“S&T Ingredients for the Back to Basics Recipe”

DUANE DEAL
The Johns Hopkins University
APPLIED PHYSICS LABORATORY
The right idea …
The right idea …

2007 National Security Space Policy and Architecture Symposium

“Commitment to Space Partnerships”

“Commitment to Space Partnerships”

That’s what it’s all about!
Overview

• Peeking at what’s happened -- the environment

• The right recipe: “Back to Basics”

• A few S&T perspectives & credentials (via a “1-Person Panel”)

• Applying S&T capabilities to the end-to-end cycle

• Summary
Theme

If --

“Back to Basics” is the question …

Then --

a government, industry, & lab mix is the best answer.

“Commitment to Space Partnerships”
Peeking at what’s happened:

The environment via 20-20 hindsight
Military Ordered To Trim Budgets 5-Year Plans Must Be Cut By $32.1 Billion  

By Renea Merle and Bradley Graham, Washington Post Staff Writer

Thus, the cuts are expected to come at the expense of expensive weapons programs such as Lockheed Martin Corp.’s F-35 Joint Strike Fighter and the DD(X) destroyer being developed by Northrop Grumman Corp. The military’s procurement and research and development programs, from which defense companies most of their profits, are considered vulnerable, especially those that are behind schedule or over budget.

The Pentagon’s Missile Defense Agency (MDA) proposes to axe nearly $1 billion from its five-year budget plan to satisfy the Defense Department’s budget priorities.... the MDA will cut $955 million from its 2007-11 plan to meet Pentagon budget goals set out in an Oct. 19 directive from Gordon England, acting U.S. deputy secretary of defense. England’s memo ordered agencies to find $32.1 billion in cuts for 2007-11....

The US Navy: lost in space?  

by Taylor Dinerman

The cost and engineering problems the Air Force is having with their space programs and in trying to train a solid cadre of qualified and effective space personnel are all too familiar. Now it seems that, on a smaller scale, the Navy is stuck with a similar dilemma. This problem could become more serious in the future since, unlike the Air Force, the senior Navy leadership may not even be aware that there is anything wrong.

AF Space Program Woes Hurting Army Capabilities  

COLORADO SPRINGS, Colo. -- The commander of the U.S. Army Space and Missile Defense Command expressed concern on Jan. 24 about cost and schedule troubles in Air Force space programs, saying they have a negative effect on Army capabilities and reduce the confidence of Pentagon officials in Army programs.
Defense Acquisition Performance Assessment (DAPA)

- Cited prominent examples
  - Cost tripled, delays
  - Complex technology … not sufficiently prototyped

- Emphases:
  - **Timing** as a Key Performance Parameter (KPP)
  - Budget to most realistic cost estimates; contract similarly (or be unexecutable from square one)
  - Choose low risk solution over best value; reward for adhering to schedule versus only paying for performance
Addressing National Security Space problems

Ref: “What Went Wrong in National Security Space?,“ remarks to Space Enterprise Council, U.S. Chamber of Commerce, by Loren Thompson, COO Lexington Institute, 13 Sep 05)

- Study revealed not-so-surprising major problems:
  - Unplanned cost growth
  - Excessive/unrealistic performance requirements
  - Poor management practices
  - High workforce turnover

- NSS Acquisition Policy 03–01
  - Demands rigorous approach to technical baselines & performance requirements
  - Mandates early testing of critical components
The Cost “Axis of Evil”

- **Realistic Cost**
- **Government Range**
  - Costs understated
- **Government Budget**
  - Less than understated costs
- **Contract Price**
  - Somewhere in between
- **Low Bid Prices**
- **Eventual Product**
  - Requirements, Scope, Schedule, Quantity, Budget Profile

**Changes**

**Cost**

**Time**
The TSPR road

“We expect to achieve greater successes from every person, dollar, and hour we expend to acquire and sustain our current and new weapon systems.”

Darleen Druyun
(then) Principal Deputy Assistant Secretary of the Air Force for Acquisition and Management

“The TSPR approach addresses General McPeak's assessment of acquisition and seeks to turn failures into successes … TSPR is certainly more than a passing catchy phrase or acronym ….”

Air Force Journal of Logistics
Summer 2001
“…. space programs will continue to be challenging by their very nature. As a result of a decade or more of acquisition reform and the Total System Program Responsibility [TSPR] concept, ... less government oversight led to less insight, and any initial cost savings due to manpower savings became cost overruns. **We have eliminated TSPR as a process.**”
“Total System Performance Responsibility, or TSPR—was intended to facilitate acquisition reform and enable DOD to streamline a cumbersome acquisition process and leverage innovation and management expertise from the private sector. However, DOD later found that this approach magnified problems related to requirements creep and poor contractor performance.”
"If you do not know where you are going, any road will take you there."

Cheshire Cat in Alice in Wonderland
The Right Recipe: “Back to Basics”

“Preventing recurring nightmares”
"Change is inevitable. Growth is optional."

Walt Disney
Back to Basics in Acquisition

- Four-stage process
  - System Production
  - Systems Development
  - Technology Development
  - Science & Technology

- Reapportion Risk
  - Lower risk in Production
    - Use mature technology
  - Higher risk in S&T

NOTE: Presented by USecAF Sega, National Space Symposium, 5 Apr 06
Strategic Space & Defense, 11 Oct 06
NDIA Symposium, 1 Feb 07

Integrity - Service - Excellence
Acquisition Stages—Block Approach

System Production
Block 1 ➔ Block 2 ➔ Block 3

Systems Development
Block 2 ➔ Block 3 ➔ Block 4

Technology Development
Block 3 ➔ Block 4 ➔ Block 5 ➔ Block 6

Science & Technology
Block 4 ➔ Block 5 ➔ Block 6 ➔ Block 7

NOTE: Presented by USecAF Sega, National Space Symposium, 5 Apr 06 Strategic Space & Defense, 11Oct 06 NDIA Symposium, 1 Feb 07

Integrity - Service - Excellence
Back to Basics

"Focus on Fundamentals."
Vince Lombardi

- Addresses DAPA concerns
  - Complex technology not sufficiently prototyped ... timing ... low risk solutions ... schedule
- Addresses independent assessments
  - GAO
    - Mature technology, funding stability, requirements, schedules
  - NSS Acquisition Policy 03–01
    - Early testing, baselines, requirements, evolutionary acquisition
  - Lexington Institute
    - Risks, schedule, requirements, cost growth
- Confirms “TSPR R.I.P.”
- Addresses QDR requirements
  - New acquisition policies, procedures, and processes
Mitigating risks, preventing “disasters” --

A few S&T perspectives

“Been there, doing that”

AFRL, NRL, Draper, SDL, & APL
AFRL Space S&T for Risk Reduction

- USECAF Block Approach: vigorous experimentation to reduce risk
- AFRL Space Vehicles Directorate is embracing this philosophy
  - Strong program in space experimentation
  - 8 major flight experiments on docket
- AFRL legacy space S&T for risk reduction -- examples:
  - CRRES – microelectronics & space sensor risk reduction
  - APEX – solar cells and microelectronics risk reduction
- Current AFRL space S&T for risk reduction -- examples:

<table>
<thead>
<tr>
<th>Major Experiments</th>
<th>Component Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR-AIRSS – Risk Reduction - Alternate IR Satellite System</td>
<td>Solar cells</td>
</tr>
<tr>
<td>TacSat series – small satellites with tactical utility</td>
<td>IR detectors and read-outs</td>
</tr>
<tr>
<td></td>
<td>Cryocoolers</td>
</tr>
<tr>
<td></td>
<td>Space electronics</td>
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</table>
Examples of AFRL Space S&T for Risk Reduction

RR-AIRSS: Risk Reduction - Alternate IR Satellite System

- OSD/AT&L mandated AIRSS program to provide hedge against further difficulties with SBIRS GEO satellites
- SMC & AFRL using USECAF Block Approach to reduce AIRSS risk
- Develop, build, and flight qualify wide-field-of-view, full-Earth staring sensor
- FX-AIRSS flight experiment: investigate data processing & full-Earth backgrounds
  - Seeking FY10 launch to GEO

TacSats and Operationally Responsive Space

- ORS S&T mandated by Congress
- Mission: timely satisfaction of JFC needs
- S&T goal: mature technology to TRL 7
- ORS S&T Roadmap to guide S&T
- TacSat-2: launched on 16 Dec 06
  - Panchromatic imager
- TacSat-3: launch in 2008
  - Hyperspectral imager

Wide-Field-of-View
Full-Earth Staring Sensor

TacSat-2
Naval Research Lab has a Long History Developing New Space Capabilities with Major Operational Impacts

- NRL Has a Long and Diverse History in Space and Transition to Operations
  - 90 Satellites and 36 Launches for National, DOD, and Civilian Sponsors

Extensive Experience Developing, Launching & Operating Satellites

NRL is a Leader in Space
- 1st Ground Station & Object Tracking System (BP, 1955)
- 1st U.S. Reconnaissance Satellite (GRAB, 1959)
- 1st Communications to and From Space
- 1st Large Scale Photos From Space
- 1st Observatory on Moon (Apollo 16, 1971)
- 1st Multiple Satellite Launch From Single Rocket
- 1st Global Positioning System (GPS) Satellite (NTS-2)
- 1st Actively Stabilized Large Transfer Stage
- 1st Tactical Broadcasts From Space (TADIXS-B)
- 1st On-Orbit Autonomous Mapping Operations (Clementine)
- 1st Wind Speed and Direction From Space (WindSat)

Consistent Record of R&D Prototyping Which Transitions to Industry & Operations
# NRL History: Making Space Tactically Relevant to the Joint Community

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956</td>
<td>Blossom Point “Mini-Track”</td>
<td>1st Satellite Ground Tracking Station, Transitioned to NAVSPASUR</td>
</tr>
<tr>
<td>1960</td>
<td>GRAB / Poppy</td>
<td>1st U.S. Reconnaissance Satellite &amp; First National ELINT Operational System</td>
</tr>
<tr>
<td>1974</td>
<td>Timation/NTS</td>
<td>1st Global Positioning System (NAVSTAR GPS) Satellite/Time From Space</td>
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<tr>
<td>1987-1993</td>
<td>TRAP/TRE</td>
<td>Global Tactical Broadcast System Lead to TRAP/TRE and IBS</td>
</tr>
<tr>
<td>1994</td>
<td>Clementine</td>
<td>Multiple Components Developed With Industry and Flown for First Time: Frangibolts, Common Pressure Vessel Battery, etc. Rotary Award for 1st “Faster Cheaper Better” Satellite</td>
</tr>
<tr>
<td>1996</td>
<td>Onboard Processor</td>
<td>Largest Supplier of Tactical Direct Downlink Reporting</td>
</tr>
<tr>
<td>2002</td>
<td>WindSat</td>
<td>Wind Vector From Space Transitioned to NPOESS</td>
</tr>
<tr>
<td>2004</td>
<td>TacSat-1</td>
<td>First ORS TacSat Experiment Completed May 2004 within 1 year (Awaiting Launch). Led to TacSat Series and Broader ORS Efforts.</td>
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</table>
NRL’s Integration, Test, & Operations Capability

NRL has the Full Range of Facilities for Assembly, Integration, Test, and Flight Operations. Personnel are Experienced from Many Programs and Constant Use.
ORS in “Back-to-Basics” Construct is Useful for Articulating Strengths (1 of 2)
ORS in “Back-to-Basics” Construct is Useful for Articulating Strengths (2 of 2)

- This construct is generally space systems development and acquisitions oriented so operations, for example, is not a specified component of this construct
  - NETWARCOM probably best fits between tech dev & system integration in this construct, but fundamentally not the best construct to explain their role
  - OPNAV needs/gaps assessments & rqmts guide tech dev and system integration; SPAWAR performs system integration & production for MUOS/UFO
  - TENCAP supports some tech development but mostly focuses on exploiting on-orbit production systems

ONR**/NRL*** Strength & Focus

**ORS does much broader S&T than shown here but not for space systems as discussed here.

***NRL has extensive expertise creating & transitioning new space systems to operations and industry acquisition.

S&T
(Exploratory & Basic Research)

Operational Experimentation
Somewhere Within These Two

Technology Development
(Eval S&T Discoveries)

System Integration
(Mature TRLs in for Integration into an Op. System)

Production of Op Systems
Draper Laboratory Role in Space System S&T

• An independent, not-for-profit corporation dedicated to solving the nation's most challenging problems by ...
  ▪ Helping our sponsors clarify their requirements and conceptualize innovative solutions to their problems
  ▪ Demonstrating those solutions through the design and development of fieldable engineering prototypes
  ▪ Transitioning our products and processes to industry for production and providing follow-on support

• An acquisition strategy that utilizes national labs as development partners & trusted agents can reduce development risk for first-of-a-kind systems
  ▪ Labs support design, early prototype and initial production
  ▪ Provides proven non-proprietary design
  ▪ Transitions mature design to Industry for production

An objective engineering resource linking research to production
Draper Lab Risk Reduction Examples

Shuttle/ISS Large Space Structure Control
NASA/JSC

Assured Landing & Hazard Avoidance
JSC/LaRC/JPL

NASA Design Team for ARES Upper Stage Avionics
NASA/MSFC

Inertial Pseudo Star Reference Unit
34 nRad Jitter Stabilization

Inertial Stellar Compass on TacSat-2
3 kg Stellar Inertial System

X-38 Fault Tolerant Parallel Processor
2-Fault Tolerant Flight Computer
SPACE DYNAMICS LABORATORY

A not-for-profit corporation owned by Utah State University

- Founded in 1959
- 350 employees
- 500+ successful missions
- 200,000+ ft² of state-of-the-art facilities
- DoD designated UARC with the following core competencies:

1. Electro-optical sensor systems research and development
   - Innovative sensor components and systems
   - Cryo-systems, thermal design, development, and handling
   - Data processing, handling, and analysis
   - Sensor calibration, characterization, test and evaluation
2. Ground, airborne and space rated instruments and payloads development, test and evaluation, integration, validation and operations
3. Data compression/decompression and data visualization for sensor analysis, data exploitation and data fusion
4. Phenomenology measurements, modeling, and simulation
5. Sensor modeling and simulation
SDL: Provider of Space Technologies

- Extensive sensor systems experience
  - Design, development, and prototyping
  - Performance assessments
  - Modeling and simulation
- Expertise, equipment, and facilities to calibrate and characterize electro-optical sensors
  - Internationally recognized for expertise in calibrating complex sensor systems, analyzing calibration data, and disseminating calibration information
- Proven ability and flexibility to work with the customer in addressing real world challenges
- Technology transfer to Government and Industry
- Opportunity to help shape the future by training undergraduate through post-doc students. Industry and Government staff can advance their education while working at a UARC
Representative SDL Sensor Programs
Not-for-profit University-Affiliated Research Center

Staff: 4,000+ employees (70% scientists & engineers)

Business areas:
- Air & Missile Defense
- Biomedicine
- Civilian Space
- Homeland Protection
- Infocentric Operations
- National Security Space
- Precision Engagement
- Science & Technology
- Strategic Systems
- Undersea Warfare
- Warfare Analysis
SPACENEWS
Nov 13, 2006

AGILENESS AND INNOVATION

SPACENEWS
Nov 13, 2006

AFRL Picks 3 to Do Space Surveillance Sensor Designs

The U.S. Air Force Research Laboratory (AFRL) recently awarded three contracts worth $1 million each for initial design work on a prototype space-based surveillance sensor that could keep tabs on objects in geostationary orbit, according to an AFRL spokesman.

Johns Hopkins Applied Physics Laboratory, Ball Aerospace and Technologies Corp., and Goodrich Aerospace won the Lightweight Electro-Optical Space Sensor contracts (LEOSS), according to Michael Kleinman, an AFRL spokesman.

Follow-on work could include a flight demonstration, according to a Johns Hopkins news release issued on Nov. 8, but Kleinman said in a Nov. 9 e-mail that the Air Force is still defining the extent of the work that could follow those three contracts.

SPACENEWS
Nov 13, 2006

NASA’s STEREO Solar Observation Mission Begins

A pair of solar observation satellites was successfully launched into orbit Oct. 26 by a Boeing-built Delta 2 rocket. The nearly identical Solar Terrestrial Relations Observatory (STEREO) will generate the first near real-time, 3-D images of the Sun.

STEREO’s main mission is to image coronal mass ejections, immense eruptions from the Sun that spew high-energy particles that can pose a radiation hazard for astronauts and satellites, as well as interfere with power and communications systems on Earth.

Engineers at the Johns Hopkins University’s Applied Physics Laboratory built the STEREO spacecraft for NASA, and will oversee the $500 million mission.

SPACENEWS
Nov 28, 2006

New Horizons probe makes its first Pluto sighting

A white arrow marks Pluto in this New Horizons Long Range Reconnaissance Imager (LORRI) picture. Seen at a distance of about 4.2 billion kilometers (2.6 billion miles) from the spacecraft, Pluto is little more than a faint point of light among a dense field of stars. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute

Oct 30, 2006

AIAA
Cover story
Nov 2006

Dec 2006

Oct 30, 2006

A white arrow marks Pluto in this New Horizons Long Range Reconnaissance Imager (LORRI) picture. Seen at a distance of about 4.2 billion kilometers (2.6 billion miles) from the spacecraft, Pluto is little more than a faint point of light among a dense field of stars. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute

Oct 30, 2006
A tradition of “Firsts” in space since 1958

- 1958 Satellite Navigation System
- 1961 Nuclear-powered spacecraft
- 1963 Gravity gradient stabilization
- 1967 Color picture of the full Earth
- 1972 Drag-compensated satellite
- 1975 Pulsed plasma thrusters
- 1982 Autonomous satellite navigation with GPS
- 1984 Artificial comet
- 1986 Intercept of a thrusting target in space
- 1988 Autonomous target acquisition and track
- 1996 Hyperspectral Imager in space (MSX)
- 1996 Invention of Polymer Battery
- 2001 Landing on an asteroid (NEAR)
- 2003 Re-Configurable Self-Repairing Processor (on FEDSAT)
- 2004 Orbital Mercury exploration mission launched (MESSENGER)
- 2006 Mission to Pluto (New Horizons)
APL’s “Space Portfolio” …

**developing new space capabilities**

- APL -- 64 spacecraft, 150+ payloads since 1958
- Produce operational prototypes
  - e.g., TRANSIT to Midcourse Space Experiment (MSX)
- National Security Space roles
  - **Technical Direction Agent**
    - Studies and analyses, technology advice
    - Data analyses, decision aids
  - **Advanced Technology Development**
    - S&T components
    - Sensors
  - **Implement Space Missions**
    - Mission Design
    - Build spacecraft, integration, T&E, operations
    - Applications

*Unique bridge between NASA space and DoD/IC needs*
APL spacecraft – 1996-2006

Key
- From PDR to delivery.
- Arrival at I&T facility through launch.

-10 to +22% Cost History
Ground segment experience –
APL actively operates 6 spacecraft

Connectivity:
- Air Force Satellite Control Network (AFSCN)
- Deep Space Network (DSN)
- Universal Space Network (USN)
- Tracking and Data Relay Satellite (TDRS)

Decades of hands-on operational experience
Recurring theme

If --

“Back to Basics” is the question ...

Then --

a government, industry, & lab mix is the best answer.

“Commitment to Space Partnerships”
Applying S&T capabilities to the end-to-end cycle

“Ready, willing, and quite able”
Choose your (preventable) “disaster” …

- Satellite toppling
- Mars Climate Orbiter
- Sago Mine
- Genesis
- Enron
- Pipeline leak
- Comair 5191
- USS San Francisco
- Katrina
- Challenger
- Mars Polar Lander
- Denver highway beam
- Refinery fires
- USS Greeneville
- Tank versus road
- Car versus fighter
- The Big Dig
- 9/11
- Columbia
- Concorde
Developing “crack stoppers”

Per Mr. Payton, DUSecAF:
- Liberty ships’ structural failures – “crack stoppers” saved the day
- Common thread between space disasters & other disasters
- Root causes similar, identifiable – and can be mitigated
- Acquisition problems are disasters
  - National security capabilities absent/diminished/delayed
  - ~$12B remediation impacts other areas (= Space Pearl Harbor?)
- Need to stop those “cracks” to deliver what’s promised
  - Technical/schedule risks, cost estimates, requirements
Labs as “crackstoppers”

- Four-stage process
  - System Production
  - **Systems Development**
  - Technology Development
  - **Science & Technology**

- Reapportion Risk
  - Lower risk in Production
    - Use **mature technology**
  - Higher risk in S&T

Labs’ “Sweet spot”
Assume mission-oriented, end-to-end development …

A Systems Approach

Managing Risks:
- **Program**
  - Schedule
  - Cost
  - Scope
- **Technical**
  - Performance
  - Drawings
- **Quality**
  - Non-conformances
  - Changes
- **Institutional**
  - Process deviations
  - Training

Diagram showing different stages of development:
- **Concept Exploration**
- **Capability Assessment**
- **Critical Needs**
- **Deployment**
- **Solution Implementation**
- **Solution Validation**
Critical Needs

Defining Requirements
Capabilities Improvement Needs Definition

Managing Risks:

- Program
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  - Training
Capability Assessment

Data Collection
Mission Performance Analysis

Managing Risks:
- Program
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Concept Exploration

Develop Enabling Science & Technology

Hypothesis, Concept Development Trade-offs, & Critical Experiments

Modeling and Simulations

Managing Risks:
- Program
- Technical
- Quality
- Institutional

- Schedule
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Prototype Development

Performance Demonstration

Critical Field Experiments

Government

Industry

Solution Validation

Technology Knowledge Transfer (*NLT this step*)
Solution Implementation

Product Development & Production

Test & Evaluation
Performance Verification

Managing Risks:
- Program
- Technical
- Quality
- Institutional

Schedule
Cost
Scope
Drawings
Performance
Non-conformances
Changes
Process deviations
Training
Deployment

Operational Data Collection

Lessons Learned

Managing Risks:
- Program
- Technical
- Quality
- Institutional

- Schedule
- Cost
- Scope
- Performance
- Drawings
- Non-conformances
- Changes
- Process deviations
- Training
Assume mission-oriented, end-to-end development ... A Systems Approach

Managing Risks:
- Program
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  - Process deviations
  - Training

Operational Data Collection
Lessons Learned

Test & Evaluation
Product Development & Production

Prototype Development
Performance Demonstration
Critical Field Experiments

Capabilities Improvement
Needs Definition

Data Collection
Mission Performance
Analysis

Capability Assessment
Critical Needs

Concept Exploration

Solution Validation

Government

Industry

Enabling Science & Technology
Hypothesis, Concept Development
Trade-offs & Critical Experiments
Modeling and Simulations
Interactive Government / Industry / Lab partnership to:

- Freeze requirements (minimize ECPs)
- Make rigid, realistic schedule start to launch (target XX months)
- Shape external environment during program (level funding)
- Small multi-expert, experienced, collocated team
- Team authority to do the missions
- Spacecraft and instruments designed to cost
- Minimize low TRL components / TRL maturation
- Get long lead items early
- Use lead engineer and method for all subsystems
- Design in reliability and redundancy
- Have R&QA engineer reporting directly to project manager
- Have single agency manager to interface with contractor
Summary

“Committing to space partnerships”
Acquisition Stages—Block Approach

Block 1: System Production

Block 2: Systems Development

Block 3: Technology Development

Block 4: Science & Technology

Block 5: Labs

Block 6: Industry

Industry - Labs

Integrity - Service - Excellence

NOTE: Presented by USecAF Sega, National Space Symposium, 5 Apr 06 Strategic Space & Defense, 11 Oct 06 NDIA Symposium, 1 Feb 07
Acquisition Stages—Block Approach

System Production

Block 1
Block 2
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Block 7

"Commitment to Space Partnerships"

Industry

Labs

Science & Technology

Integration - Service - Excellence

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