

Satellite Operations on \$15 a Day

Ground System Architectures Workshop 2003

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Agenda

Background/Problem Statement

Solution Path

Architecture

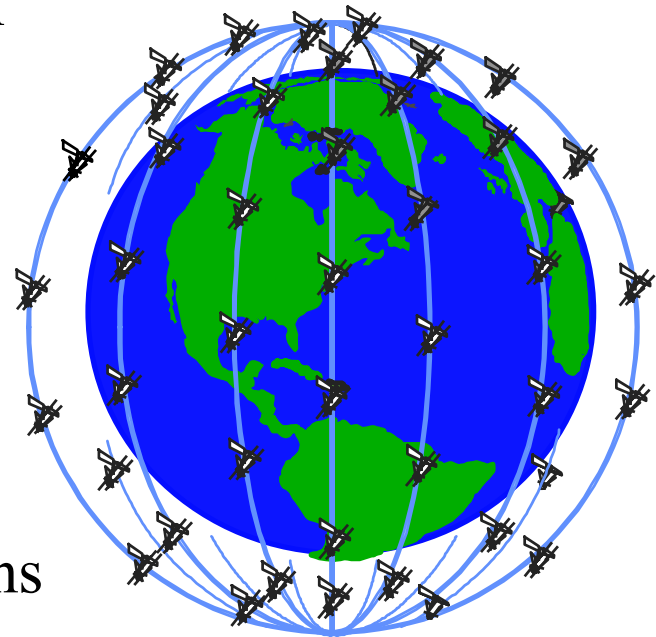
Results

Future Work

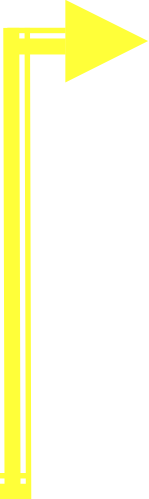
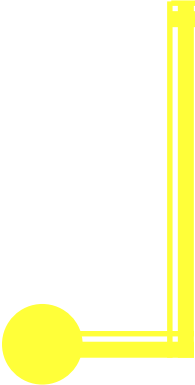
Lessons Learned

Background

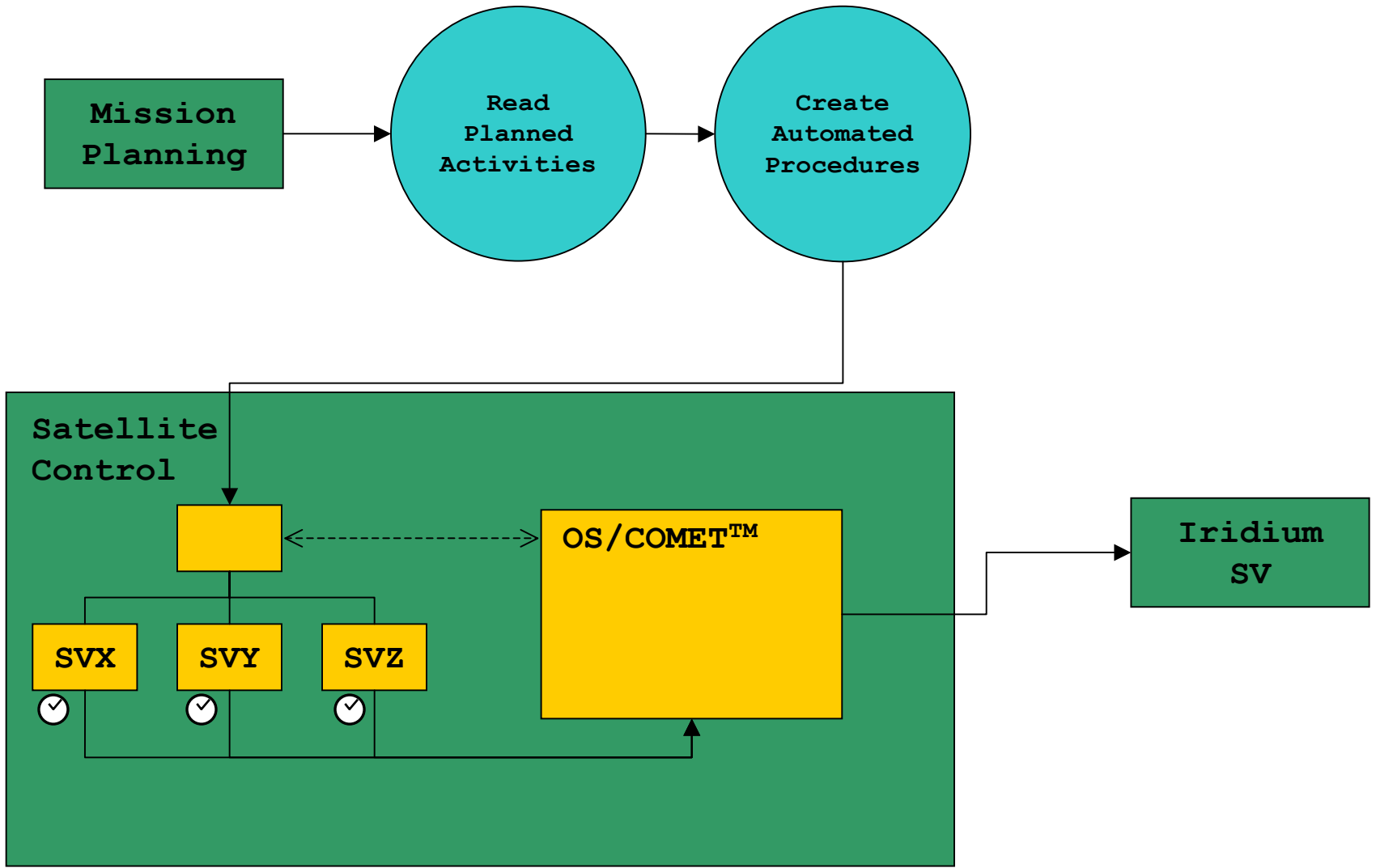
- 80 Satellite Vehicle (SV) LEO constellation controlled from a distributed OS/COMET™ based ground system
- Average 8.5 activities / SV / day \Rightarrow 680 daily activities
- 8 operators / shift x 4-12hr shifts \Rightarrow 32 operators
- Average 15 operator errors/month
 - No breaks
 - Fatigue
 - Repetitive work
- Shrinking ops budget
- The state of the delivered ground system software was not optimized for automated operations



Solution Path

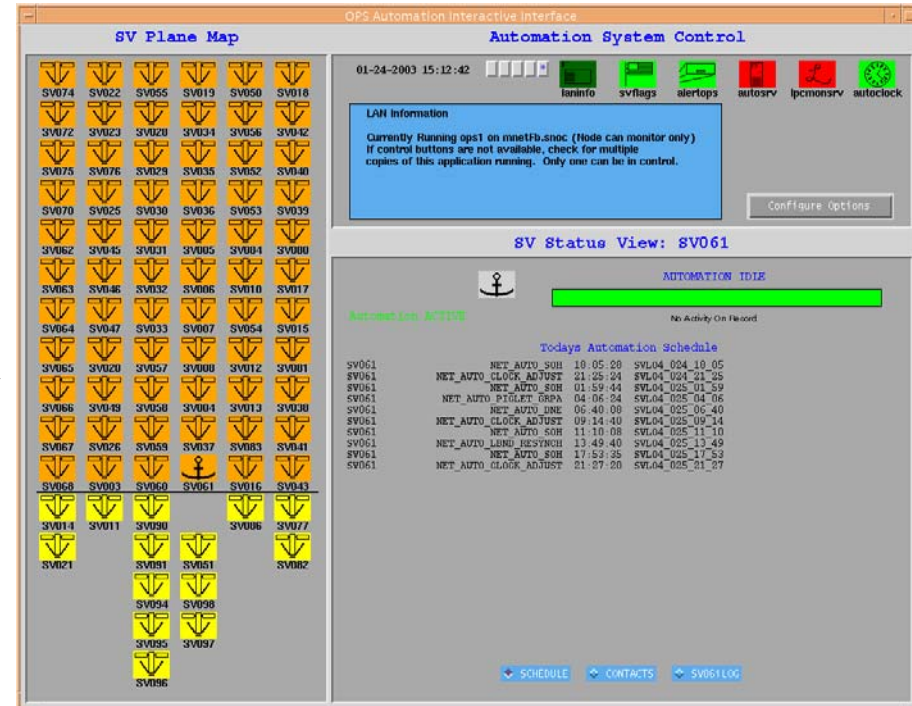
- Mechanization precursors:
 - Pass plans / perform files
 - Automated testing tool
 - Operations staff built automation system
 - Hybrid prototype / incremental build lifecycle
 - Relied on system hooks built into ground system
 - Trial & error to mitigate ground system deficiencies
 - Open source platform (Perl) combined with Comet Command Language (CCL)
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Architecture



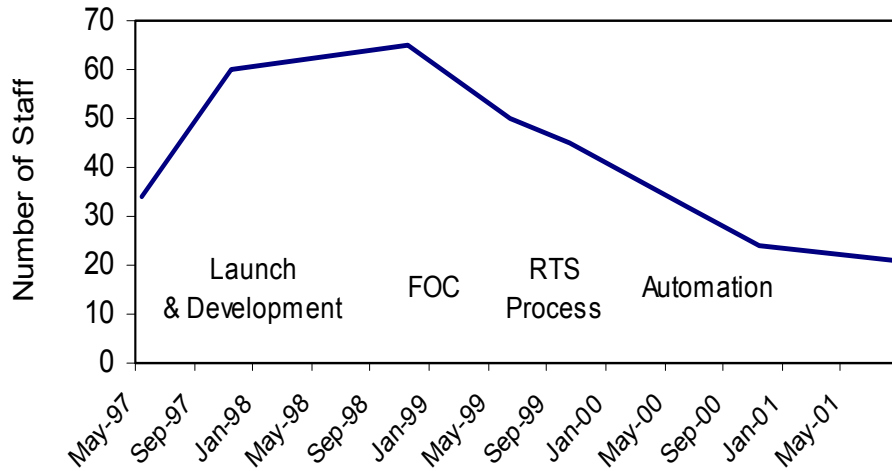
Architecture (continued)

- Properties:
 - ~12 KSLOC
 - Perl / Tk / CCL based
- Features:
 - Activity feedback
 - Retry ability
 - Activity flow control
 - Failure reporting / logging / metrics
 - 99.9% success rate

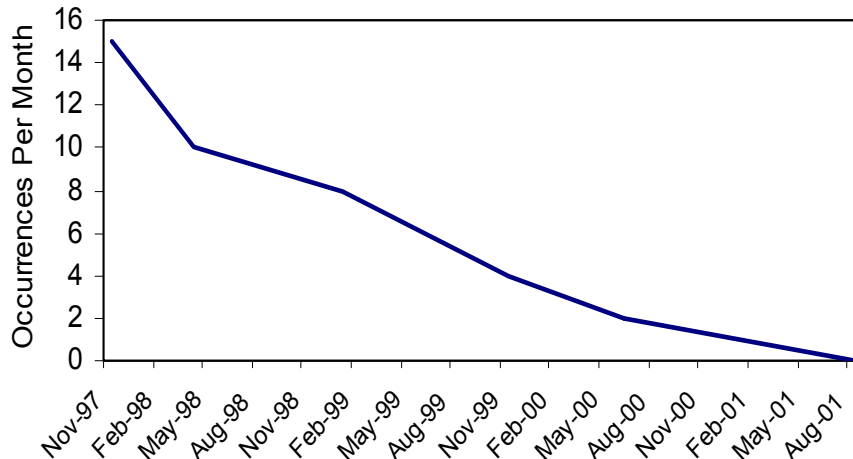


Results

RTO Staffing History



Operator Error Reduction



- At FOC there were 8 operators per shift on a 7 by 24 schedule executing over 900 objectives per day. (32)
- Through process improvements the number of operators was reduced to 5 per shift on a 7 by 24 schedule. (20)
- The workload was further reduced to 2 per shift on a 7 by 24 schedule by implementing automation. (8)
- In the initial stages of the program there was an average of 15 operator errors **per month**.
- With process improvements, training, and automation the operations now average less than 10 operator errors **per year**.

Future Work

- Clean up code (*in progress*)
 - Further modularization.
 - Add more comments/documentation
 - Facilitate maintenance
 - Promote code re-use
 - Remove unutilized functionality
- Implemented markup language to define activities
 - Simplify the addition of new activities
 - Allow addition of new features
 - Facilitate file maintenance
- Implemented dynamic activity re-schedule (*in progress*)
- Implement full feedback loop (*in design*)
 - Auto-respond to SV anomalies
 - Heuristics based on metrics to further improve performance

Lessons Learned

- Automation work would not have been possible without having ground system hooks in the software.
- Changing requirements due to a dynamic operations environment makes it impossible to completely determine requirements for automation software.
- Ground system developer and vendor support are an important key to success.
- It is critical to plan for automation from the beginning of the lifecycle and lay the foundation for automation along the way.
- Plan to perform the automation work when the operations has matured, or at least plan to dedicate resources to tuning the automation to suit the realities of operations.
- Plan for real-time operations process improvement as early as possible to free up resources to work on automation tasks.

End of Presentation

QUESTIONS?