FUZZY CONTROL/SPACE STATION AUTOMATION

by

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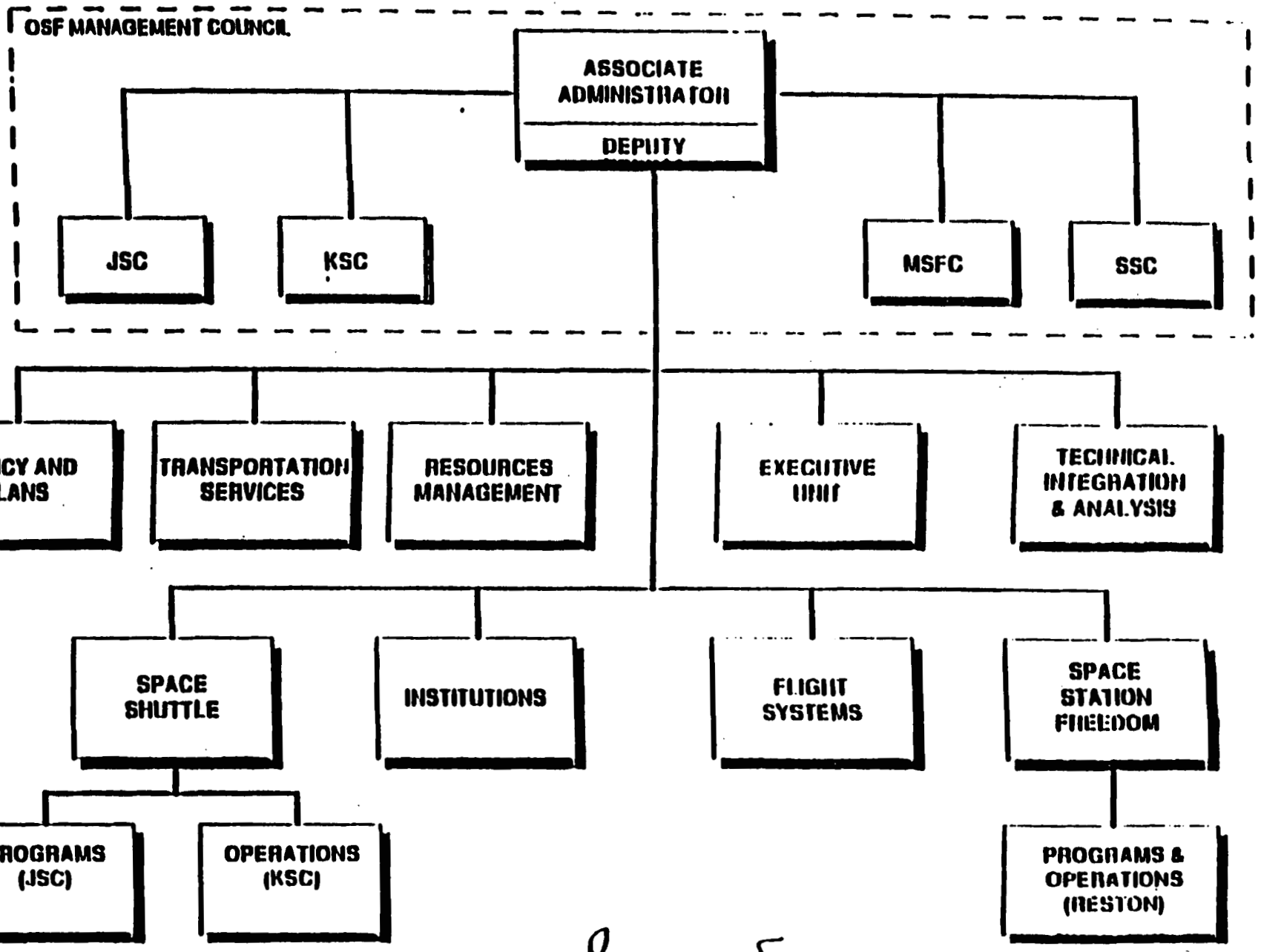
NASA Headquarters

14 November 1990

Office of Space Flight



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FREEDOM

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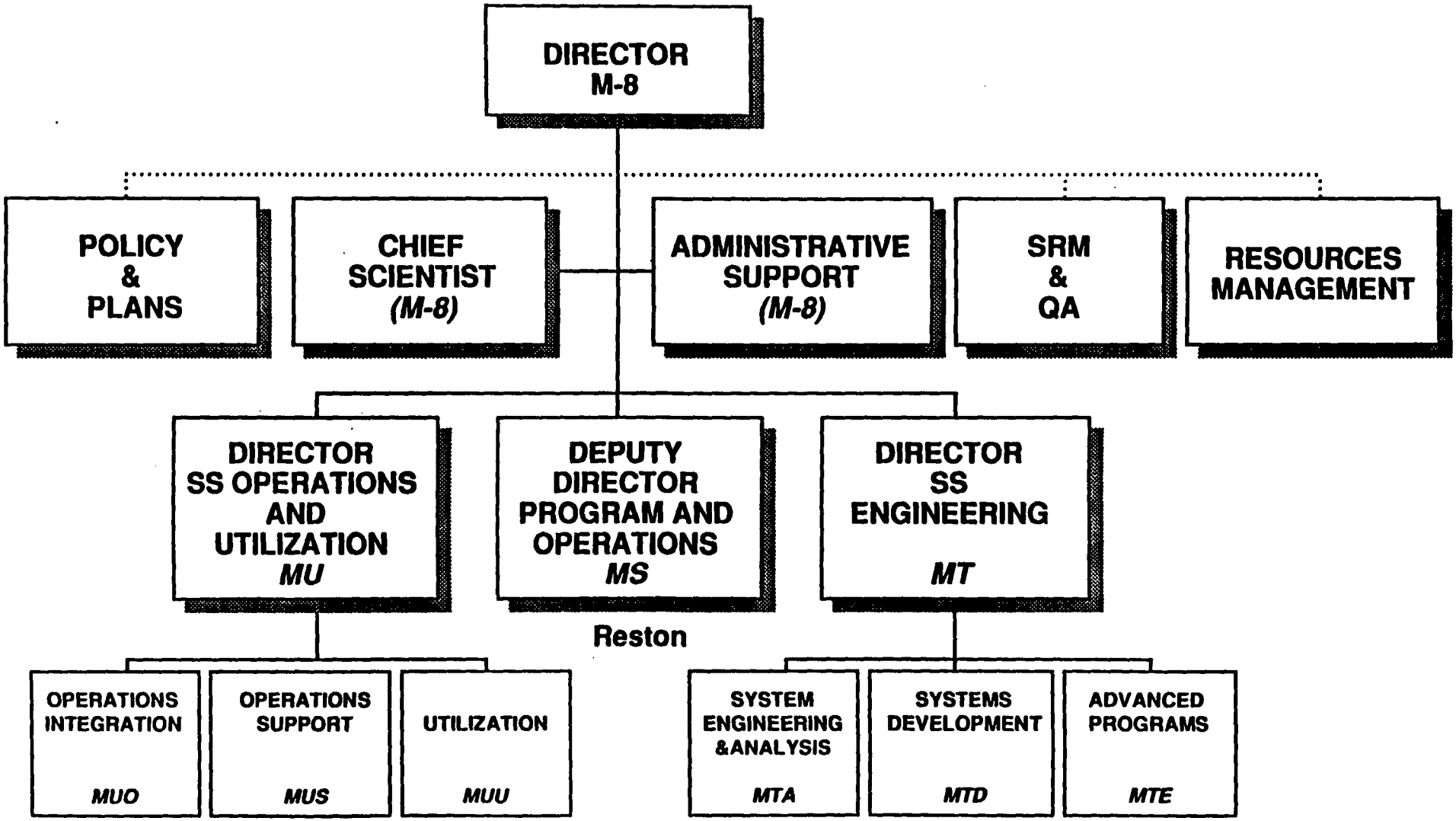
SPACE STATION FREEDOM



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Code MT Organization and Responsibilities

Space Station Engineering Organization

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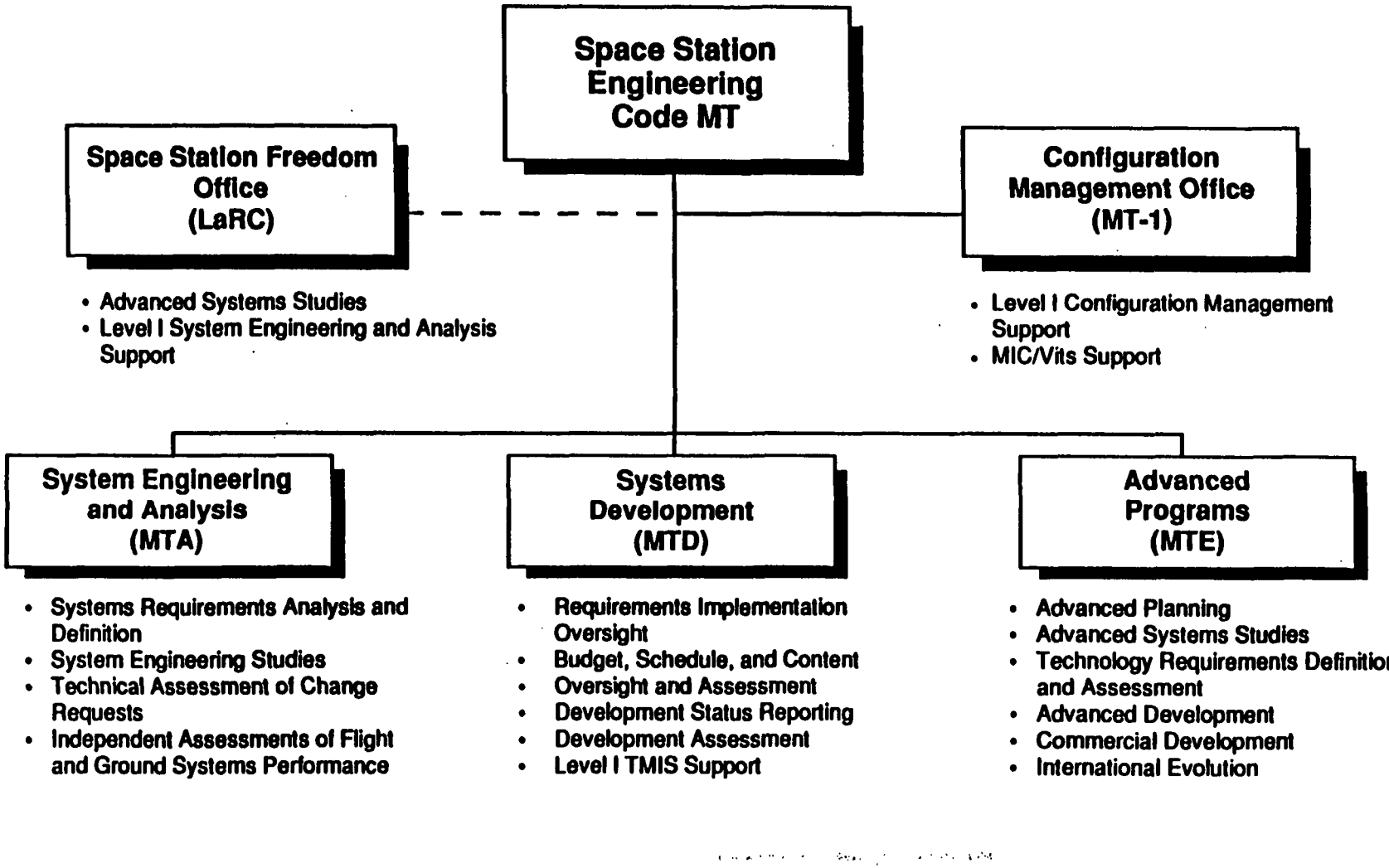
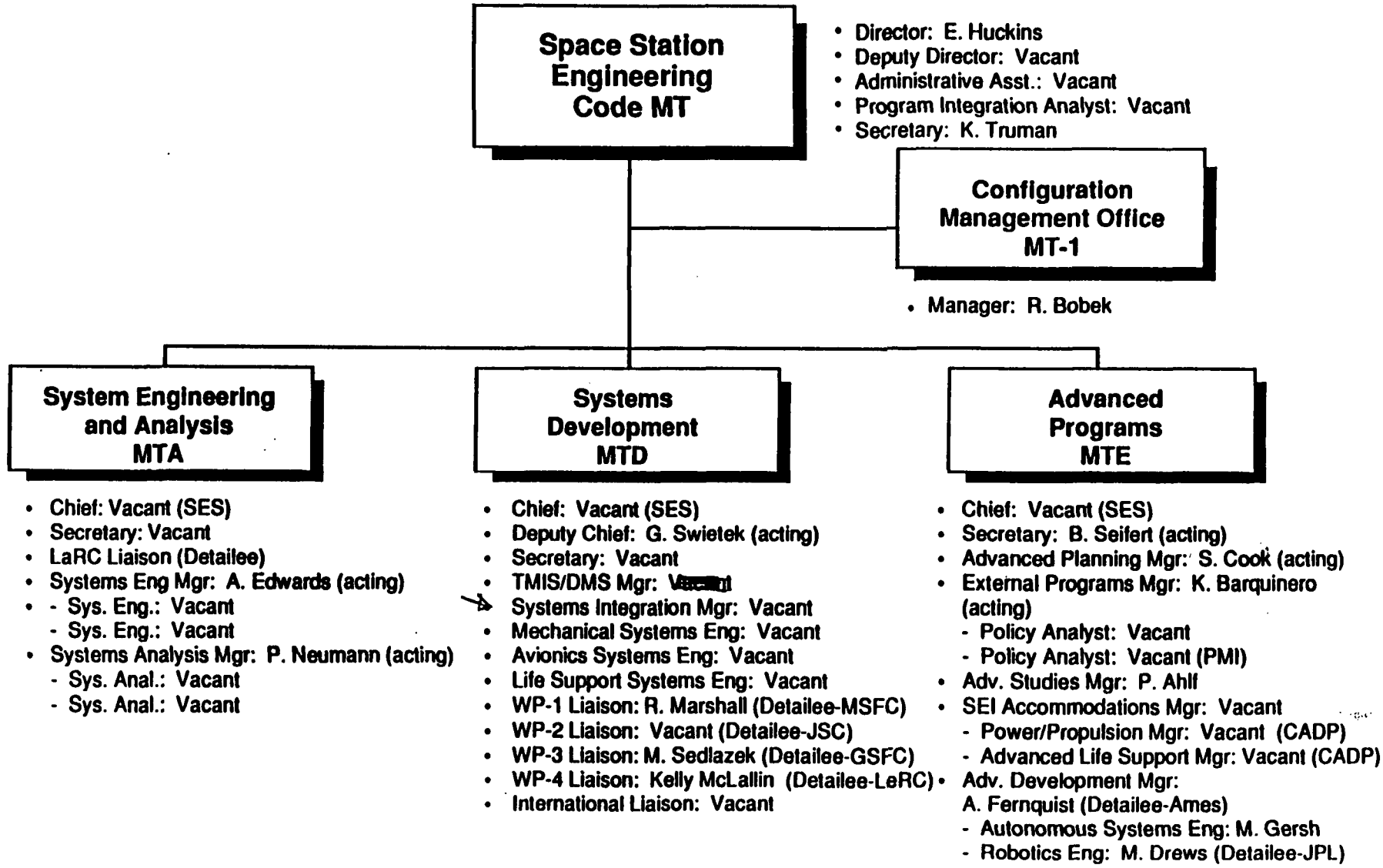


Code MT Staffing



SPACE STATION FREEDOM

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Objectives

- Provide a permanently manned presence in space
- Enhance capabilities for space science and applications
- Stimulate advanced technologies
- Promote international cooperation
- Encourage private sector participation and utilization
- Provide options for future endeavors in space

SPACE STATION FREEDOM

Evolution

- **Freedom is a permanent facility:**
  - **Upgrades and configuration changes will take place on-orbit**
- **During the operational life of the Space Station:**
  - **National priorities will change**
  - **User needs and mission requirements will change**
  - **Technology will evolve and components will become obsolete**

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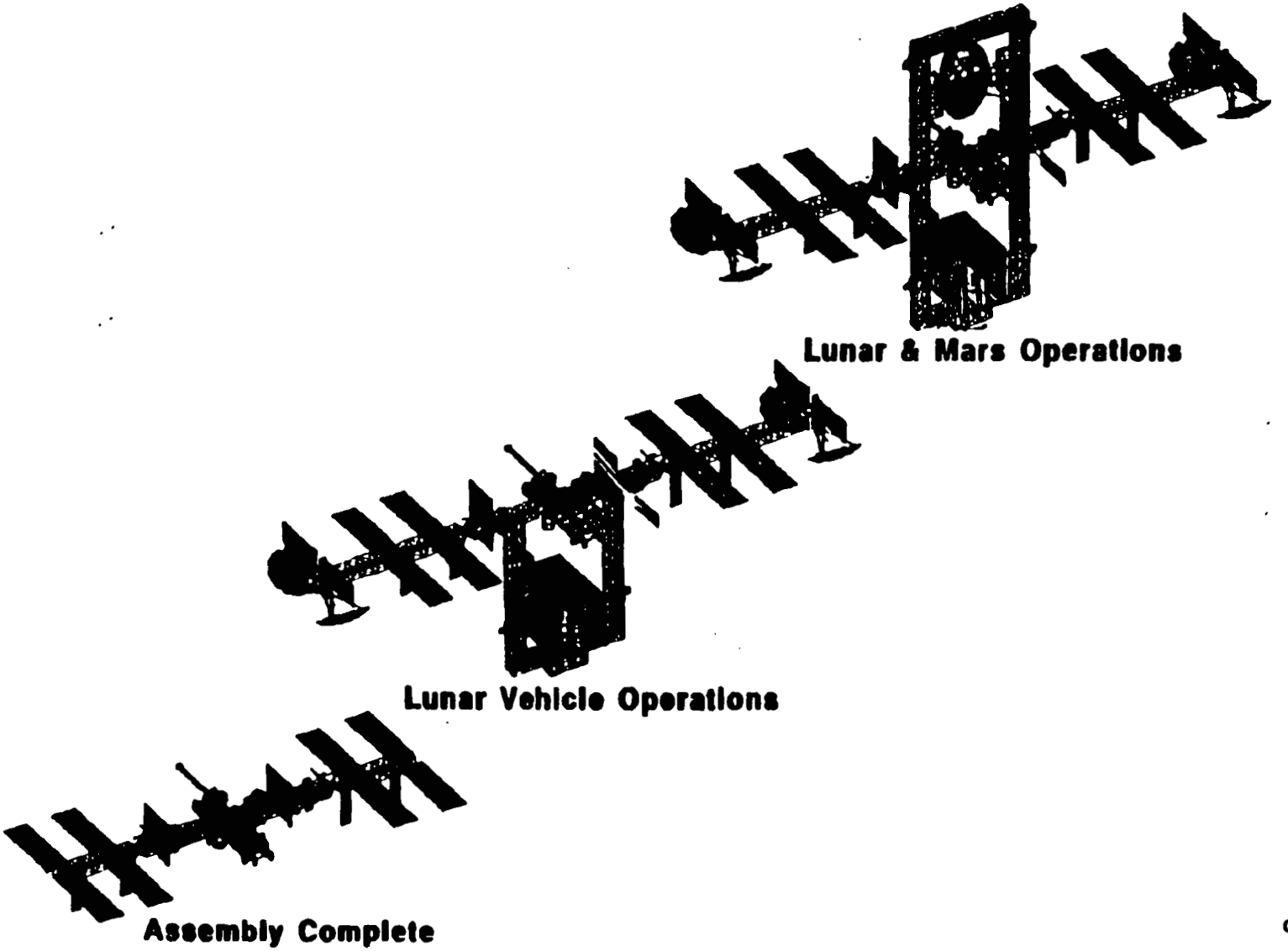
EVOLUTION FOR HUMAN EXPLORATION



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SPACE STATION FREEDOM

Factors Pointing to Automation & Robotics (A&R)

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- Space Station has a 30 year operational life
  - Operations costs, reliability are important concerns
  - Incorporation of new technology essential
- Crew is most scarce resource
  - Productivity is crucial in meeting assembly, user, and servicing requirements
- Evolution mission scenarios are crew-intensive
  - Science missions will grow and increase demand for crew time
  - On-orbit assembly, checkout, launch of Lunar/Mars vehicles

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The A&R Promise

- Increased Mission Safety, Reliability
  - Manage system complexity
  - Trend analysis, fault detection, isolation, and reconfiguration
  - Reduce EVA required
- Increased Mission Productivity, Services
  - Reduce "housekeeping" overhead
  - Reduce experiment overhead
- Increased Probability of Mission Success
  - Re-planning for contingencies, reactive science
- Reduced Operations Costs
  - Training, software maintenance, sustaining engineering

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Astronaut Office Inputs Concerning A&R

- Regarding Advanced Automation
  - Simple, standardized human interface (idiot proof)
  - Provide flexible operations capability
  - User (versus technology developer) oriented
  - Develop and implement easier applications first
  - Help the user do the job easier (don't make it harder)
  - Include "What if?" Capability (In-line simulation)
  - Backup mode of operation
  - System must be able to explain conclusions and actions
- Automate tedious and repetitive tasks, time dependent tasks, calibration and alignment tasks, robotic set-up for EVA

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Astronaut Office Inputs Concerning A&R

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- Applications supported by crew for improving productivity:
  - Automated record keeping and documentation (100%)
  - Automated inventory management (96%)
  - Automated FDIR (93%)
  - Improved human-computer interfaces (92%)
  - Robotic construction (92%)
  - Exception reporting and alarm filtering (88%)
  - External camera and light pointing (87%)
  - Robotic external repairs (85%)
  - Automated trend analysis (incipient failure detection) (85%)
  - Checklist automation (85%)

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Astronaut Office Inputs Concerning A&R

- **Applications supported by crew for improving productivity:**
  - **Systems Monitoring and Control (82%)**
  - **EVA retriever robotics (81%)**
  - **Payload-specific automation (79%)**
  - **On-board training systems (72%)**
  - **Internal camera and lighting pointing (58%)**
  - **Speech Recognition (56%)**
  - **Speech Synthesis (54%)**
  - **On-board scheduling/re-scheduling capability (52%)**
  - **IVA rack robot (50%)**
  - **IVA housekeeping robot (46%)**

SPACE STATION FREEDOM

Advanced Development Program

- Objectives
  - Enhanced baseline Space Station Freedom capabilities
    - -- Improve productivity and reliability
    - -- Reduce operations costs
    - -- Prevent technological obsolescence
  - Enable Space Station Freedom evolution

- Products
  - "Engineering" fidelity demonstrations, evaluations
  - Detailed requirements, performance specifications
  - Mature technology, tools, applications

SPACE STATION FREEDOM

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Flight System Automation and Ground Operations Applications

- Focused on Automated Status Monitoring, Fault Detection, Isolation, and Recovery (FDIR) using Knowledge-Based System (KBS) techniques
- Understand design accommodations ("hooks and scars")
  - Instrumentation, control redundancy, interfaces
- Identify KBS implementation issues
  - Integration with conventional techniques
  - Processing, data storage, communication requirements
  - Software development, testing, maintenance
  - Boundaries of KBS technology (performance, scale, brittleness)
- Applications under development for Thermal, Power, Life Support, Data Management, Mission Control

SPACE STATION FREEDOM

Transition Definition Program
Advanced Development - FY 1990

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- Flight Systems and Ground Operations Automation Tasks
  - Focused on automated status monitoring, fault detection, isolation, and recovery (FDIR) using Knowledge-Based System (KBS) techniques
  - FDIR KBS applications under development for the Thermal Control System, Power Management and Distribution/Control Systems, Environmental Control and Life Support System, Data Management System, Operations Management System, Mission Control Center (MCC), and the Space Station Control Center (SSCC)
  - MCC applications were jointly developed with OAST and OSF and have supported STS-26, STS-29, STS-30, STS-28, STS-34 and STS-32; all will be transitioned to SSCC

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Advanced Automation Software Tools

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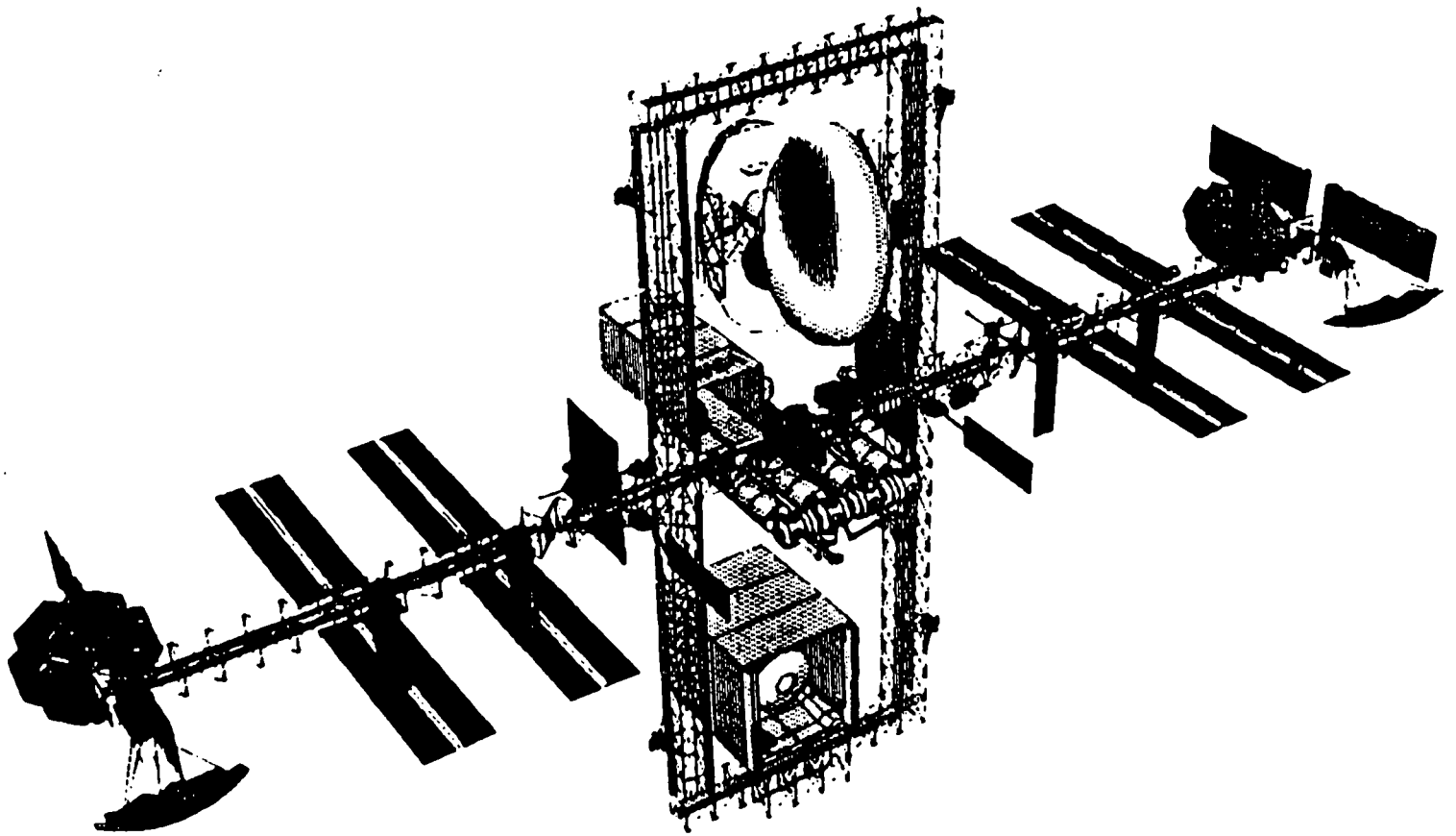
- Focused on providing programming tools to enable development of integrated KBS applications within the Software Support Environment (SSE)
  - KBS programming tools which produce Ada code are under development and evaluation
- Develop and demonstrate advanced programming tools which reduce the cost of software development and maintenance for flight and ground systems
  - "Programmers Assistant" that uses KBS techniques to aid programmers in Ada software re-use under evaluation
  - Programming environment for Intelligent Computer-Aided Training (ICAT) applications under development

LUNAR/MARS TRANSPORTATION NODE



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Some General Thoughts on Technology Transition

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- In an ideal world, technology transition happens when...
  - The user is interested and involved in application development
  - The application and technology are consistent with operations concepts, procedures, and doctrine
  - Implementation is compatible with existing hardware and software and isolated ("firewalled") during initial evaluation period
  - "Success" metrics are defined early and guaranteed at some minimal level
  - "Bottoms up" and "top down" pressure is simultaneous and consistent
  - Post deployment "care and feeding" issues are addressed early

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Some General Thoughts on Technology Transition

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- It's not an ideal world...
  - Organizational structure creates, encourages insular and myopic view of technology insertion opportunities and operational realities
  - Ego and fear of the unknown tends to reinforce status quo
  - Personnel and financial resources are limiting factors
  - Risk and schedule pressure are harsh realities

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Summary

- Automation is a key element in meeting Space Station Freedom baseline and evolution requirements
- Automation technology is sufficiently mature to warrant early use within the Program
- Scope and pace of automation applications will be determined by:
  - Success of early testbed prototypes
  - Support and acceptance of managers and users
  - Consistent implementation methodology and tools
- "Technology transfer is a body contact sport." - John Muratore, JSC
  - People are a key factor in affecting or preventing technology transfer and utilization