The Concept Design Center (CDC) Lessons Learned

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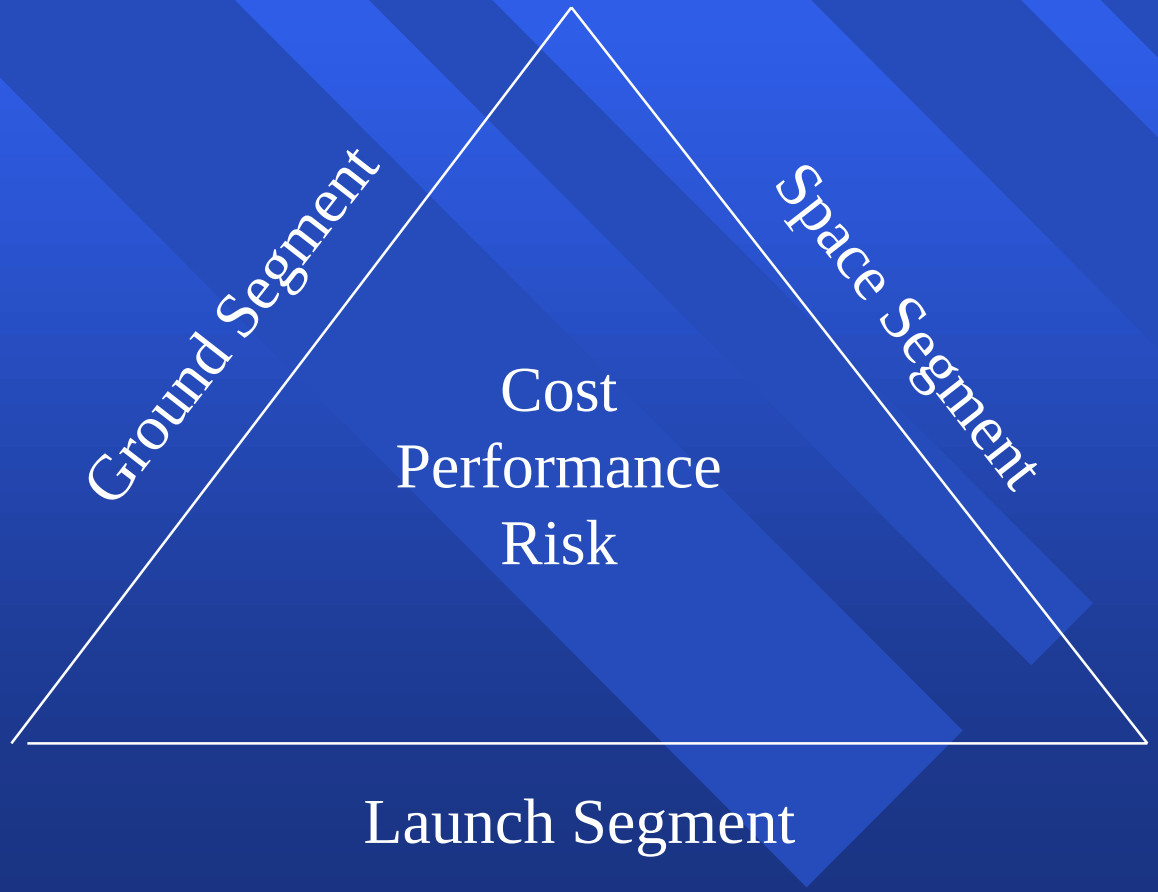
Concept Design Center Trade Space Emphasis

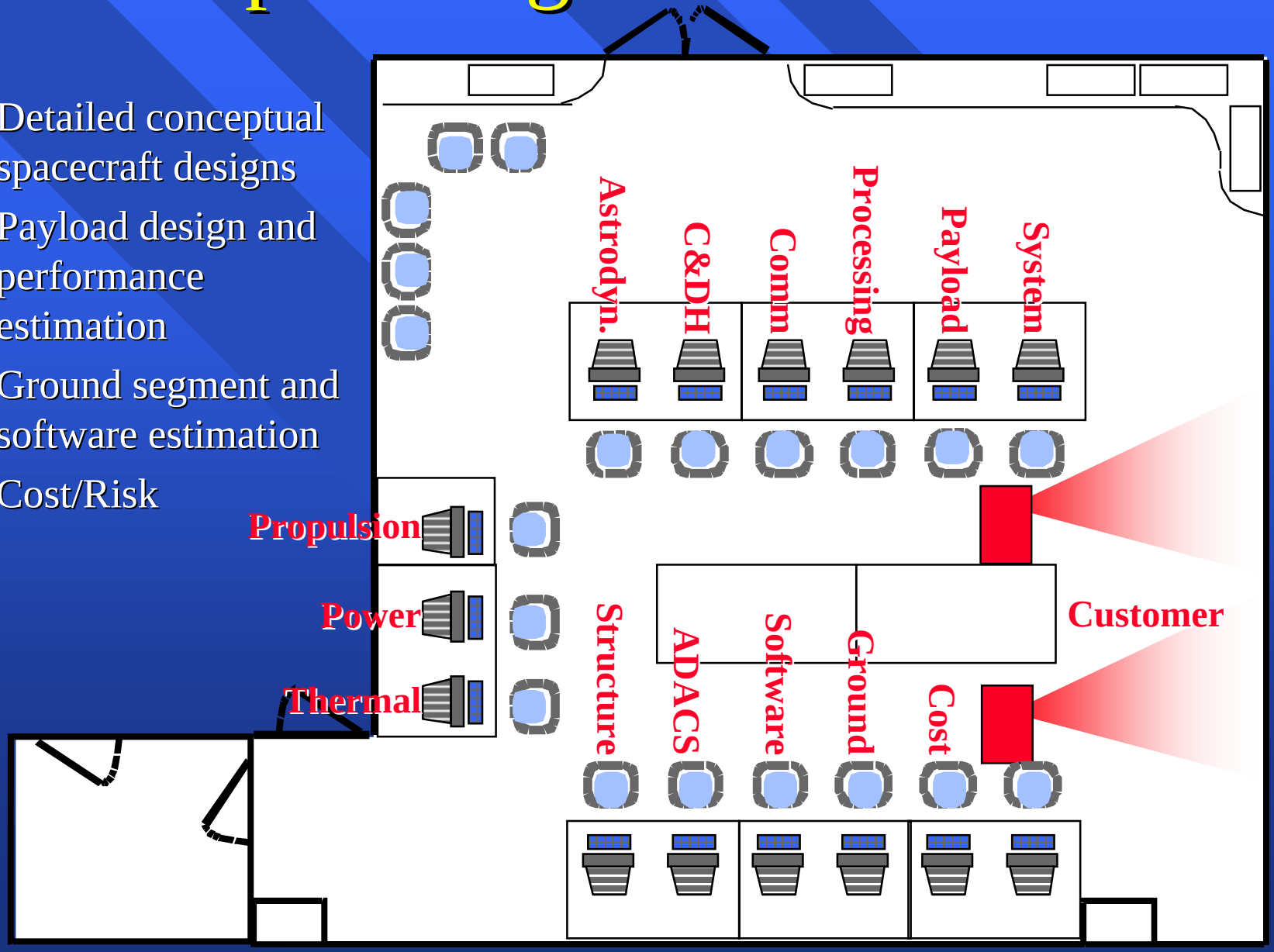


What is the Concept Design Center?

- **Team**
  - Technical expertise in space system disciplines
  - Includes the customer as a key player
- **Facility**
  - Unclassified and classified facilities
  - Co-location of experts, customer, and tools during study
  - Networked computers for automated information transfer
  - Video projection for focusing group activities
- **Process**
  - Simultaneous (concurrent) interaction among technical experts encourages synergy
  - Experts own their models and bring them to the sessions
  - Experts see the impact of their contribution on the entire system

Space Segment Team

- Detailed conceptual spacecraft designs
- Payload design and performance estimation
- Ground segment and software estimation
- Cost/Risk



Design Center Studies

- Eight studies completed
- Five currently planned through April 98
- Examples of studies
  - Custom bus and payload
  - Existing bus and payload with technology insertion
  - Autonomous, multi-mission smallsat constellation
  - Smallsat demo with data processed in several research facilities and minimal ground site support
  - Smallsat constellation demo and operational system
  - Commercial bus with government payload
- Future studies include microsat and lunar mission

Assumptions for Lessons Learned

- Conclusions from small set of studies
- CDC Space System Team has space segment emphasis (bus, payload, constellation visibility…)
- Impacts to ground system modules at this phase
  - Typically, no ground system studies provided
    - Few driving requirements for ground defined
    - Minimal if any operational concept available
  - Initial ground segment design provided by CDC
    - Very high-level design with many assumptions defined
    - Significant ground segment cost issues identified
  - Ground Systems Team formed to improve ground system fidelity and capabilities

Software Architecture Lessons Learned

- **COTS cost estimation for 2005+ complex systems**
  - On-board COTS to support commercial satellites
  - Assumptions of functionality, licenses, COTS glue
- **Difficulties in establishing system boundaries**
  - Multi-organizational systems sharing software
  - Commercial satellites hosting government payloads
- **Multiple end user needs**
  - Direct payload tasking and reporting for remote users
  - Seamlessly integrating information across systems
- **Custom versus smallsat / microsat philosophy**
- **Centralized versus distributed site architecture**

COTS Issues

- **Examples of issues**
  - Forecasting COTS 2005+ capabilities and costs
    - Support to high-performance systems
    - Operability by fewer, lower skilled operators
    - Interoperability across space, UAV, ground
  - Cost Estimation
    - One site license per facility (site, van, manpack)?
    - Required staffing levels and skills
    - COTS glue / database, integration and update
- **Lesson learned**
  - Paradigm shift which invalidates traditional cost database, but not yet understood for 2005+ timeframe

System Boundary Issues

- **Examples of issues**
  - Mission planning allocated to external organizations
  - Minimal site mission planning & payload processing
  - Payload processing allocated to research labs
  - Payload commanding by tactical users (not expert in satellite and payload commanding)
- **Lessons learned**
  - Historical cost databases have different boundaries
  - Ripple impacts from moving boundaries
    - Heritage software may require significant modifications
    - Cost impact of separating interrelated functions
    - Performance / timeliness penalties may be incurred

Multiple End User Issues

- **Examples of issues**
  - Differences in processing software for each type user
  - Tasking conflict resolution approach complexity
  - Satellite health concerns with multiple users commanding satellite payload
  - User priorities shift as a function of scenario
    - Peace, conflict, war
  - Bandwidth on demand versus fixed capacity
- **Lessons learned**
  - Added complexity typically increases software costs
  - Multiple scenarios can increase software costs

Smallsat Issues

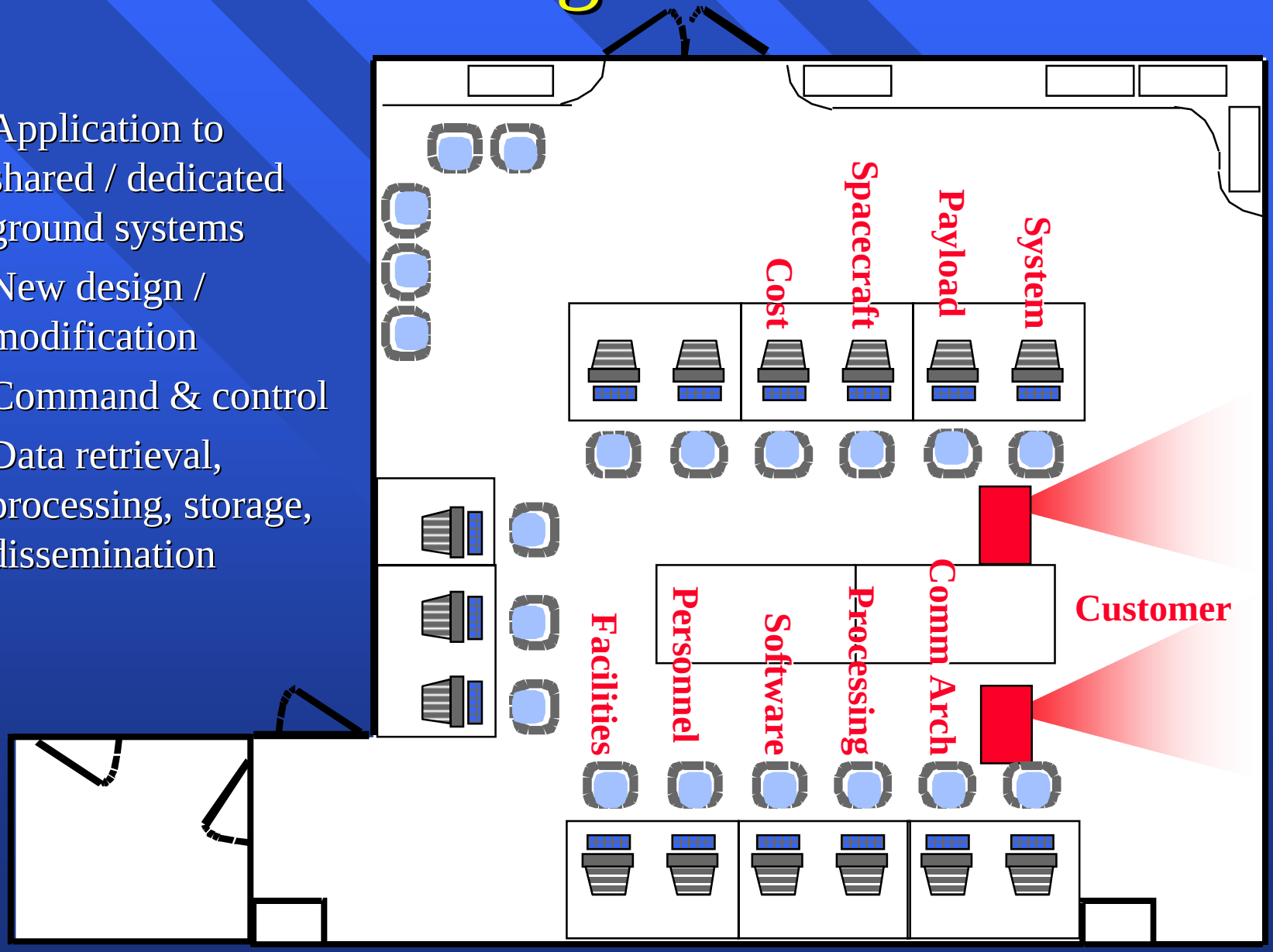
- **Examples of issues**
  - On-board smallsat bus software size drivers
    - Smallsat philosophy with reduced cost and lower reliability
    - Robust military satellite with 5+ year expected life
  - Opportunities for reduced ground site functionality
    - Possibly lower system reliability / autonomy requirements
    - Potentially fewer multifunctional on-board processors
  - Less smallsat heritage space and ground software
    - Increased challenge to maximize smallsat cost savings
- **Lessons learned**
  - Another paradigm shift which requires updated software architecting and costing methodologies

Ground Site Architecture Issues

- **Examples of issues**
  - Software and hardware technology enables plethora of new approaches for future systems
    - push/ pull architectures, dynamic reconfiguration, internet and web technologies, information security
    - wearable computers, increased computational power
  - Increasing presence of commercial satellite systems
    - multi-national industry increases opportunities for innovation
- **Lessons learned**
  - Paradigm shift as commercial space grows
    - Satellites and ground stations are or soon will be commodities
    - Bottom line approach in commercial and government systems

Ground Segment Team

- Application to shared / dedicated ground systems
- New design / modification
- Command & control
- Data retrieval, processing, storage, dissemination



Lessons Learned from GST Participation

- **Multi-discipline CDC team with external advisors simplifies process of understanding system**
  - discuss satellite and payload support needs
  - propose changes to satellite and understand impacts
  - listen to team discussions and find new issues
- **Identifying shortfalls and issues requires synergy with ground-oriented team members**
- **Where there is chaos and paradigm shifts, there is opportunity for innovation**
  - Establishing a ground-focused team for CDC
  - Appreciate any feedback and discussion