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Storm Control Systems

Architectural Evolution to Support 21st Century Control System Requirements

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Ground Systems Architecture Workshop
February 21-22, 2001

Satellite Control - Then and Now

10 Years Ago

- Using COTS for Satellite Command and Control systems was considered "crazy"
- Primary requirements of Satellite Control Systems:
  - *Functionality*
  - *Reliability*
  - *Efficiency*
  - *Cost*

NOW

- "Off the shelf" solutions are "common" in multiple phases of the satellite industry
- Primary requirements of Satellite Control Systems
  - *Functionality*
  - *Reliability*
  - *Efficiency*
  - *Cost*

The difference in requirements is defined mostly by how the results are achieved and the relative requirement priorities

Current Control System Priorities

- **Efficient Utilization of COTS**
  - *COTS based solutions are "here to stay"*
  - *Reduce acquisition and maintenance costs*
  - *Avoid unnecessary development costs required to create new software that might already exist*
  - *Challenge is to manage customer/vendor expectations, satisfy mission unique requirements and support customer administrative needs*
- **Satellite Control Automation**
  - *Improve operational efficiency, reduce errors, improve reaction time, improve operator morale*
  - *Consistent with the effort to improve efficiency, reliability and cost*
  - *Challenge is to balance automation with end user comfort*
- **Fleet Monitor and Control**
  - *More owner/operators are moving to a multi-satellite capability*
  - *Need to improve efficiency of control system for multiple satellites*
  - *Challenge is to control "more with less" without reducing or risking reliability and efficiency*

Efficient Utilization of COTS

"Success or failure with COTS systems depends on understanding and adapting to the constraints, challenges, and opportunities of this environment."

- Col. Ralph D. Monfort, USAF, Space and Missile System Center

- **If you've had success with COTS, then you probably…**
  - ***Have a strong technical staff committed to understanding/developing requirements***
  - ***Can describe what need and want the system to do but are open to "how" the system will do it***
  - ***Are capable and willing to work with vendors to perform tradeoffs on requirements, ops concepts and capabilities***
  - ***Are willing to plan and coordinate system upgrades throughout the life of the mission.***

Efficient Utilization of COTS

Early (important) decisions…

- **Partnership with supplier vs. classic "customer/vendor" relationship**
- **Loosely vs. tightly integrated solution**
- **Is a 70-80% off-the-shelf capability….**
  - ***"Good Enough"***
  - ***"the foundation for a complete solution"***

Satellite Control Automation

Effective automation provides multiple benefits…

- **Operational costs savings**
  - *Fewer staff to support more on-station assets*
- **Improved efficiency of operations staff**
  - *Operators focus more on critical/important tasks vs. repetitive/mundane tasks*
  - *Operator interest and motivation is improved*
- **Reduced error potential**
  - *Significant reduction in the chance of an operator error*
  - *Reduction of repetitive, boring and mundane activities*

Inmarsat Ltd. – A Success Story

- **Success story for both Automation and effective use of COTS**
- **Established in 1979 as an Inter-governmental organization (IGO)**
  - ***In April 1999, Inmarsat transitioned to a private limited company, Inmarsat Limited***
  - ***Service portfolio includes maritime (including safety and distress applications), aeronautical and land mobile. Over 180,000 Inmarsat terminals in use world-wide***
- **Satellite Constellation**
  - ***Four Inmarsat-2 satellites (MMS/Astrium Eurostar), launched 1990-1992***
  - ***Five Inmarsat-3 satellites (LM 4000), launched 1996-1998***
  - ***Recently ordered three Inmarsat-4 satellites (Astrium Eurostar 3000)***
- **Established "cooperative agreement" with L-3 Storm**
  - ***Combine Inmarsat operations expertise with L-3 Storm technology***
  - ***Leverage Inmarsat/L-3 Storm development efforts across multiple programs***

Inmarsat's Approach and Results

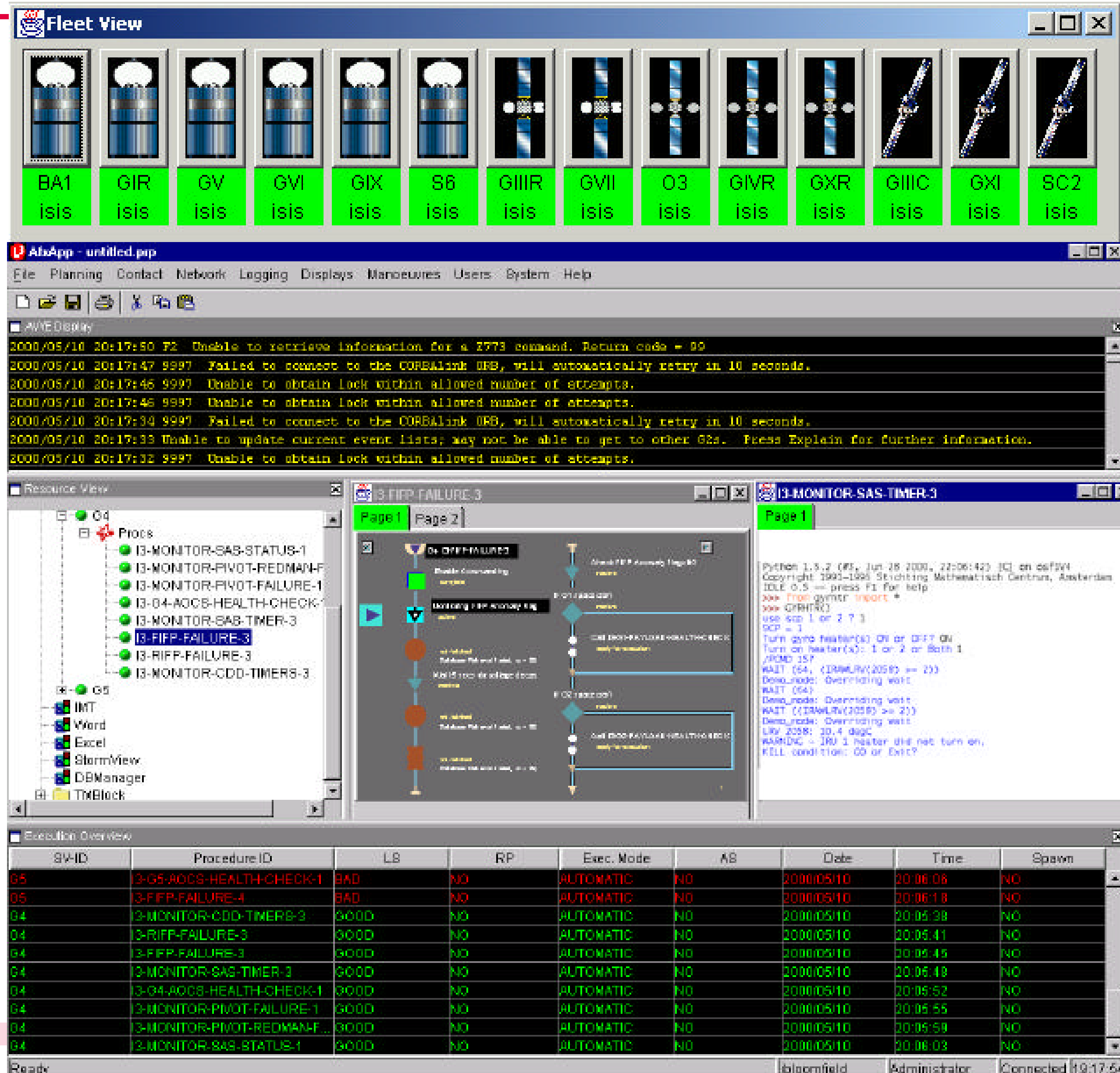
- Formed a small core engineering team to define SCC automation requirements for existing, well understood Inmarsat-2 class of satellites
- Performed Technical Validation Program - "Fly before Buy"
- Selected vendor/partner
- Automated Inmarsat-2 satellite operations
- Added each Inmarsat-3 satellite while incrementally migrating their daily and seasonal operations to an automated approach
- Results:
  - *Added all five Inmarsat-3 satellites and associated ground equipment while cutting satellite operations staff in half.*
  - *Have applied similar automation to network control applications further reducing staff requirements*

Fleet Monitor and Control

Critical items for effective Fleet Monitor and Control …

- **Ability to concurrently monitor and control multiple assets from a single workstation**
- **Effective graphical user interface design**
- **Effective automation capabilities**
- **Ability to "take control" and "hand off" satellites to support health and maintenance commanding or to handle a specific problem**

Fleet Monitor and Control User Interface



L-3 Storm Control Systems, Inc.

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Specific Architectural Activities

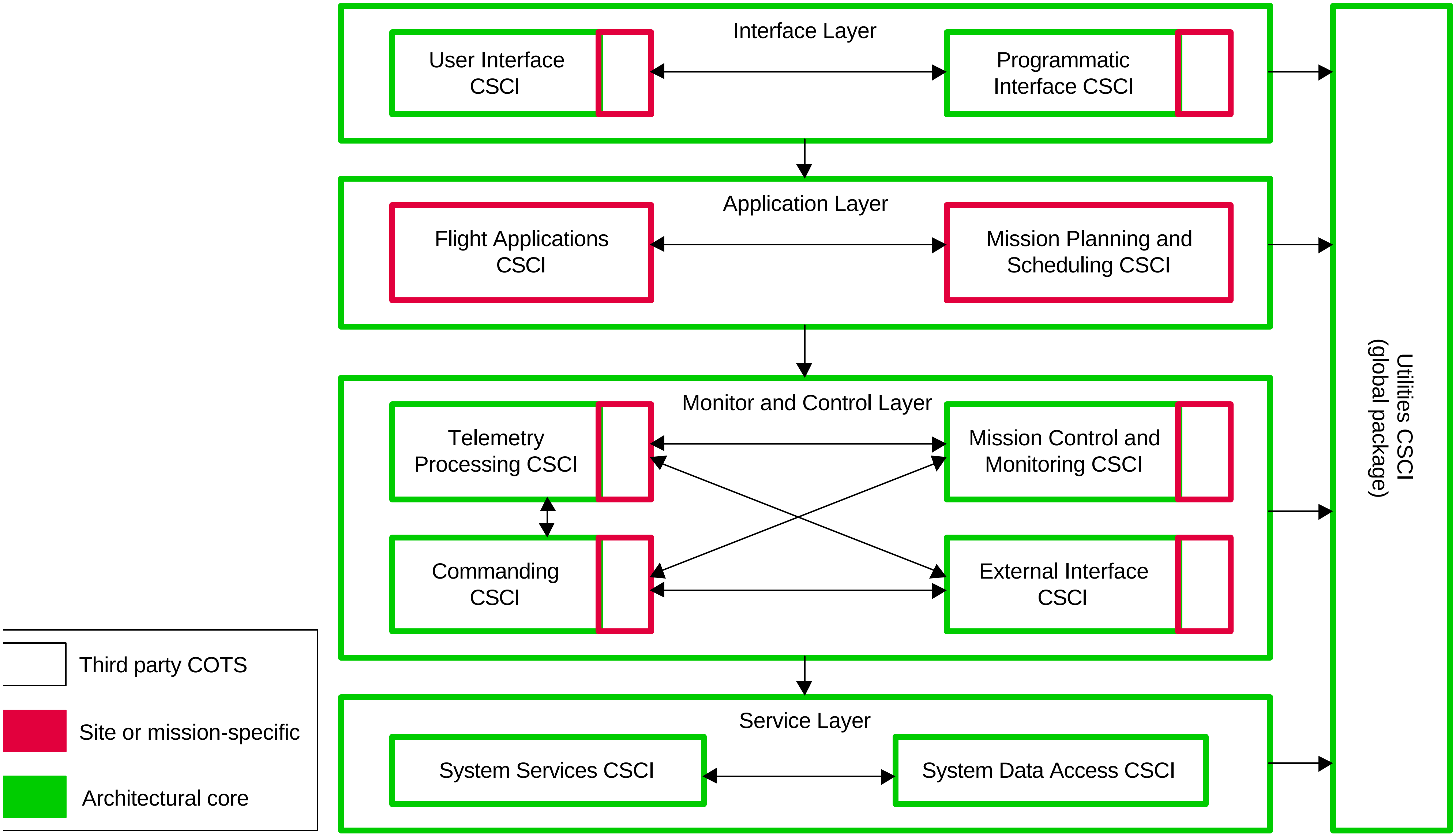
L-3 Storm Architectural Evolution

- **Multiple Goals**
  - *Increase the commonality of fielded systems*
  - *Improve training and maintenance costs*
  - *Provide better value for customers*
- **Specific Actions**
  - *Definition of use cases for all current and future customers*
    - Focus on “users”
    - User-centric approach vs. system-centric
  - *Focus on well defined interfaces and clear component definitions*
  - *Integrate a distributed, object-oriented approach based on CORBA*
  - *Provide a “single system GUI” using Java*

Implement Strong Building Blocks

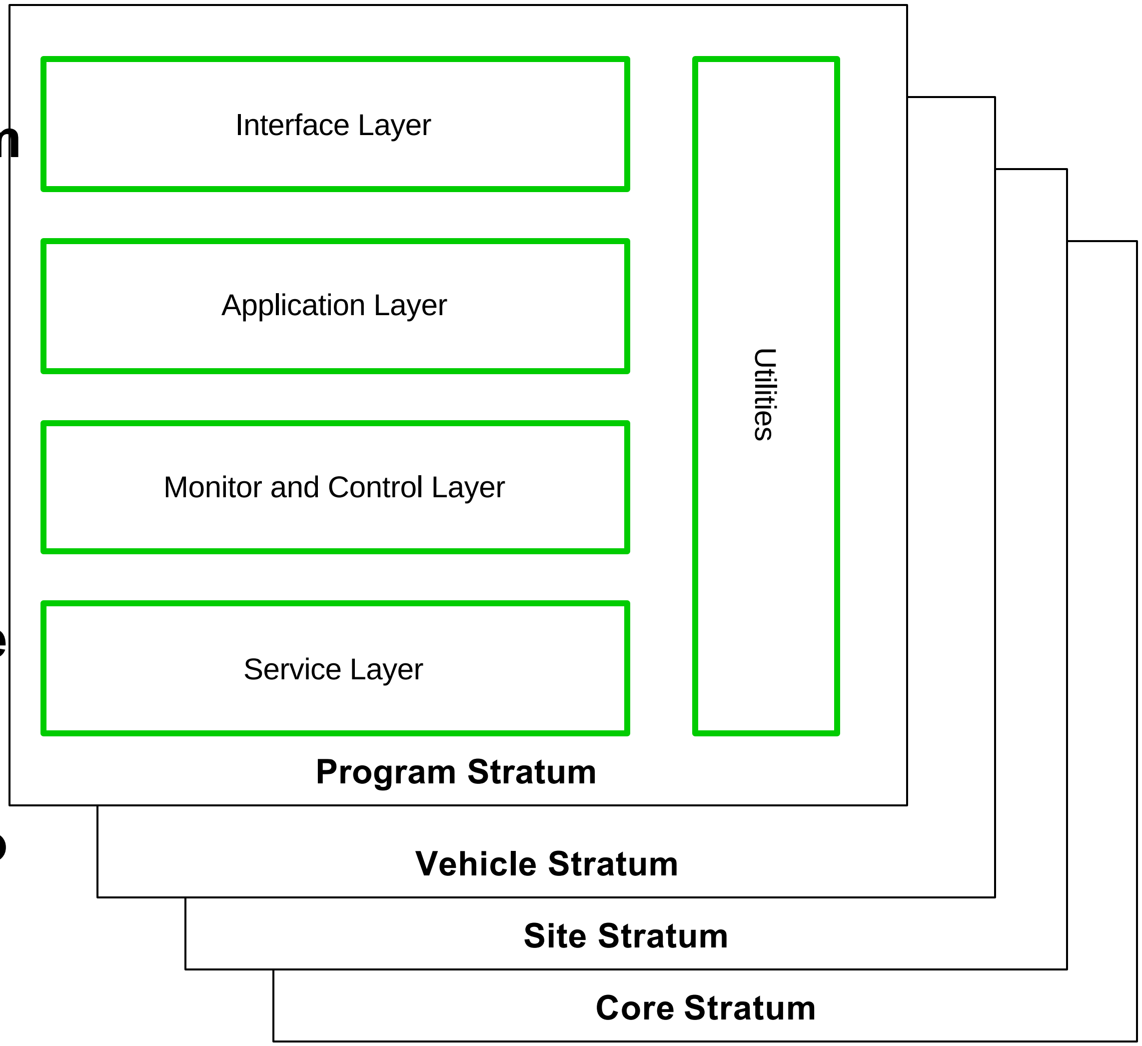
- **Strata**
  - *Core (CORE)*
  - *Site (SITE)*
  - *Entity (ENTY)*
  - *Program (PROG)*
- **Layers**
  - *Interface (IF)*
  - *Application (AP)*
  - *Monitor and Control (MC)*
  - *Service (SR)*
- **Computer Software Configuration Items (CSCIs)**
  - *User Interface (GUI)*
  - *Programmatic Interface (API)*
  - *Mission Planning and Scheduling (MPS)*
  - *Flight Applications (FLT)*
  - *Mission Monitor and Control (MCM)*
  - *Commanding (CMD)*
  - *Telemetry (TLM)*
  - *External Interface (XIF)*
  - *System Data Access (SDA)*
  - *System Services (SYS)*
  - *Utilities (UTL)*

Architectural Layers and CSCIs

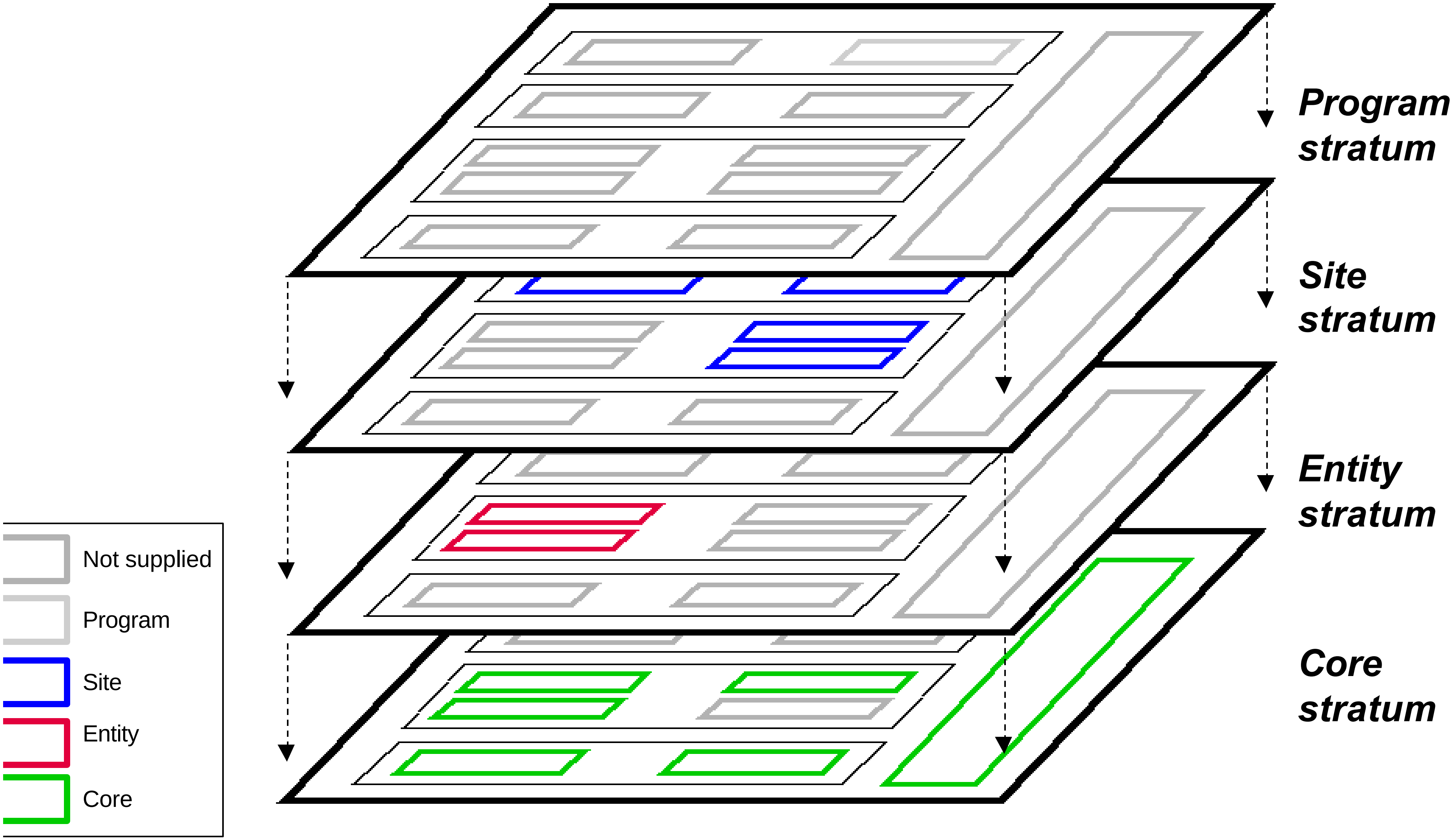


Architectural “Strata”

- **Allows hierarchical customizations to system**
- **Functionality at Program stratum overrides Vehicle, which overrides Site, etc.**
- **The same layers and CSCIs exist in all strata**
- **Layers and CSCIs can be empty in a stratum**
- **Not all strata need be present for the system to work**
- **Applies to database as well as code**



L-3 System Instance (example)



Analysis Mechanisms/Design Patterns

- **A set of abstractions that work together to carry out common and interesting behavior**
- **Builds support for such non-functional requirements directly into the architecture**
- **Reduces complexity of analysis and improves its consistency by providing developers with a short-hand representation of complex behavior**
- **Typical patterns:**
  - ***Process Activation***
  - ***Multiple Mission Operations***
  - ***Distribution/Communication***
  - ***Persistence***
  - ***Resource Management***
  - ***On-line Definitional Changes***
  - ***Multiple Operational Phases***
  - ***Checkpoint/Restart***
  - ***Fault Tolerance***
  - ***Error Handling and Reporting***
  - ***Authorization/Security***

Last Chart...

- **Summary**
  - ***COTS software can provide significant cost savings for space applications***
  - ***To effectively take advantage of COTS software, satellite operators must be flexible and adjust to a COTS procurement and ongoing support paradigm***
  - ***If possible, pick a "partner" not just a vendor***
  - ***If you are successful with the above, you can really save money through the intelligent use of automation***
- **The future…**
  - ***Those operators who have flexibility and are willing to invest time, effort, and money to automate their operations can realize significant mission cost savings***
  - ***Those who do it best can turn their satellite operations "cost" centers into "profit" centers by offering satellite launch and fly satellites for other satellite service providers***