



The Foundation of Making “Smarter Ground Systems”

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The Issue

- What normally comes to mind when thinking about “smarter ground systems” is necessary but not sufficient to achieve one
 - *New algorithms, analytic “apps”, software paradigms/genres (AI, machine learning, etc.) and human/machine interfaces are required but there is more to a system...*
 - If the system is not adaptable to new technology, difficult to sustain, and/or is a fully vertical integration of capability (e.g. a stovepipe/cylinder of excellence) it may meet mission need in the short term but not be sustainable in the long run – it also doesn't meet the need of an enterprise
- “Other foundational elements” required for long term success:
 - *Appropriate flexible infrastructure*
 - Constantly evolving to new needs, threats and technology – never a “final operational capability”
 - *Appropriate organization, governance and processes*
 - Fosters rapid identification/vetting of needs, funding, development, test and delivery to operations
 - *Appropriate leadership & culture*
 - Consistent leadership to transform culture and, ultimately, behavior
 - All programs now service the enterprise as part of their mission



Case Study

Migration to Stovepipes

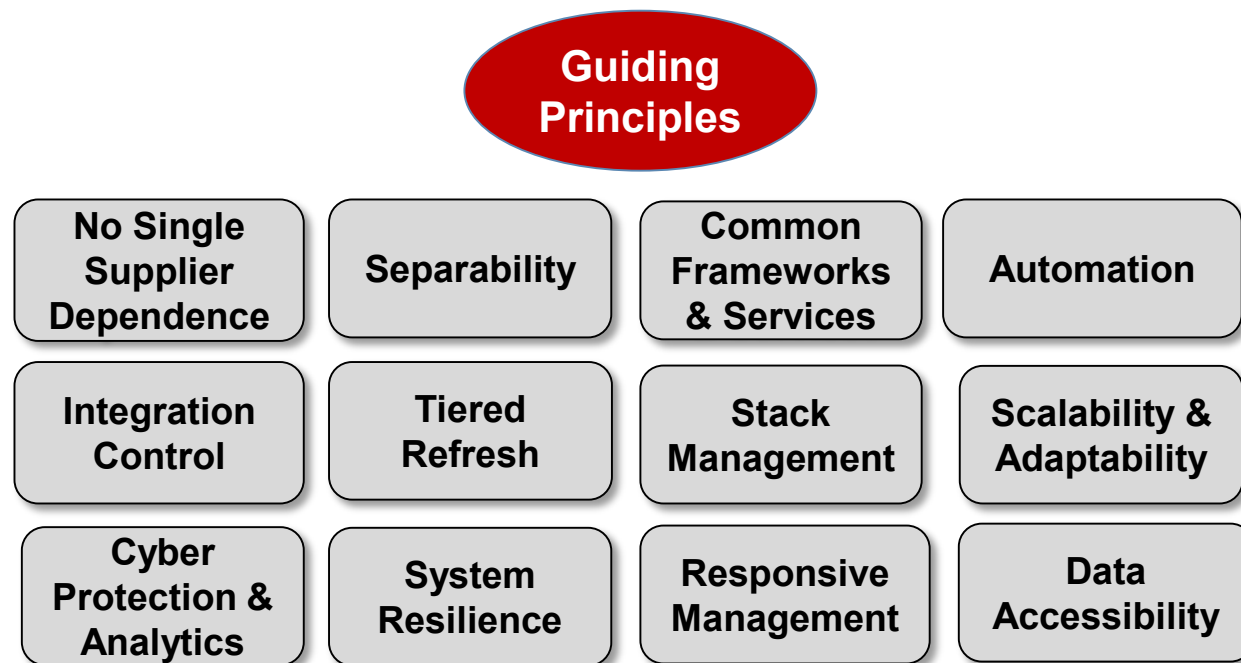
- Late 1980's – Single mainframe based T&C system supported multiple satellite programs
 - *Large overruns and many delays*
- Logistical Nightmare
 - *New programs brought many new requirements without enough funding*
 - No design constraints placed on satellite command or telemetry designs
 - *Amount of mission unique code became much greater than common*
 - *Architecture at that time yielded one giant codebase for all programs*
 - Changes for one program require regression testing for all
 - *Not very responsive to issues/needs of any single program*
 - *Rollout of new versions into OPS dependent on each individual program's schedule*
 - Many baselines in Operations simultaneously which impacted sustainment cost
- Non-mainframe based replacement system ordered and quickly overruns budget
- Mid 1990's - Senior management decides to cancel replacement & let each program procure and sustain their own T&C system(s)

Not addressing “Other Foundational Elements” can have effects that last for decades



Other Foundational Elements

Infrastructure



- **May not represent a complete set, but they are the most dominant and reflect both architecture and acquisition guidelines**
- **Use of these Guiding Principles in the Architecting, Acquisition and Life Cycle Management of Ground Enterprises will yield the most cost effective, resilient systems to meet mission requirements**

*Graphic adapted from TOR-2015-00801. "Framework for an Affordable and Resilient Satellite Ground Enterprise for National Security Space Missions," The Aerospace Corporation. Also presented during GSAW 2015.



Other Foundational Elements

Organization, Governance & Processes

- Very tight coupling between *capability* vetting/prioritization, acquisition, operations & sustainment groups are required during lifecycle
 - *Shift in emphasis from requirements to capabilities*
 - *Requires rapid access to and control of funding lines*
 - *Enables design decision balance between all phases of lifecycle*
 - **All stakeholders must be *accountable*** for rapid, successful capability development, delivery & sustainment
- All organizations & business/program processes need to reflect a streamlined, responsive paradigm
 - *Risk management vs. Risk aversion*
 - Some level of failure needs to be tolerated by the organization – how else can one learn?
 - *Impacts of failure can be minimized by appropriately structuring the size of individual efforts*
 - Individual efforts should be parsed to be well focused and of short duration
- All members need to have enterprise success as part of their individual mission success criteria
 - *Enterprise must **balance** own needs with needs of individual members*

For a successful enterprise: We are all in this together or “we” aren’t...



Other Foundational Elements

Organization, Governance & Processes – Commercial Process Adoption

- Example #1: Use of Model Based Systems Engineering & Design
 - *Inevitable at some level - systems are getting too complex*
 - *Need to scope expectations to funding - you get what you pay for*
 - *Promises of cost savings over today's costs is debatable*
 - If systems are becoming more complex then they will likely cost more than today regardless of what design technology is used
 - *Future cost avoidance due to less rework is likely if MBSE&D is employed*
 - If one can't afford to correctly document the "as delivered" system today they probably can't afford the model either
 - *Even good models aren't reality*
 - *Incorrect or incomplete models contribute to poor decisions which will propagate into future efforts – not as likely with stovepipe procurement*
 - *Automated code and documentation generation may not meet customer standards or need*

Lesson: Do the right thing the right way for the right reason and maintain reasonable expectations



Other Foundational Elements

Organization, Governance & Processes – Commercial Process Adoption

- Example # 2: Focus on capabilities and outcome vs requirements and verification (an important element of “agile development”)
 - *Capabilities and outcomes are usually easier to articulate than requirements*
 - Capabilities focus requires very tight cooperation and coupling between customer & developer with a clear, common vision
 - *Hard to implement within a company even harder to implement in a group of contracted parties*
 - *A misbehaving or misunderstanding contracted developer much more difficult and impactful to replace than a single employee in a company team*
 - Capabilities are useful for conveying abstract thoughts (i.e. the Vision) and work well with small very focused projects
 - *Traditional requirements and verification may still be needed for larger, well defined efforts*
 - *Can still be responsive if the requirement generation/vetting process streamlined*
 - *Requirements compliance easier to enforce with contracted parties*
 - *A mix of both capabilities and requirements for tasks within a large mission system is probably appropriate*

Lesson: When considering commercial processes and practices ensure they are applicable to your organization and customer - adaptation is probably required



Other Foundational Elements

Leadership & Culture

- Consider longer assignments for senior leaders
 - *Need time for vision to take root and bloom*
- Encourage accountability of all parties throughout lifecycle
 - *Acquisition Lead becomes first Operations Lead for a delivered system?*
 - *Fiscal impacts to Operations for systems not accepted?*
- Acquisition decisions need to be consistent with Vision
 - *Deviation or the perception of it encourages return to old culture and mindset*
 - *All missions now also serve the enterprise*
- Incentivize behavior that is coherent with the new vision and paradigms
- Examine processes top to bottom to insure consistency with vision
 - *Culture is reflected in process and process is driven by culture – change in one influences change in the other*
- The a well-considered effort that fails should be tolerated and learned from
 - *Fosters risk management vs risk aversion*

Old culture and mindset are an organization's lowest energy state and unless consistent leadership energy is applied the organization will always gravitate back to it (organizational entropy)



Summary

- The long term success of “smarter systems” is not solely based on new algorithms and cool “apps”
 - *“Other Foundational Elements”*:
 - Appropriate flexible infrastructure
 - Appropriate organization, governance and processes
 - Appropriate leadership & culture
- The effects of not addressing “Other Foundational Elements” can last for decades
- Adherence to Guiding Principles will help to ensure a resilient, flexible, lasting infrastructure
- All stakeholders must be represented and accountable from “cradle to grave” or even “lust to dust”
- Commercial process and practice adoption in non-commercial entities must be carefully considered
- An organization or enterprise will always gravitate back to “business as usual” (its lowest energy state) unless continuous, consistent leadership energy is applied to the organization and individuals
- Success of the enterprise needs to be an essential part of each member’s individual mission

The realization of smarter ground systems is predicated on being smarter about creating and sustaining ground systems in the first place