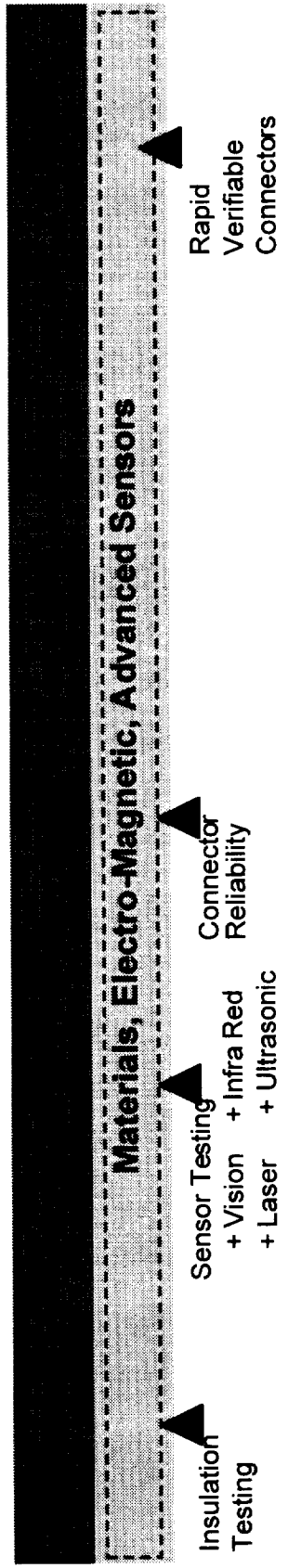


Focused Technology

Remote Servicing Automated Servicing On-Demand Servicing

- ▲ Fiber Optics Connector
- ▲ De-Icing System
- ▲ Latching Sys EMA Magnetic Vacuum
- ▲ Location System
- ▲ Self Checking Fluid Connector (Leak, Cleaning)
- ▲ Wireless Data & Power System
- ▲ Next Generation Fluid Connector

Core Technology

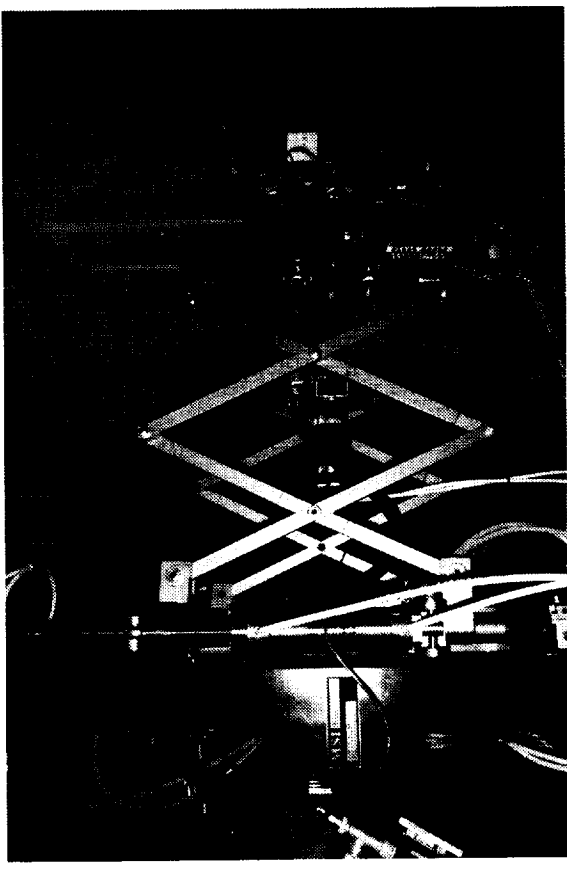
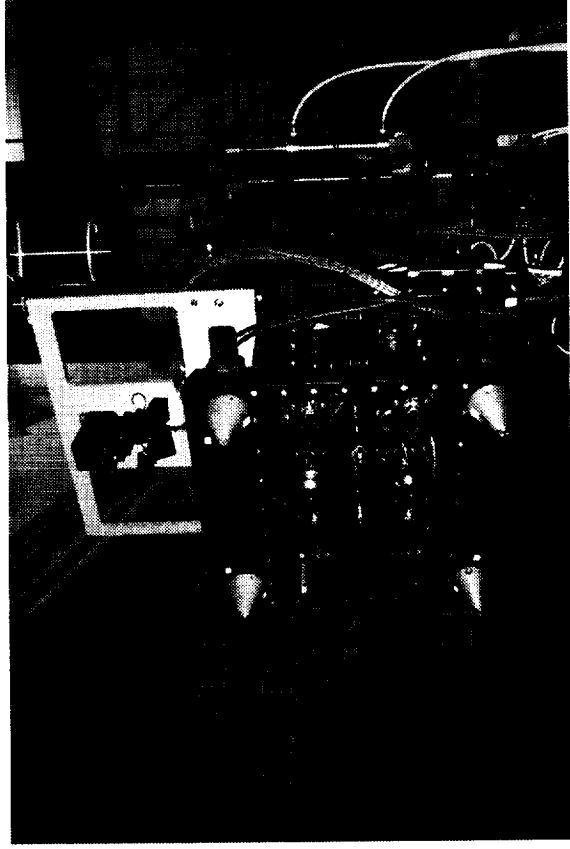


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Umbilical Roadmap

◆ Automated Umbilical Mating Technology

- Project began as SBIR Phase I
 - Merritt Systems Inc. of Oviedo, FL
- Further developed under SBIR Phase II
 - Scissors-type mechanism
 - Pneumatic actuators
 - Vision system



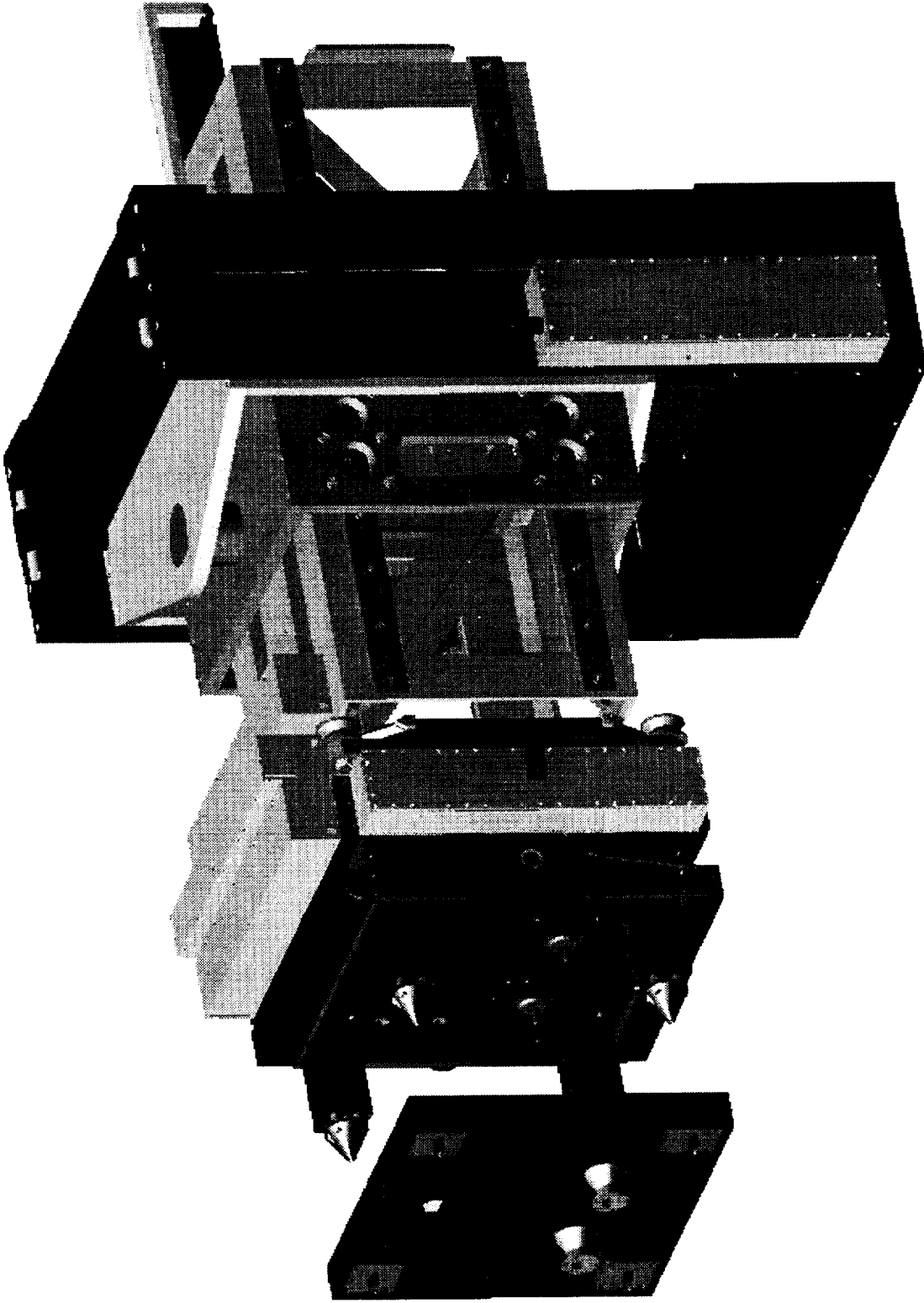
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Automated Umbilicals

- ◆ **Phase III**
 - **Initially funded under Bantam X program**
 - **No specific umbilical requirements for Bantam were developed**
 - **Focus shifted to development of enabling core technologies required for an automated umbilical system**
 - Location/tracking (vision system)
 - Positioning (actuators)
 - Control system (hardware/software)
 - De-icing (required for re-mate capability)
 - **Looked at existing and future launch vehicle configurations to determine requirements common across all systems**
 - **Developed a generic, scalable, adaptable, “worst-case” design concept**
 - End of swing arm, active control of 6 DOF, harsh environment, re-mate capability, fail-operational, etc.
 - **Basic technology can then be tailored to fit specific vehicle requirements**
 - Possible on-orbit or planetary surface applications
 - Commercial aircraft and automotive refueling

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Automated Umbilicals



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Automated Umbilicals

- ◆ **Operational concept**
- **Independent system required to position automated umbilical into its operational envelope**
 - Swing arm, TSM, rail, etc.
- **Initial approach to vehicle using vision system**
- **Actuators based on linear induction motors provide precise control of movement in X, Y, Z, yaw, pitch, and roll**
- **After alignment cones enter receptacles on flight side, force-feedback control is employed**
- **Linear motors allow adjustment of “compliance” of system to ensure excessive loads are not imparted to vehicle**
- **Mate is 2-stage process**
 - Alignment cones provide hard mate to vehicle
 - Secondary carrier plate is then driven forward to gang-mate all fluid and electrical connections
- **Once successful mate is achieved, system becomes “passive”**

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Automated Umbilicals

- ◆ **Operational Concept**
 - **At predetermined commit point in countdown, system de-mates from vehicle and withdraws to a safe position**
 - **If launch is aborted after de-mating, umbilical will re-mate to vehicle to allow fuel drain**
 - System must be fail-operational to ensure re-mate can be accomplished
 - Redundant actuators
 - Fault-tolerant control system
 - Any build-up of ice/frost from mating surfaces must be removed prior to re-mate
 - Infrared lamps
 - Warm fluid loops

- ◆ **Status**
 - **Design currently being finalized**
 - **Fabrication and delivery of prototype/demonstrator in FY01 pending funding**

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Automated Umbilicals