



GSAW 98



COTS AI Technologies for Satellite Control

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Overview



- Position: identifying state-of-the-art technologies for SGSs
- High-payoff technologies available today
 - COTS Vendors
 - Government Agencies
- Possible future SGS products
- Recommendations
- Conclusions



Position



- Several important technologies are ready now as COTS/GOTS capabilities
 - Rule-based and finite state-based systems
 - Distributed ground architectures
 - Data Visualization
 - Middleware
- Bottom Line
 - These products can provide immediate and dramatic cost-effective advances in SGS capabilities



Caveats



- I'm not here to peddle software products!
- My goals are to save
 - Dollars: get the most technology for the buck, **now**
 - Resources: provide dramatic personnel and workload savings, **now**
 - Effort: ensure we fund activities that aren't being duplicated somewhere else
- In short, make autonomous satellite operations a reality--as efficiently as possible



Rule-based Systems



- Inference engines that determine H&S by creating “if <cond’n> then <action>” rules
- Advantages
 - Easily capture contingencies (routine or anomalous)
 - Promote iterative software development
- Disadvantages
 - Non-deterministic
 - Rule base can explode as satellite complexity increases



Rule-based Systems



- COTS products
 - Spacecraft Command Language (SCL), by Interface and Control Systems
 - Previously used on ROMPS and Clementine
 - Currently used in FUSE (at JHU)
 - Originally developed for on board control, but now moving toward a complete ground/flight system
 - Interfaces easily with other commercial products
 - CLIPS (NASA/GSFC)
 - Numerous others



Finite State-based Systems



- Define a set of nominal and off-nominal states, and transitions to safely move between states
- Advantages
 - Fully deterministic
 - Perform operations within the context of a state (i.e., trending battery voltages during normal operation)
 - Hierarchical states reflect actual physical components
- Disadvantages
 - Unknown states can hinder closed-loop control



Finite State-based Systems



- COTS product
 - Altair Mission Control System (AMCS), by Altair Aerospace Corporation
 - Used extensively at NASA/GSFC (LandSat, SOHO, others)
 - Running at SAIL (UFO-1 operational testbed)
 - Down-selected to final two contenders on Teledesic
 - Originally developed for ground, but now targeting space
 - Designed to operate with 3rd-party products (DataViews, Satellite Toolkit, automated paging facilities)



Other Technologies



- Distributed Ground Architectures
 - Virtual Mission Operations Center (VMOC), NASA/GSFC (Julie Breed)
 - Enables real-time vehicle anomaly resolution among geographically separated personnel via web-based protocols
 - Tracks events with an Episode/Incident/Alert model, where alerts are forwarded to engineering personnel
 - Includes graphical tools for tasks such as building and editing pass plans
 - COTS-based, with minimal custom coding



Other Technologies



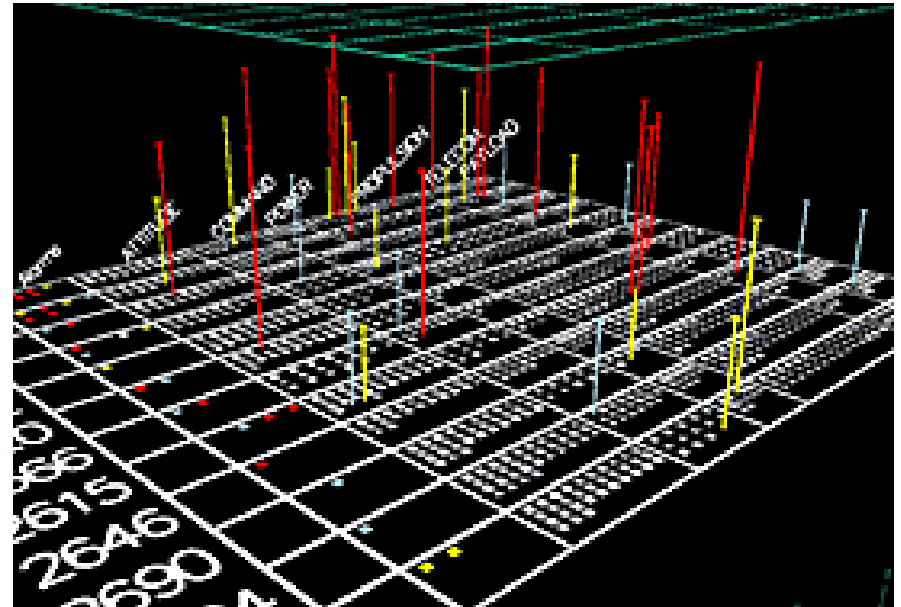
- Middleware
 - Common Object Request Broker Architecture (CORBA), Object Data Management (ODM)
 - Requests for services all flow through the ORB
 - The ORB manages which services are active or inactive
 - Vendors include ORBIX (Iona), ILU (Xerox)
 - Distributed Communications Object Model (DCOM), Microsoft
 - Initial request for services flows through the service control manager (SCM)
 - The SCM creates a direct link for client/server communications
 - Available on multiple OSs, but runs best on Windows



Other Technologies



- Data Visualization
 - TowerView (High Tower Software)
 - Advanced displays for rapid H&S assessment of a constellation
 - Alarms for rate of change, continuous increment/decrement, and derived data





Future SGS products?



- Short-term
 - Case-based reasoners
 - Model-based reasoners
 - Marple (TRW)
 - Neural Networks
- Long-term
 - Agent Technology
 - Boeing
 - Carnegie-Mellon University



Recommendations

- Conduct unbiased evaluations of today's AI COTS products
 - AMCS
 - AFRL's ASCEND project, supporting the FORTE satellite
 - On board demonstration with MightySat II.2
 - SCL
 - PHLASH Module A: automation of CU's ground control center
- Use all these products in ground and flight systems wherever possible
- If necessary, use them as price benchmarks



Conclusions



- The days of the multi-million dollar turnkey systems are over
- COTS AI products can decrease satellite risk and increase capabilities--at dramatic cost savings
- They are available **today**