

GPS PROGRAM UPDATES AND ITS ROLE IN THE SMC SPACE ENTERPRISE ARCHITECTURE

BEFORE WE BEGIN

Have questions?

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GPS WORLD

SPEAKERS



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SPACE AND MISSILE
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SPACE AND MISSILE SYSTEMS CENTER

Space and Missile Systems Center

GLOBAL POSITIONING SYSTEM STATUS AND MODERNIZATION



Col. Ryan Colburn
Space and Missile Systems Center
Portfolio Architect's
Senior Materiel Leader, Spectrum Warfare



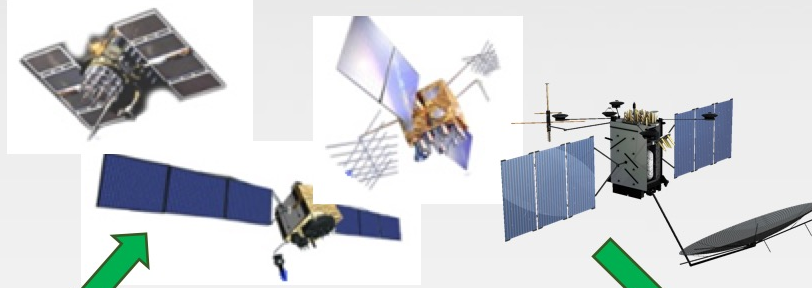
AGENDA

- GPS Organizational Changes & Overview
- GPS Status and Future plans
- COVID-19 Effects
- Q&A



GPS OVERVIEW

Space Segment



Broadcasting since 1978

Control Segment



20 monitoring and control stations worldwide

User Segment



Reaching over 4 billion users every second



Committed to Cooperation

Department of Defense • Army • Navy • Air Force • Space Force • USMC • NGA • DISA • USNO • NSA • **PNT EXCOM**
 National Nuclear Security Administration (NNSA) • **Department of Transportation** • Federal Aviation Administration
Department of Homeland Security • U.S. Coast Guard • **International Civil Aviation Organization**
Global Navigation Satellite Systems • Galileo • Beidou • GLONASS • QZSS • NAVIC
International Committee on GNSS • **International Telecommunication Union**

Bold font identifies parent organizations

Images: U.S. Space Force

Space Starts Here

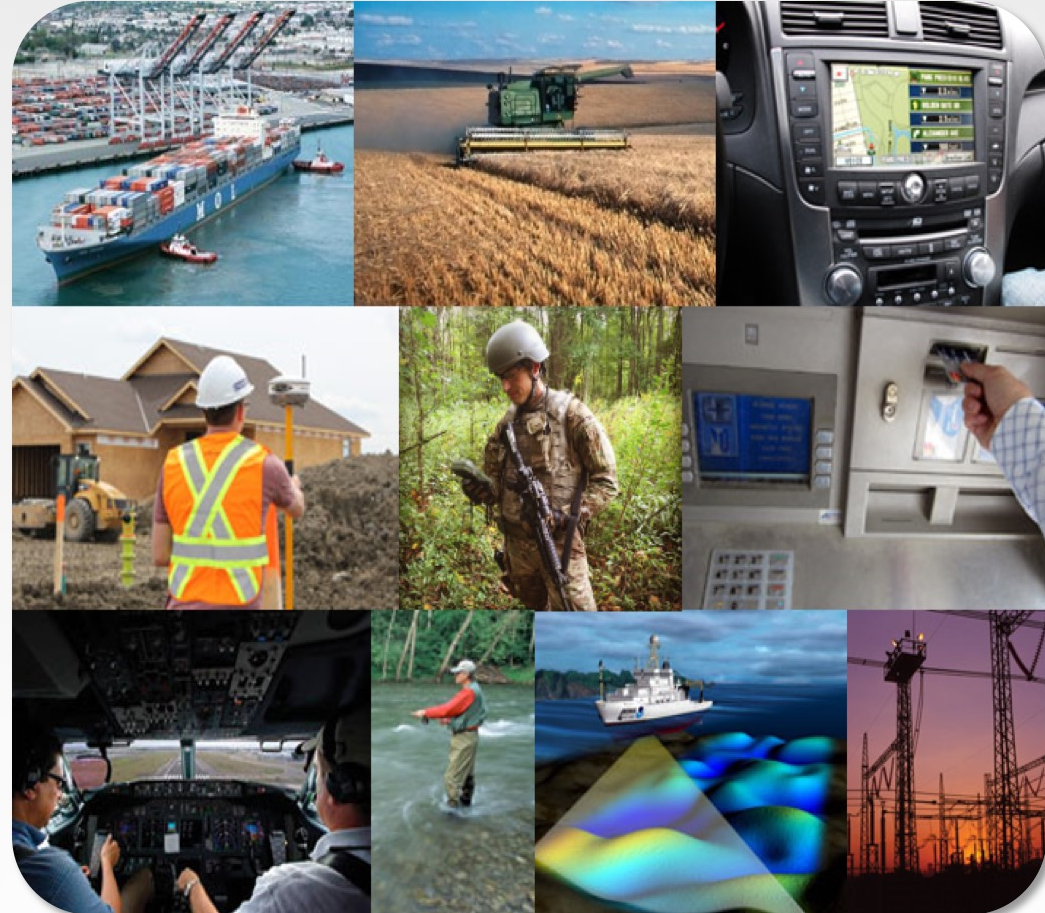
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GLOBAL IMPACT OF GPS

*<https://www.gps.gov/governance/advisory/meetings/2019-11/gallagher.pdf>

- GPS is utilized across the world with +4B users!
- GPS impacts almost every industry. Some of these industries include:
 - Agriculture
 - Maritime
 - Public Safety
 - Recreation
 - Space
 - Aviation
 - Finance
 - Telecommunications
 - Telematics
 - Oil/Gas
- GPS economic benefit ~\$1.4 Trillion*

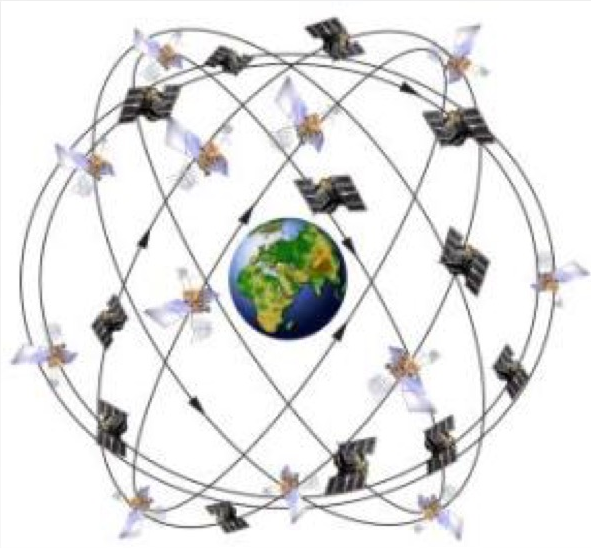


*GPS consistently met all technical performance commitments:
Accuracy, Integrity, Availability and Continuity*



GPS CONSTELLATION STATUS

35 Satellites • 30 Set Healthy
 Baseline Constellation: 24 Satellites



Satellite Block	Quantity	Average Age (yrs)	Oldest
GPS IIR	9 (3*)	18.7	23.1
GPS IIR-M	7 (1*)	12.9	15.0
GPS IIF	12	6.6	10.3
GPS III	2 (1*)	1.0	1.7

*Ops capable; not set healthy

As of 19 Sep 20

GPS Signal in Space (SIS) Performance

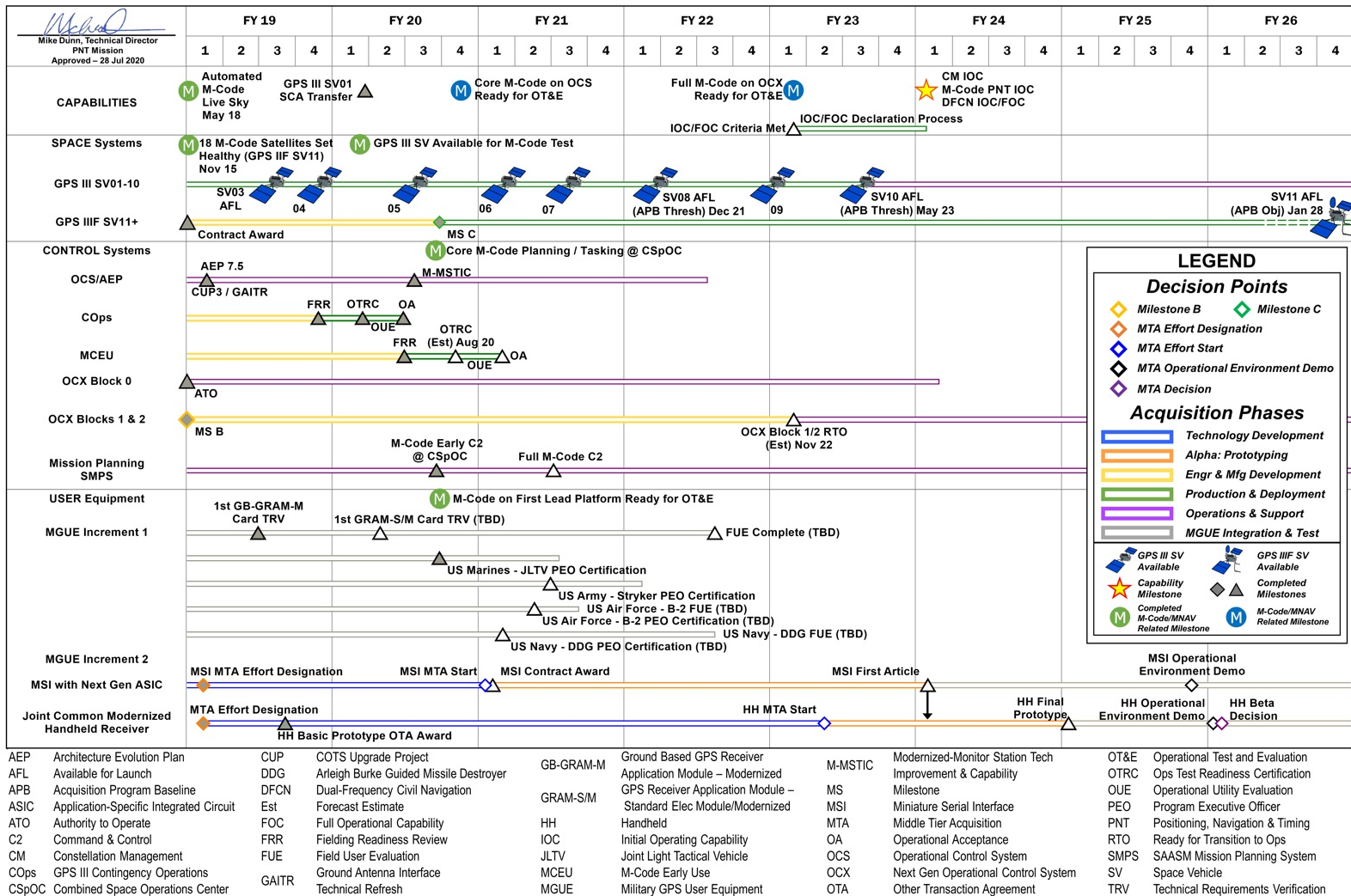
From 19 Sep 19 to 19 Sep 20

Average URE*	Best Day URE	Worst Day URE
52.0 cm	38.5 cm (01 Jun 20)	90.2 cm (26 Jul 20)

*All User Range Errors (UREs) are Root Mean Square values

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GPS Enterprise Roadmap





GPS III

- SV01 Set healthy and available for use on 13 Jan 20
- SV02 Set healthy and available for use on 1 Apr 20
- SV03 Operationally accepted 27 Jul 20
- SV04 Launch is TBD
 - Second NSSL mission on a recoverable Falcon 9
- SV05 Declared Available for Launch 7 May 20
- SV06 Available for Launch Spring 2021
- SV07 TVAC forecast completion Sep 2020
- SV08 Core Mate completed 15 Apr 20
- SV09-10 Component deliveries in progress





GPS III FOLLOW-ON (GPS IIIF)

- GPS IIIF additional features:

- Regional Military Protection (RMP) and redesigned Nuclear Detonation Detection System (NDS)
- Search-and-Rescue (SAR) payload – faster detection and location of distress signals
- Laser Retroreflector Array (LRA) – provides more precise ranging data



- Partnering with Air Force Research Laboratory (AFRL) for future technology opportunities

- Digital Reprogrammable Payloads
- Demo on Navigation Technology Satellite (NTS-3)
- Near Real-Time Commanding/Crosslinks

- Status: Design Phase Completed 13 Jul 20; SV11 launch forecasted for 2026

Ensuring the Gold Standard today and into the future

A **GPS** III **WORLD** WEBINAR,
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NEXT GENERATION OPERATIONAL CONTROL SYSTEM (OCX)

- Next-generation command, control and cyber-defense for GPS
 - Enhanced command and control capability
 - Modernized architecture
 - Robust information assurance and cyber security
- Incremental Development
 - OCX Block 0: Launch and Checkout System (LCS) for GPS III
 - OCX Blocks 1 and 2: Controls and manages all GPS IIR, GPS IIR-M, GPS IIF, and GPS III spacecraft; and controls all legacy and new GPS signals
- Current Status
 - LCS successfully supported GPS III SV01, SV02, and SV03 Launch and Checkout
 - Exceeding operational requirements for availability and dependability
 - OCX Block 1 software coding complete – 12 Aug 19
 - System integration and verification ongoing
 - Ready to Transition to Operations: 4QCY22



OCX program continues to execute and meet schedule



GPS III CONTINGENCY OPERATIONS (COPS)

- Upgrade to current control system that enables limited operations on GPS III vehicles until OCX Block 1/2 delivery
 - Provides legacy and modernized signal (L2C, L5, M-Code test) operations
 - Uses OCX Block 0 for GPS III launch, major anomaly, and disposal capabilities
- COps Status
 - Space Force formally Operationally Accepted COps on 27 Mar 20

COps enables Command and Control for GPS III satellites



MILITARY CODE EARLY USE (MCEU)

- Description
 - Provide early use of GPS M-Code signal from 2020 until OCX Block 1 Ready for Transition to Operations
 - Enable and operate M-Code messaging on all M-Code capable satellites, including GPS IIR-M, GPS IIF, and GPS III (at a GPS IIF performance level)
- Software Development
 - Updates to current Operational Control System (OCS)
 - Integration of M-Code Keying and Modernized Monitoring Stations
- Current Status
 - MCEU AEP 9.0 fielding completed 25 Jun 20
 - Developmental and operational testing targeted for Aug-Oct 2020
 - Operational Acceptance Target Date 18 Nov 20

MCEU is operationalizing core M-Code in 2020



MILITARY GPS USER EQUIPMENT (MGUE)


- Description

- The Military GPS User Equipment Program is responsible for the development of standard modernized receivers for Service-nominated lead platforms to deliver capabilities where current legacy receiver performance would be compromised.

- Current Status:

- Increment 1 on track to support Core M-Code Operations in 2020
- Increment 2 Acquisition Strategy approved in Nov 2018 as two Middle Tier Acquisition rapid prototyping efforts:
 - Miniature Serial Interface (MSI) receiver card w/ Next Generation Application-Specific Integrated Circuit (ASIC) with projected contract award in 1QFY21
 - Joint Modernized Handheld Receiver in Risk Reduction/Prototyping phase

MGUE core technologies prime market for 2M+ receivers



global utility
uninterrupted service
strength through partnership
gold standard

GPS



MIKE SHEPHERD
ASSOCIATE DIRECTOR
OF BUSINESS DEVELOPMENT
COLLINS AEROSPACE

 **Collins Aerospace**

NET SALES \$26 BILLION



 **Pratt & Whitney**

NET SALES \$20.9 BILLION



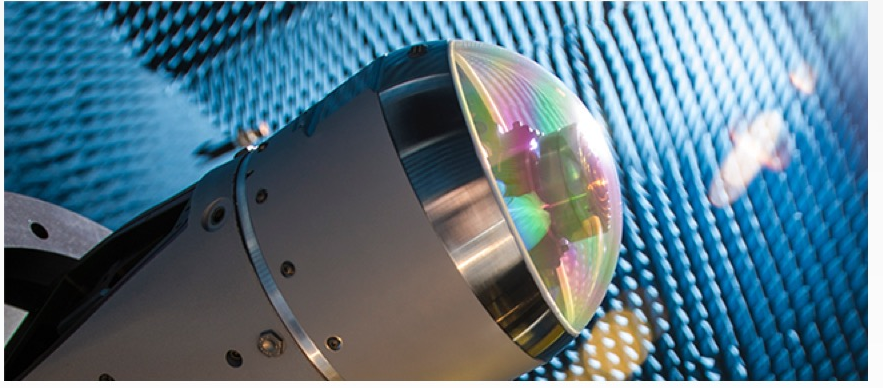
 **Raytheon Intelligence & Space**

NET SALES \$14.5 BILLION



 **Raytheon Missiles & Defense**

NET SALES \$15.6 BILLION



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Formed to meet customer needs and represent the best in innovation, technology and expertise.

Aerostructures



Avionics



Interiors



Mechanical Systems



Mission Systems



Power & Controls



LEADERSHIP



PRESIDENT
Stephen Timm

STRATEGIC BUSINESS UNITS



AEROSTRUCTURES
Marc Duvall



AVIONICS
Dave Nieuwsma



INTERIORS
Troy Brunk



MECHANICAL SYSTEMS
Samir Mehta



MISSION SYSTEMS
Phil Jasper



POWER & CONTROLS
Tim White

FUNCTIONS



AFTERMARKET SERVICES
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(Acting)



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OPERATIONS & QUALITY
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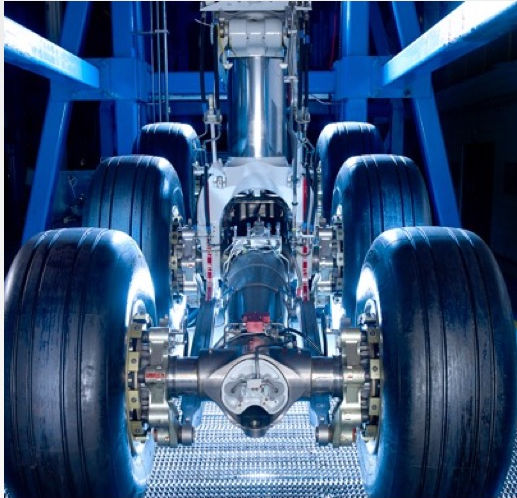


STRATEGIC DEVELOPMENT
Jeff Standerski

STRATEGIC BUSINESS UNITS

MECHANICAL SYSTEMS

Based in Charlotte, North Carolina



- Landing systems
- Actuation
- Propellers
- Flight controls
- Pilot controls
- Hoist and winch systems
- Cargo systems

MISSION SYSTEMS

Based in Cedar Rapids, Iowa



- Communication, navigation and guidance
- Missile actuation
- Simulation and training
- Strategic command and control
- Unmanned aircraft systems
- Electronic warfare
- Ejection seats
- Intelligence, surveillance and reconnaissance
- Space solutions

POWER & CONTROLS

Based in Windsor Locks, Connecticut



- Electric systems
- Engine controls
- Air management
- Airframe controls

MISSION SYSTEMS

COMMUNICATION, NAVIGATION & GUIDANCE SOLUTIONS



Ryan Bunge
Communication, Navigation,
& Guidance Solutions



Carla Hermanson
Executive Administrative Assistant

PORTFOLIOS



Rob Scott
Tactical Communications Solutions



Chris Steinberg
Data Link Products



Hugh Dunkley
Fuels and Health & Usage
Management Systems (HUMS)



Philippe Limondin
Guidance & Navigation Solutions
/ Advanced Solutions

FUNCTIONS



Rodney Mickelson
Comm & PNT
Systems E&T



Chris Wilson
Guidance Solutions
Engineering



Kurt Grigg
Strategy



Greg Pilon
Business
Development



Lea Montross
Manufacturing



Nate Haas
Finance



Andrew Wallace
Contracts



Kim Mitchell
Human Resources



Jill Wojciechowski
Communications

Dotted Line Support

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MISSION SYSTEMS PORTFOLIOS

COMMUNICATION, NAVIGATION & GUIDANCE SOLUTIONS



- Airborne and ground secure military communications
- Tactical data links
- Assured position, navigation and timing solutions
- Precision weapon guidance and actuation systems
- Advanced fuel measurement and management systems
- Shipboard and tactical landing systems
- Health and usage monitoring systems

ISR & SPACE SOLUTIONS



- Airborne intelligence, surveillance and reconnaissance (ISR)
- National security space systems
- Human exploration
- Precision optical products
- Satellite reaction wheels

INTEGRATED SOLUTIONS



- Simulation and training
- Test and training instrumentation
- Ejection seats and propulsion
- Strategic/nuclear command and control
- Unmanned aircraft systems
- Integrated targeting solutions
- Custom interconnect and mission components
- Electronic warfare
- Global service and support

GUIDANCE & NAVIGATION SOLUTIONS

LEADERSHIP TEAM



Mandy Kuker
HR Business Partner



Philippe Limondin
General Manager
Guidance & Navigation Solutions



Rachel Fisher
Administrative Assistant

PORTFOLIOS



Nathan Franzen
PNT Systems



Patrick Bory
International PNT
Systems



Stu Cooper
Inertial Systems



Rob Birmingham
Missile & Integrated
Weapons Systems

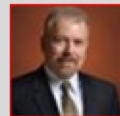
FUNCTIONS



Rodney Mickelson
PNT Engineering



Chris Wilson
Inertial / Missile &
Integrated Weapons
Engineering



Eric Schwaigert
Strategy



**Todd Conerly /
Bill Rublee**
Business Development



**Chas Hughes /
Kevin Pindard /
Brad Canterbury**
Operations



**Meredith Smith /
Sandra Fumei**
Finance



**Elizabeth Schaapveld /
Nikki Beatty**
IPP&C / Pricing



Andrew Wallace
Contracts



**Randy Bunge /
Eli Willey**
Subcontracts /
Supply Chain

Dotted Line Support

COMMUNICATION, NAVIGATION & GUIDANCE SOLUTIONS

TACTICAL COMMUNICATIONS



- Airborne and ground H/U/VHF communications
- Tactical data links
- Software defined radios
- Waveforms and networking

GUIDANCE & NAVIGATION SOLUTIONS



- Assured PNT Solutions
- Airborne radio navigation receivers
- Shipboard and tactical precision landing systems



- Inertial sensors
- Measurement units
- Micro-electro-mechanical systems (MEMS)
- Control actuation systems
- Advanced digital terrain-referenced navigation
- Predictive ground proximity warning

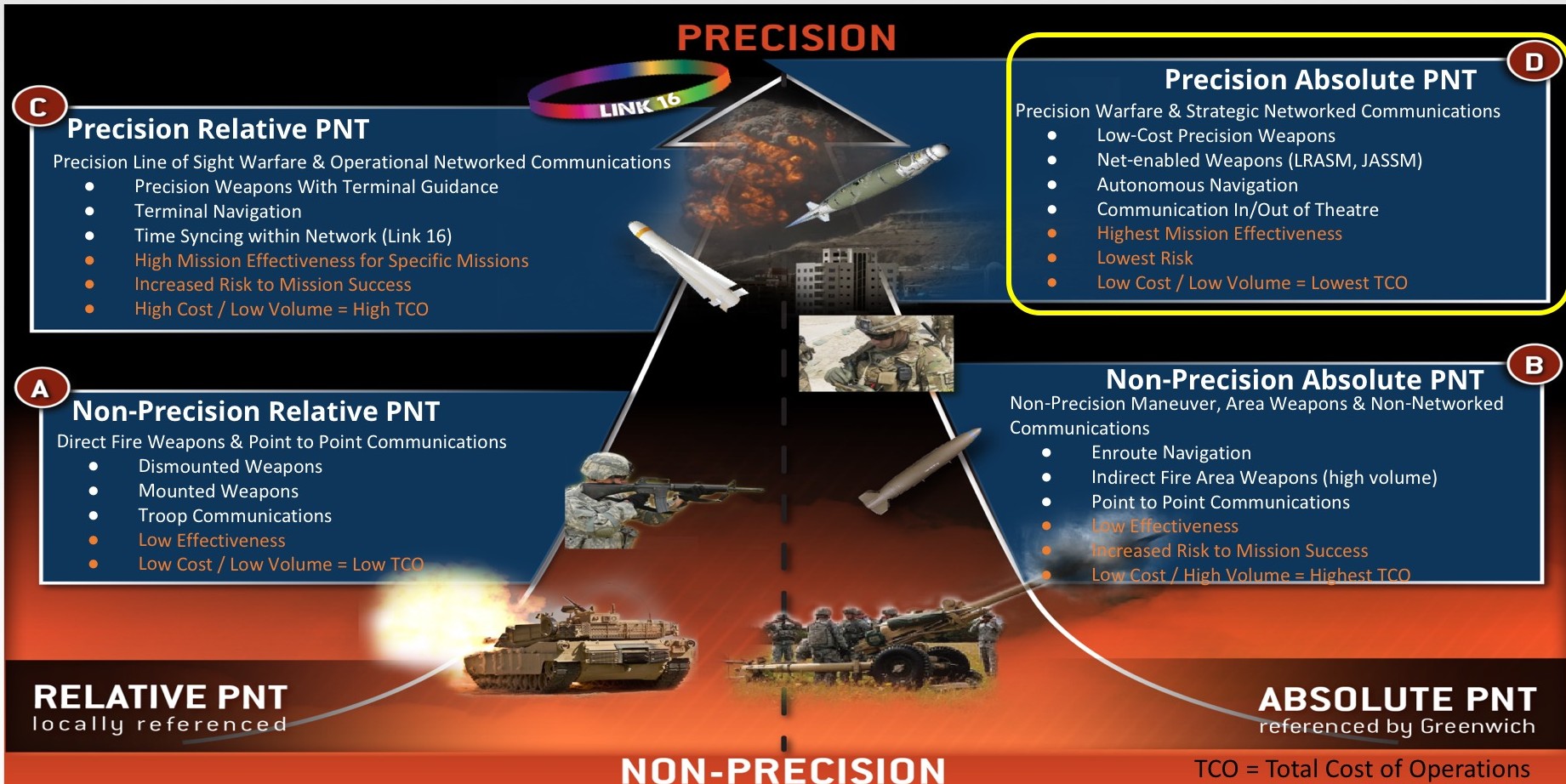
MONITORING & SENSING



- Fuel level and management systems
- E-brakes
- Proximity sensors
- Health and usage monitoring systems (HUMS)

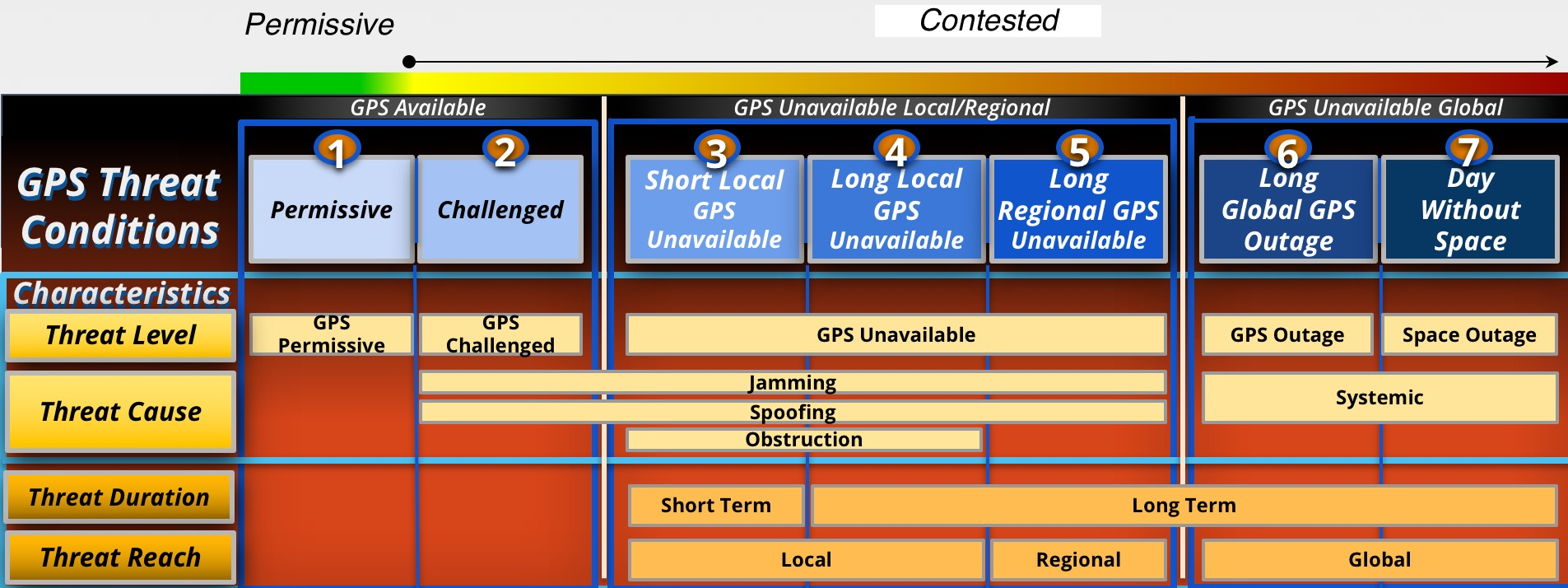
Enhancing situational awareness, networking forces and assuring precision navigation.

WHAT IS THE APNT PROBLEM TO BE SOLVED?



Maintaining Assured Precision Absolute PNT

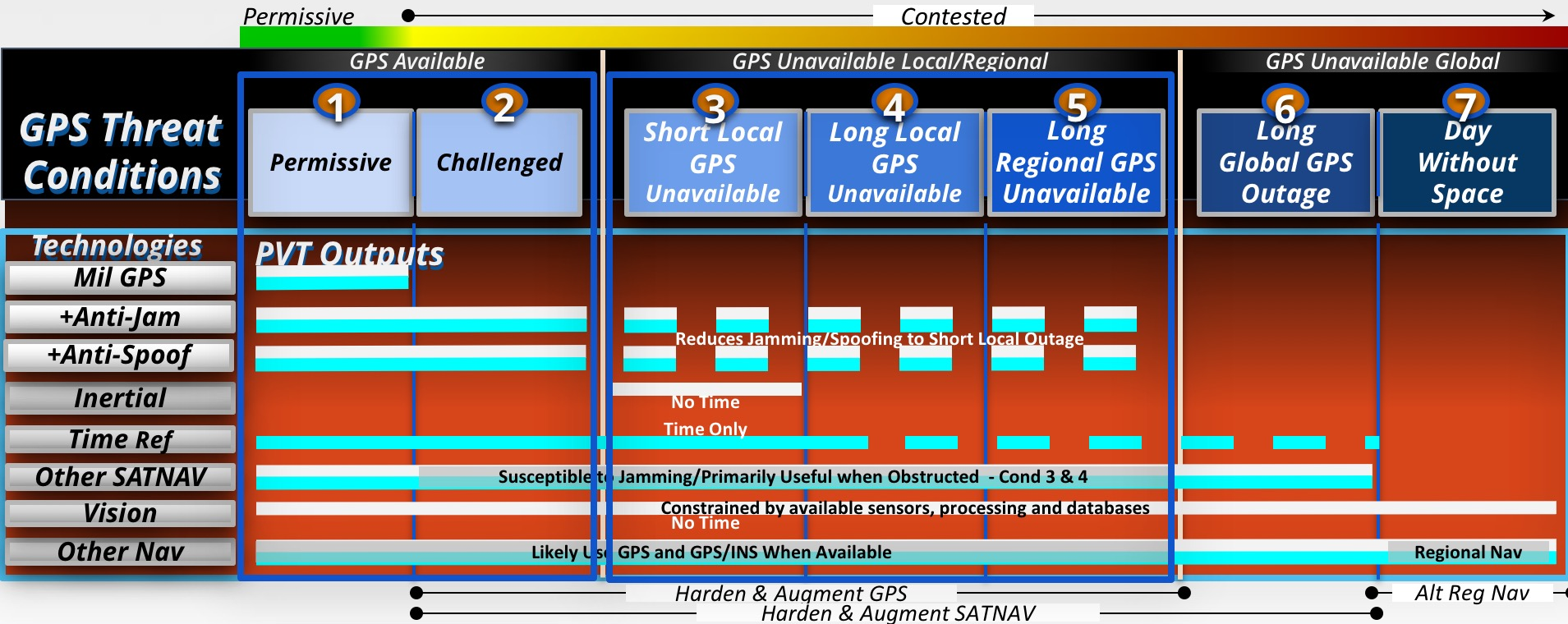
PNT THREAT ENVIRONMENT - COMMON MODEL FOR ANALYSIS



7 threat conditions emerge as our adversaries become sophisticated
Analysis of Missions & Platforms in This Model Will Reveal Requirements

ASSURED PNT - APPLICABLE TECHNOLOGIES

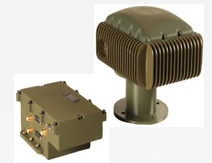
Position/Velocity 
Time 



APNT is a System Problem - Complementary Technologies Are Necessary To Solve The Total APNT Problem

COLLINS PNT SOLUTIONS RETAINED BUSINESS

- Radio Navigation Product Lines
 - TACAN
 - ADF
 - VOR/ILS
- Systems Programs & Assured PNT Programs
 - Joint Precision Approach and Landing System (JPALS)
 - NavHub/NavHub+ Products
 - Army Mounted Assured PNT Solutions (MAPS)*
 - Army Dismounted Assured PNT Solutions (DAPS)*
 - Tactical Intelligence Targeting Access Node (TITAN)*
 - Military Underwater Navigation System (MUNS)
 - Resilient Open PNT Solutions (ROPS)
 - Range and Training PNT (TCTS II)



**Assured PNT remains a System Problem
Complementary Technologies Are Necessary To Solve The Total A-PNT Problem**



SHAWN RYAN

**BAE SYSTEMS NAVIGATION & SENSOR SYSTEMS
DIRECTOR OF BUSINESS DEVELOPMENT
SPACE AND MISSILE SYSTEMS CENTER**



NAVIGATION & SENSOR SYSTEMS (NSS) UPDATE

SHAWN RYAN
NSS BUSINESS DEVELOPMENT DIRECTOR
FOR SPACE & MISSILE SYSTEMS CENTER

NAVIGATION & SENSOR SYSTEMS (NSS)



Military GPS at BAE Systems

NAVIGATION & SENSOR SYSTEMS

Military GPS is now part of BAE Systems Precision Strike & Sensing Solutions (PS)

- Scope - Military GPS and Anti-Jam Antenna Electronics providing our warfighters with trusted, assured PNT in a contested environment

Team is 700 strong with 400+ Engineering

- All functions are with business – Programs, Engineering, Operations, Contracts, Finance, Business Development, Procurement, Quality, Human Resources, etc.

1.5M PPS GPS delivered

- Weapons – Patriot, JDAM, MOPs, more
- Ground – Class 1-3 UAVs, Handheld radios, PLGR/DAGR, more
- Airborne/Maritime - EGIs (F-16, C-130, Global Hawk, UAV, more), US Navy Mk 41 VLS
- Five M-Code receivers in development leveraging MGUE Inc 1 with three more prototyped and ready for launch programs

**Military GPS Team Intact and is now Navigation
& Sensor Systems**

NAVIGATION & SENSOR SYSTEMS

Design and manufacture the most advanced GPS receiver technology for commercial and military devices. Used on many types of weapons systems, ground and airborne platforms, and are compliant with military M-Code, anti-jamming and anti-spoofing requirements.

Discriminators:

- High-immunity to jamming and spoofing
- Lowest power SAASM and M-Code
- High reliability
- Built-in functionality to support wide variety of platforms

Key Products:

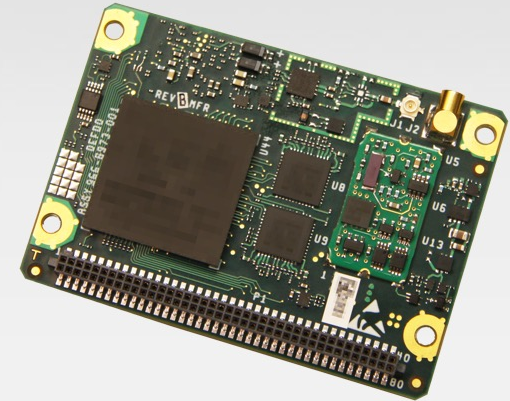
- MPE™
- MicroGram
- DIGAR™ GPS anti-Jam receiver
- NavStrike™ GPS receiver
- NavFire™ GPS anti-jam receiver
- NavStorm+™ GPS anti-jam receiver



Specifically designed for reliable, high-performance operation in the most extreme physical and EMI environments

NAVIGATION & SENSOR SYSTEMS

- MPE-M our first M-Code card to market
- LRIP Part Number 987-2618-011
 - Making deliveries today
- Full Rate Production Part Number 987-2618-021
 - Now accepting orders for CY2021 delivery
- MPE-M delivers geolocation and precise positioning capabilities for space-constrained applications while providing increased security and anti-jam capabilities
- Leveraged from GB GRAM-M and common small Type-II form factor with MPE-S receiver
- Utilizes the security-approved MGUE Inc 1 Common GPS Module (CGM)



PHYSICAL CHARACTERISTICS

Power	Operating: +3.3 VDC, <1.0 W typical Keep alive: +3.0 VDC to +6.0 VDC, 4 mW typical
Weight	1.4 oz (40 gm) nominal
Size/volume	2.45" x 1.76" x 0.285" maximum (6.2 cm x 4.5 cm x 0.724 cm)
Temperature range	-40° C to 85° C operating -55° C to 85° C storage

<https://www.baesystems.com/en-us/product/miniature-plgr-engine---m-code--mpe-m--receiver#>

<https://www.baesystems.com/en-us/download-en-us/20200728205450/1434654955143.pdf>

M-Code is Here

NAVIGATION & SENSOR SYSTEMS

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BAE Systems Inc. – We Protect Those Who Protect Us



CHRISTOPHER HOGSTROM
ENGINEER
SPIRENT FEDERAL SYSTEMS



- SimMNSA 2018
- SimMNSA update
- Standardized Ethernet Protocol
- Alternate RF Simulator

QUESTIONS?

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