FUZZY CONTROL/SPACE STATION AUTOMATION

by

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OFFICE OF SPACE FLIGHT
SPACE STATION FREEDOM

DIRECTOR M-8

POLICY & PLANS

CHIEF SCIENTIST (M-8)

ADMINISTRATIVE SUPPORT (M-8)

SRM & QA

RESOURCES MANAGEMENT

DIRECTOR SS OPERATIONS AND UTILIZATION MU

DEPUTY DIRECTOR PROGRAM AND OPERATIONS MS

DIRECTOR SS ENGINEERING MT

OPERATIONS INTEGRATION MUO

OPERATIONS SUPPORT MUS

UTILIZATION MUU

SYSTEM ENGINEERING & ANALYSIS MTA

SYSTEMS DEVELOPMENT MTD

ADVANCED PROGRAMS MTE

Reston

Last Modified 10/10/90
Space Station Engineering Organization

Space Station Freedom
Office (LaRC)
- Advanced Systems Studies
- Level I System Engineering and Analysis Support

System Engineering and Analysis (MTA)
- Systems Requirements Analysis and Definition
- System Engineering Studies
- Technical Assessment of Change Requests
- Independent Assessments of Flight and Ground Systems Performance

Space Station Engineering Code MT

Configuration Management Office (MT-1)
- Level I Configuration Management Support
- MIC/Vits Support

Systems Development (MTD)
- Requirements Implementation Oversight
- Budget, Schedule, and Content
- Oversight and Assessment
- Development Status Reporting
- Development Assessment
- Level I TMIS Support

Advanced Programs (MTE)
- Advanced Planning
- Advanced Systems Studies
- Technology Requirements Definition and Assessment
- Advanced Development
- Commercial Development
- International Evolution

Last Modified 10/1/90
Code MT Staffing

Space Station Engineering Code MT

- Director: E. Huckins
- Deputy Director: Vacant
- Administrative Asst.: Vacant
- Program Integration Analyst: Vacant
- Secretary: K. Truman

Configuration Management Office MT-1

- Manager: R. Bobek

System Engineering and Analysis MTA
- Chief: Vacant (SES)
- Secretary: Vacant
- LaRC Liaison (Detaillee)
- Systems Eng Mgr: A. Edwards (acting)
- Sys. Eng.: Vacant
- Systems Analysis Mgr: P. Neumann (acting)
- Sys. Anal.: Vacant

Systems Development MTD
- Chief: Vacant (SES)
- Deputy Chief: G. Swietek (acting)
- Secretary: Vacant
- TMIS/DMS Mgr: Vacant
- Systems Integration Mgr: Vacant
- Mechanical Systems Eng: Vacant
- Avionics Systems Eng: Vacant
- Life Support Systems Eng: Vacant
- WP-1 Liaison: R. Marshall (Detaillee-MSFC)
- WP-2 Liaison: Vacant (Detaillee-JSC)
- WP-3 Liaison: M. Sedlazek (Detaillee-GSFC)
- WP-4 Liaison: Kelly McAllin (Detaillee-LeRC)
- International Liaison: Vacant

Advanced Programs MTE
- Chief: Vacant (SES)
- Secretary: B. Seifert (acting)
- Advanced Planning Mgr: S. Cook (acting)
- External Programs Mgr: K. Barquinero (acting)
- Policy Analyst: Vacant
- Policy Analyst: Vacant (PMI)
- Adv. Studies Mgr: P. Ahl
- SEI Accommodations Mgr: Vacant
- Power/Propulsion Mgr: Vacant (CADP)
- Advanced Life Support Mgr: Vacant (CADP)
- Autonomous Systems Eng: M. Gersh
- Robotics Eng: M. Drews (Detaillee-JPL)

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SPACE STATION FREEDOM

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
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
SPACE STATION FREEDOM
EVOLUTION FOR HUMAN EXPLORATION

Lunar & Mars Operations

Lunar Vehicle Operations

Assembly Complete
SPACE STATION FREEDOM

Factors Pointing to Automation & Robotics (A&R)

- 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
SPACE STATION FREEDOM

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
SPACE STATION FREEDOM
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
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%)
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
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
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
SPACE STATION FREEDOM
Advanced Automation
Software Tools

- 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
SPACE STATION FREEDOM

Some General Thoughts on
Technology Transition

- 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
Some General Thoughts on Technology Transition

- 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
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