Capabilities Overview

April 2010

Ducommun Miltec
About Ducommun

- Founded 1849 - Oldest Registered Company in CA
- Corporate Headquarters – Carson, CA
- Annual Revenues over $450 Million
- Over 1,600 Employees

Engineering, Manufacturing, Assembly & Test

Research, Design, Analysis, Development, Integration, Test, & Training

Manufacturing
About Ducommun

Diversified Customer Base
About Ducommun

Strategic Geography

Thailand

Ducommun AeroStructures
Ducommun Technologies
Ducommun Miltec
About Ducommun Miltec

Systems

**Bill Koons**  
*Vice President*

- Modeling and Simulation
- Pre and Post Flight Analysis
- Engineering and IT
- Programmatic Services
- Test Range Launch Ops

Missiles and Space

**Ivy Pinion**  
*Sr. Vice President*

- Hardware and Software Design, Development, and Testing
- Missile and Weapons Systems
- Satellite and Space Systems
- Avionics and Navigation Systems
- EO/IR Sensor Systems

- Acoustics Research
- Aviation and UAV Sensors
- Cruise Missile Detection and Tracking
- Thermal Management

- Ground-Based Acoustic Tracking
About Ducommun Miltec

Colorado Springs, CO
- Systems Engineering
- Mission Planning
- Operational Services

Iuka, MS
- Integration & Test Facility
- HWIL Testing
- Environmental Testing

Oxford, MS
- Acoustics Research
- Health Management

Huntsville, AL
- Engineering Services
- Design
- Development
- Analysis
- Prototyping

~250 employees providing system development and engineering services
Development Focus

High Tech Aerospace Disciplines

- System Engineering
- Structural/Mech.
- Avionics
- Flight Software
- Modeling & Simulation
- Control Systems
- Aerodynamics
- Thermodynamics
- Impact Dynamics
- Risk Assessment
- Risk Mitigation
- Test Planning
- Test Operations
- HWIL
- Component – Subsystem – System Integration

Analytical proof of concepts • TRL-3
Breadboard / brassboard demonstrations • TRL-4
Component and subsystem tests in relevant environments • TRL-5
System prototype in flight tests or relevant environment tests • TRL-6

Demonstrated expertise in component, subsystem, and system development from TRL-3 to TRL-6

Technology maturation through our comprehensive system engineering and risk management process.

People
- Unique ability to attract and retain engineering labor force
- Growth to more than 280 employees in 11 years

Processes
- Project Management
- Systems Engineering and Integration
- Quality Assurance
- Property Control
- Configuration Mgt.
- Safety
- ISO 9001 Certified

Tools
- MATLAB/SimuLink
- ANSYS
- Alegro
- STK
- CTH Hydrocode
- GASP CFD
- SolidWorks
- CONTOUR

Facilities
- Electronics Assembly & Test Lab
- Inertial Nav Lab
- Impact Analysis Lab
- IR Sensor O&M Lab
- HSV Research Park High Bay
- Missile Integration Fac.

Demonstrated Infrastructure

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Business Operations

- 70% of Contracts – Prime Contractor
- DOD/NASA Programmatic
  - Program Managers
  - Integrated Product Teams (IPT/PDT)
  - Program Analysts
  - EVMS
  - Risk Management
- Supply Chain Management (Deltek)
  - Make or Buy
  - Competitive Subcontracting
- Information Assurance
- ISO 9001 Certified
  - Continuous Improvement
  - Quality Assurance
- Government Approved Property System
- Government Approved Purchasing System
- Government Approved Billing System
- Government Approved Accounting System

Established Processes and Procedures That Are Controlled and Audited
Missiles Programs

- Extended Area Protection and Survivability (EAPS)
- Compact Kinetic Energy Missile (CKEM)
- Low Cost Interceptor (LCI)
- Joint Range Instrumentation Pod
- High Speed Strike
- Advanced Hypersonic Weapon
- Atmospheric Interceptor Technology
- Long Range Anti-Ship Missile
Satellite and Space Vehicle Programs

SMDC-ONE

Advanced Space Vehicle Development

Flight Experiments

Ares I Upper Stage

Multi Band Sensor

LRF Receiver (not visible)

Visible Camera

LWIR FPA/Dewar

MWIR FPA/Dewar

Fold Mirrors

Laser Tran

Kinetic Energy Anti-Satellite

LH2 and LOX Tanks Manufacturing Demonstration and Test Articles

Micro Satellite Propulsion Experiment (MPX)
Kill Vehicle Expertise and Programs

- **System Analysis**
- **Concept Development**
- **Program Experience**
- **Staff Experience**

- LRAD
- MKV
- MPX
- ACT
- HOE
- GBI-X
- ERIS
- AIT
Engineering Capabilities Overview

Broad Engineering Capabilities

Concept
Design
Development
Prototyping
Integration
Test

Systems Eng
Structural
Mechanical
Electrical
Optical
Software

Piece Parts
Components
Subassemblies
Assemblies
Subsystems
Systems
Core Competencies

Mission & Systems Engineering

EO & IR Sensor Operations, Maintenance, & Upgrades

Electronics Hardware Design & Development

Test and Evaluation

System Integration

Inertial Navigation System Design

6-DOF Simulation

Guidance, Navigation and Control

Aerodynamics

Structural /Mechanical Systems

Weapons Lethality

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Structural Design and Analysis

Paper Concept to Hardware Fabrication
- 3D Solid Modeling
- Engineering Drawings to ANSI Y14.5 Standards with Full GDT
- Design Process Under Configuration Management

Conventional and Unconventional Structural Analysis
- Linear and Non-Linear Stress
- Vibration
- Shock
- NonLinear Contact
- Impact Dynamics

Design Optimization Using ANSYS
- Light Weight Structures
- High Stiffness to Weight

Radome Stress Analysis
Missile Buckling Analysis
Missile Assembly CAD Model
Structural Dynamics

Significant Accomplishments

• Pre and Post-Test Flight Vibration Assessments
  – All Arrow/ACES Flights, HEDI Flights
  – Ground Based Interceptor Flights
• Ballistic Shock Analysis
  – Crusader, Armored Gun System, Composite Armored Vehicle

Beryllium Aeroshell
\[ f_1 = 988 \text{ Hz} \]

Staff Expertise

• Shock and Vibration
• Flight Qualification
• Structural Testing
• Ballistic Shock
• Telemetry Data
• Simulation Configuration Control

Program Experience

• GBI
• Arrow
• Crusader
• USASMDC-Lethality
• HEDI

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Aerodynamics

• Low and High Speed Aero

Aerothermal/Heating/Aero-Optics

• Window and Midbody Heating
• Irradiance, Boresight Error

Wind Tunnel Testing

• Planning and Set-up
• Pre- and Post-test Analyses

Propulsion

• Liquid and Solid Internal Ballistics
• Nozzle Design
• Ramjet Inlet Design

CFD

• Multiphase, Turbulent Flow
• Chemically Reacting Flow

Stage and Shroud Separation

Jet Interaction

• Non-Reacting Flow
• Chemically Reacting Flow

High Performance Computing

• Vector/Parallel Architectures
Experience With An Extensive Modeling and Simulation Toolbox
Significant Accomplishments

- Developed simulations for ACT, CKEM, LCI, KE-ASAT, STARS, THAAD, BAT, AIT, TSSAM, GBI, Arrow, Hera, SBI
- Flight test predictions and post flight reconstructions for CKEM, GMD Targets, THAAD, BAT, GBI, TSSAM, Arrow

Modeling and Simulation Approach

- Modular, rapidly configurable approach
- Utilizes powerful analyst tools to facilitate the development and analysis process
- Matlab-based, FORTRAN-based, and C-based simulations experience
Hardware Design

- PCB design & layout
  - A/Ds, D/As
  - Power distribution
  - Telemetry components
  - Single & multi-processor assemblies
- PCB population
- Dewars, Optics, Spectral Filters
- Structure Design & Fabrication
- Flight Computers
- Data Recording
- HWIL Electrical & Mechanical Interfaces
- Signal, Image, & Data Processing Algorithms
  - Non-uniformity Correction
  - Background subtraction (segmentation)
  - Object Segregation & Tracking
  - IR feature discrimination
  - Metric feature discrimination
- Real-time & Embedded Software
  - Device drivers
  - Multi-processor, multi-OS, no OS
  - Comprehensive GUI control
Avionics

Inertial Sensor Package (ISP)

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Sensors and Electronics

Optical Systems
• IR and Visible Systems Conceptual Design
• Radiometric Analysis, Design, & Calibration
• Passive Sensor Design
• Laser Systems Design
• Detector/Dewar and Packaging Design
• Optical System and Subsystem Diagnostics
• Testing and Analysis

Electro-Optic Solutions
• Stabilized Gimbaled Platforms
• Missile Seekers
• Stabilized Mirror Systems
• Automatic Target Tracking
• Automatic Target Cueing

RF Engineering
• RF System Analysis, Design & H/W Development
  – Radar Receiver/Exciter
  – Threat Radar Analysis/FME
  – RF Environment Simulation
• Electromagnetic Effects Analysis & Testing
  – CW/EMP/UWB
  – UWB Source and Antenna Design
  – Anechoic Chamber Design
  – System Susceptibility Testing

Electronics Hardware
• DSP (SHARC, C30)
• RISC (PowerPC)
• CISC (680x0)
• FPGA, PLDs (Altera, Xilinx)
• Custom & Hybrid Systems Development
  – Sensor Support Electronics
  – Gimbal Control Electronics
  – Custom Processors
  – Custom Interfaces

Software Programming
• Embedded Software Development
• Multi-processor System Design
• RTOS (pSOS, VxWorks, Frenzy)
• Sensor Signal & Image Processing
• Pointing and Tracking
• Guidance and Navigation
• Custom Driver Development
• Graphical Display Programming
• GUID Development
• Scene Generation and Modeling
• Data/Sensor Fusion

Integrated Solutions
• Electro-Optical & RF Systems
• Real-Time Processing Systems
• Automated Control Systems
• Data Collection Systems
• Instrumentation Systems
• Guidance and Control Systems

Flight Computers

Gimbal Emulator

Integrated Solutions

Optical Systems

Electronics Hardware

Software Programming

Integrated Solutions
Sensor Systems

Passive Sensors
- Industry tools for IR/Visible/UV Concepts
- Complex optical system design
- Use of COTS and custom components
- Detector/Dewar and IDA packaging
- Signal/Image/Track processing
- Rapid prototype development
- Multi Spectral Systems
- Laser receivers

Active Sensors
- RF System Analysis, Design & H/W Development
  - Radar Receiver/Exciter
  - Threat Radar Analysis/FME
- Laser transmitters & LRF assemblies

Seeker Development
- Custom mechanical interfaces
- Custom optical interfaces
- 5 & 6 DOF detector/IDA mounts
- Telescope/Imaging assemblies
- Sensor electronics interfaces
- Mechanical & thermal analysis
- Environmental testing
Inertial Navigation Systems

IMU Cost - Performance Optimization/Spec Development

- Pure Inertial (No Aiding)
- GPS Position & Velocity Aiding
- GPS Position & Attitude Aiding
- Magnetometer Attitude Aiding

Filter Process

- Start
- Initialize Filter
- Update Φ and Q
- Propagate P and X
- Measurement?
- No
- Update R
- Compute K
- Update P and X
- Apply Nav State Estimates ToNavSolution
- Compute Error State Residuals: Z

State Transition and Measurement Matrices

\[ M[X] = \begin{bmatrix}
    X_y & -X_z & 0 & 0 & 0 & 0 \\
    0 & 0 & -X_y & -X_z & 0 & 0 \\
    0 & 0 & 0 & 0 & X_y & -X_z
\end{bmatrix} \]

\[ P_{X,Y,Z}^T = \begin{bmatrix}
    0 & -f_{x1} & f_{x2} \\
    f_{x1} & 0 & -f_{x1} \\
    -f_{x2} & f_{x1} & 0
\end{bmatrix} \]

\[ V_{X,Y,Z}^T = \begin{bmatrix}
    l_{x3} & 0_{x3} & 0_{x3} \\
    0_{x3} & l_{x3} & 0_{x3} \\
    0_{x3} & 0_{x3} & l_{x3}
\end{bmatrix} \]

Navigation and Track Filter Design

Covariance Analysis

NGSP Flight Unit
Lethality Expertise

Operational Flight Test

Full Scale Sled Test

Sub-Scale Light Gas Gun Test

Modeling & Simulation

Fast Running Codes

First Principles Codes Analysis

Design Analysis

Algorithms

Ducommun Miltec
Integration & Test Capabilities

- System/Sub-System Integration
- HWIL/SWIL
- Environmental Testing
  - Temperature
  - Vacuum
  - Shock & Vibe
- Hardness Testing
- EMI/EMC Testing
- Functional Testing
- Field Testing
- Clean Room
- Test Management & Planning
Integration and Test Facility

Ten Integration Bays

Liquid Propellant Pad

Bay 1  Bay 2  Bay 3  Bay 4

Test Integration Lab

Office and Lab Area

High Bay

Shock and Vibe Testing
Test Assets

Inertial Lab

Thermal Vac

Vibe

Optics Lab
Leveraged Government Assets

AMRDEC Anechoic Chamber

Wallops Integration Lab

NASA Shock

RTTC Mass Properties Survey

AMRDEC 5-Axis Table
Systems and Subsystems

Missile Systems/Subsystems
- Compact Kinetic Energy Missile (CKEM)
- Low Cost Interceptor (LCI)
- High Speed Strike
- Extended Area Protection & Survivability (EAPS)

Space Systems/Subsystems
- SMDC-ONE Nanosatellite
- MDA Flight Experiments
Evolving Products

- Magnetic Inertial Navigation Instrument
- Far Target Locator
- Structural Health Monitoring (Delamination Robot)
- Fencepost
Spacecraft Development Roadmap

- **AIS**
- **RF Mapping**
- **Weather**
- **Communications**
- **EO Imagery**
- **SSA**
- **IR Imagery**
- **Battlespace Characterization**
- **Full Multi-Mission Capability**
- **HSI**
- **Radar**

**Military Utility**

- **NanoSat** 4 - 5 kg
- **MicroSat** 50 kg
- **CubeSat** 1 kg

**Operationally Responsive Space**

- **Air Force Space**
- **Environmental Monitoring**

- **MiniSat** 450 kg
- **150 kg**

**Spacecraft Development Roadmap**

- Modular Open System Architecture
- Multi-Mission Buses and Payloads
- Reconfigurable PnP Technology
- Rapid and Operationally Responsive

**Military Utility**

- **NanoSat** 4 - 5 kg
- **MicroSat** 50 kg
- **CubeSat** 1 kg
- **StenSat**
3. Determine the need for an abort
   • U/S Flight Computer

1. Detect Ares conditions indicating the need for an abort
   • U/S Flight Computer
   • Sensors and Instrumentation

2. Confirm Ares conditions indicating the need for an abort
   • U/S Flight Computer
   Confirmation algorithms
   • J-2X Controller
   • Sensors

4. Notify Orion of abort recommendation
   • Data bus and interfaces

♦ Requirements Analysis
♦ Interface Definition
♦ Sizing, Design and Configuration
♦ Payload Suite Selection
♦ Truth Instrumentation Analysis
♦ Integrated Vehicle Health Monitoring
Engineering Services

Analytical Services

- Advanced Concept Design
- Pre-Flight Predications
- Post Flight Analysis
- Dynamic Recreation and Visualization
- Optical Sensor Discrimination
- Propulsion Design Analysis
- Structural Design Analysis
- Aerodynamic Wind Tunnel Testing

Computer Technologies

- 3DOF/6 DOF Flight Simulations
- Real-time Avionics Software
- Embedded Systems
- Data/Sensor Fusion
- Hardware-In-The-Loop
- Graphical User Interfaces
- GMD Information Assurance
- Industry Standard Development Practices
Engineering Services

Applied Research

- Micro- and Nano-Systems
- Optical Science
- Material Science
- Space Science
- Complete System Development Life Cycle Capability

Training Solutions

- Computer Based Training
- Interactive Multimedia Instruction
- Immersive Game Based Instruction
- Virtual Hands on Training for Field Operation and Maintenance
- Student Tracking and Reporting
- High Fidelity 3D Modeling and Animation
Why Ducommun Miltec?

• Fast and Flexible
  – Non-Bureaucratic
  – Innovative

• Highly Responsive to the Customer
  – Demonstrated Success, On Time, and Within Budget
  – True Partnership Efforts

• Outstanding People, Tools, Processes, and Facilities
  – Efficient
  – Disciplined
  – Affordable

• Demonstrated Risk Management and Mitigation In Technology Advancement
  – Internal and Subcontracts Management / Control
  – Unique Approach To Systems Engineering Requirements Balancing

Aerospace Design – Fabrication – Integration – Test – Production