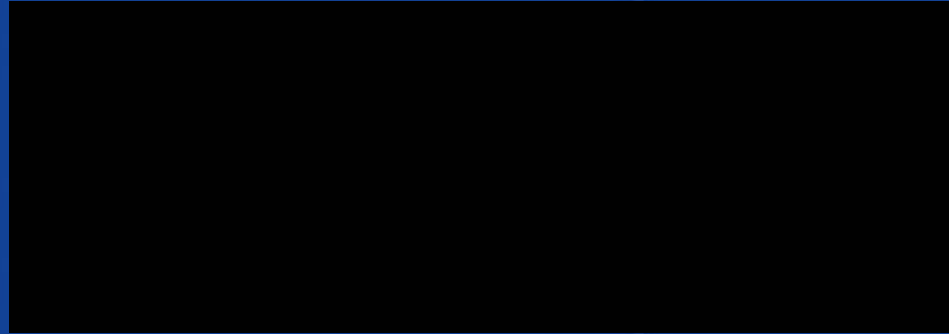




ALCOA
—***—
DEFENSE



Maritime Innovations Introduction

David R. Williams, Program Director – Sea Systems

LIGHTER, FASTER, STRONGER





Alcoa's Approach to Defense



- **Alcoa has identified the defense sector as a key target market and delivers a multi-industry approach based on commercial off the shelf technology (COTS) insertion**
- **The unique market dynamics and requirements of the defense industry demand high-value, low-risk, affordable solutions that are the hallmark of Alcoa capabilities**
- **Alcoa's growth strategy in the defense sector is predicated on a collaborative development approach with both military buyers, manufactures, and researchers throughout the community**



Competitive Discriminators

Unparalleled Lightweight Metallics Technology



Metallics database unrivaled by any firm anywhere in the world, the product of more than 100 years of research and engineering expertise

- More than 60 years of experience in developing alloys and products for defense applications
-

Structural Design Competencies



Critical design tools and competencies recognized in multiple industries, including automotive, aerospace and defense

- Design capabilities not limited to a single material or product, but covering a range of solutions, including those that call for integration of aluminum with other materials
-

Fabrication and Assembly Capabilities



Strong manufacturing pedigree, chiefly born of its work manufacturing integrated structures for the automotive industry

- Extensive experience in producing prototypes ranging from full assemblies to individuals parts
- Manufacturing and assembly issues viewed as critical elements in the design process



Innovation Leadership

Maritime Objectives

Technology Innovation

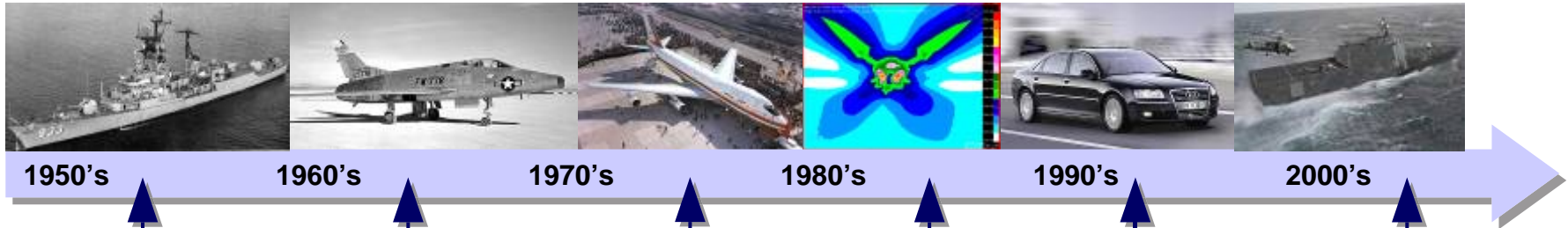
Alloy Development

Joining Technologies

Structural Design

Coating Systems

Opportunities for Collaboration



1950's

- The Navy builds ships with five 5000 series alloys basically developed in the 1950's
- By contrast the F-35 employs more than 12 alloys and the A380 more than 20 – almost all of which were developed in the last 20 years

1960's

- Beginning in the mid-60's Alcoa began an ambitious program to understand aluminum materials and the continuum from composition through processing to microstructure and the resultant properties.
- To date over 10,000 alloys have been designed, developed, tested and characterized

1970's

- In the mid-70's Alcoa had developed enough data to construct simple tools that enabled the aerospace companies to make informed trade-offs and select among various alloys and product forms
- Working with these early tools and aerospace firms, Alcoa continued its research and its design tools grew dramatically – attracting the attention of the automotive industry

1980's

- These tools now have predictive aspects – product developers can now know how a semi-fabricated material will perform in a component, how the component will perform in an assembly and how the assembly will perform in a structure

1990's

- By the early 90's Alcoa's proprietary design tools and lightweight structural competency was actively sought and engaged through industry product development teams including:
 - Automotive
 - Aerospace
 - Trucking
 - Railcar
- Alcoa supporting them with several design tools and models that grew from this cross industry interaction

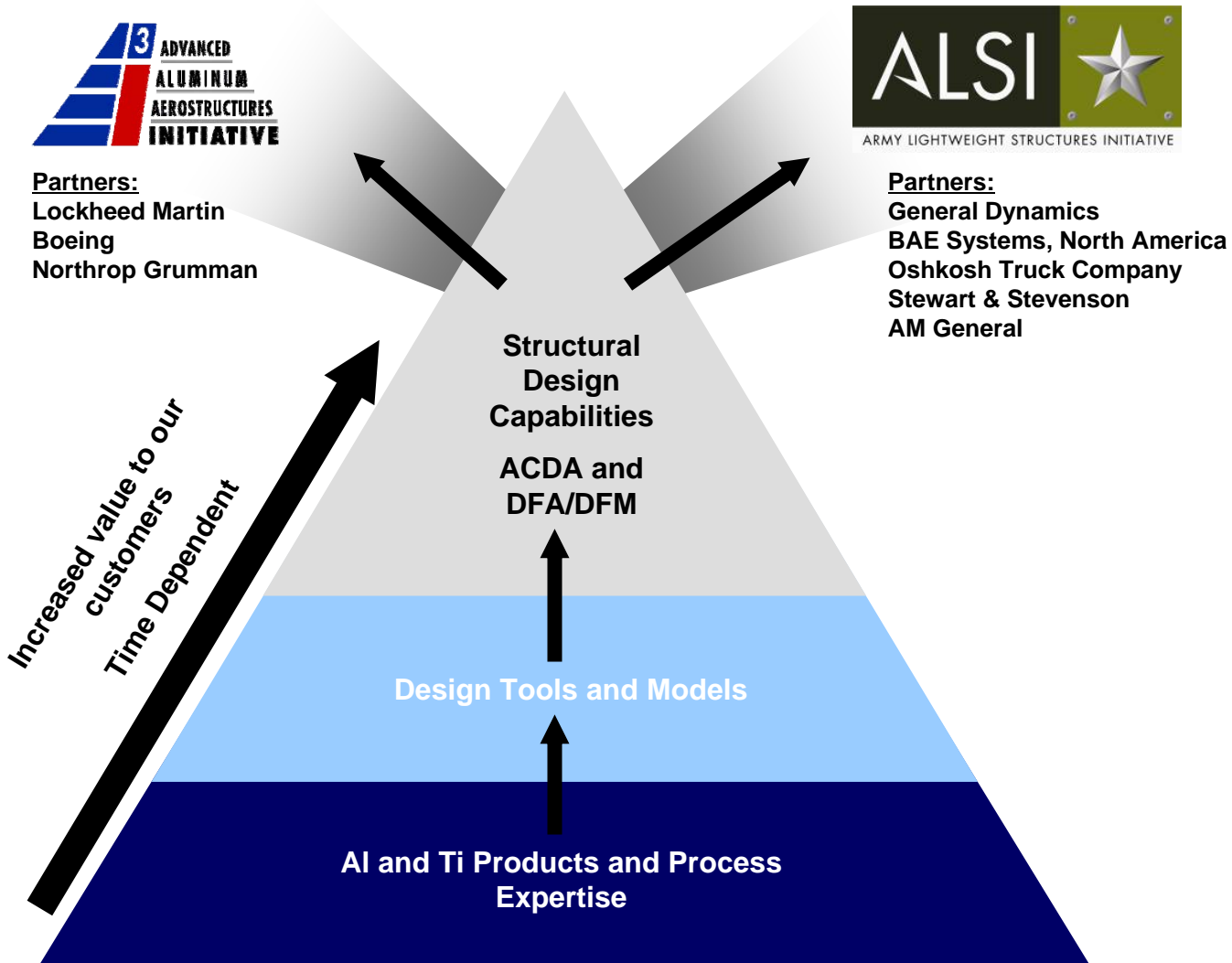
2000's

- Using the tools and the lightweight structural design competency that it had grown, Alcoa began working with the Air Force and its airframers to design, develop and prototype complex aluminum structures for cost reduction and performance enhancements
- Army came to Alcoa seeking to engage us in work with their ground vehicle primes
- Alcoa is finalizing negotiations with the Navy for a program to assist naval primes in design of effective and efficient structural solutions



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 ★★★★★
DEFENSE

Alcoa is unique: Aluminum competency bred design tools that bred design capability that bred ACDA (DFM/DFA)



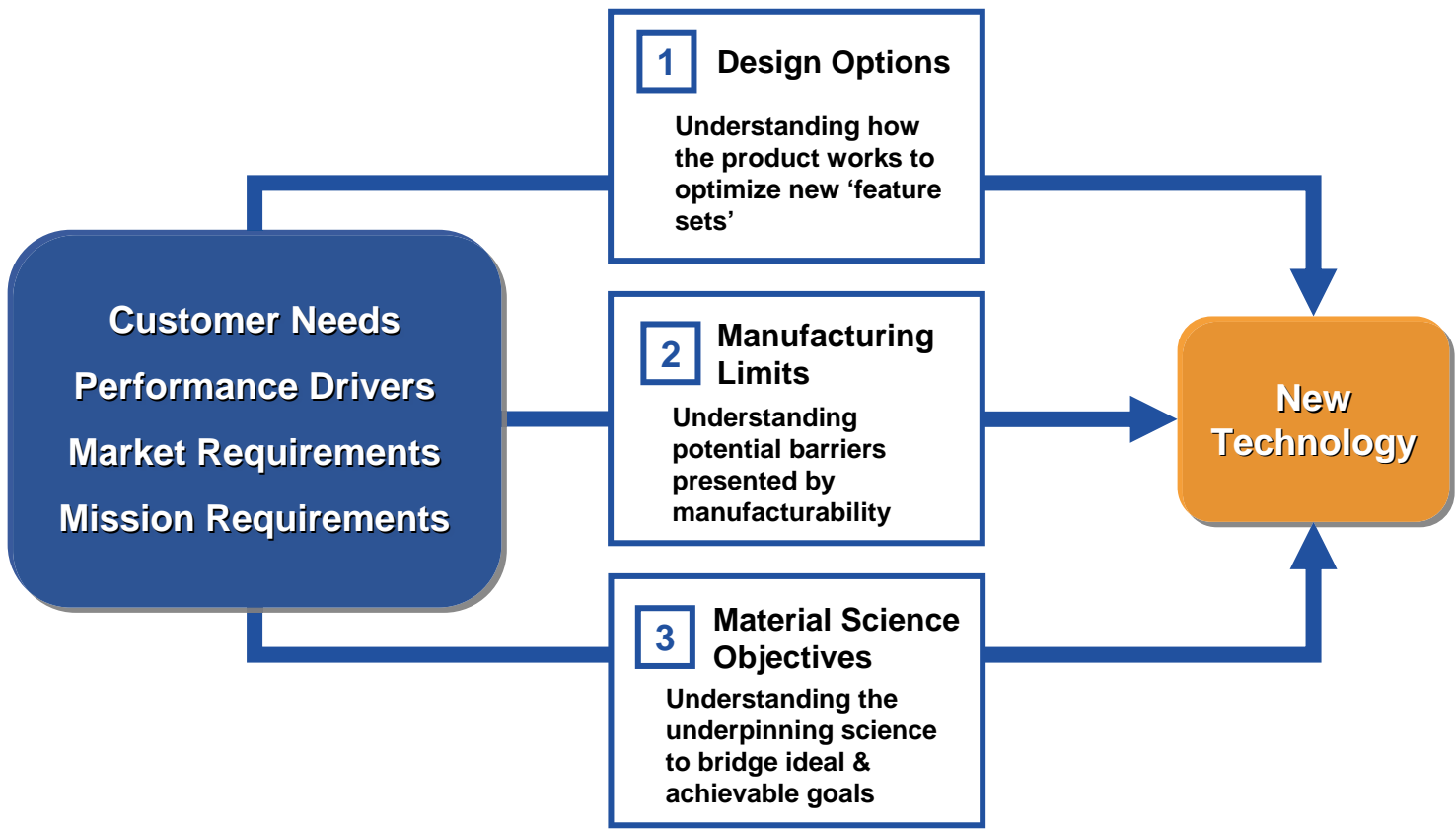


Alcoa Technical Center (ATC), Alcoa Center, PA

- **Alcoa operates the nation's largest non-ferrous research center in suburban Pittsburgh, PA**
- **Over 575 materials researchers work at the ATC on a wide range of commercial and defense applications**
- **Today, the vast majority of commercially successful aluminum alloys can trace their origin to work done by Alcoa at the ATC**



Technology development is driven by customer and market requirement and is filtered through three critical concept areas to ensure that Alcoa leverages the right tools and expertise

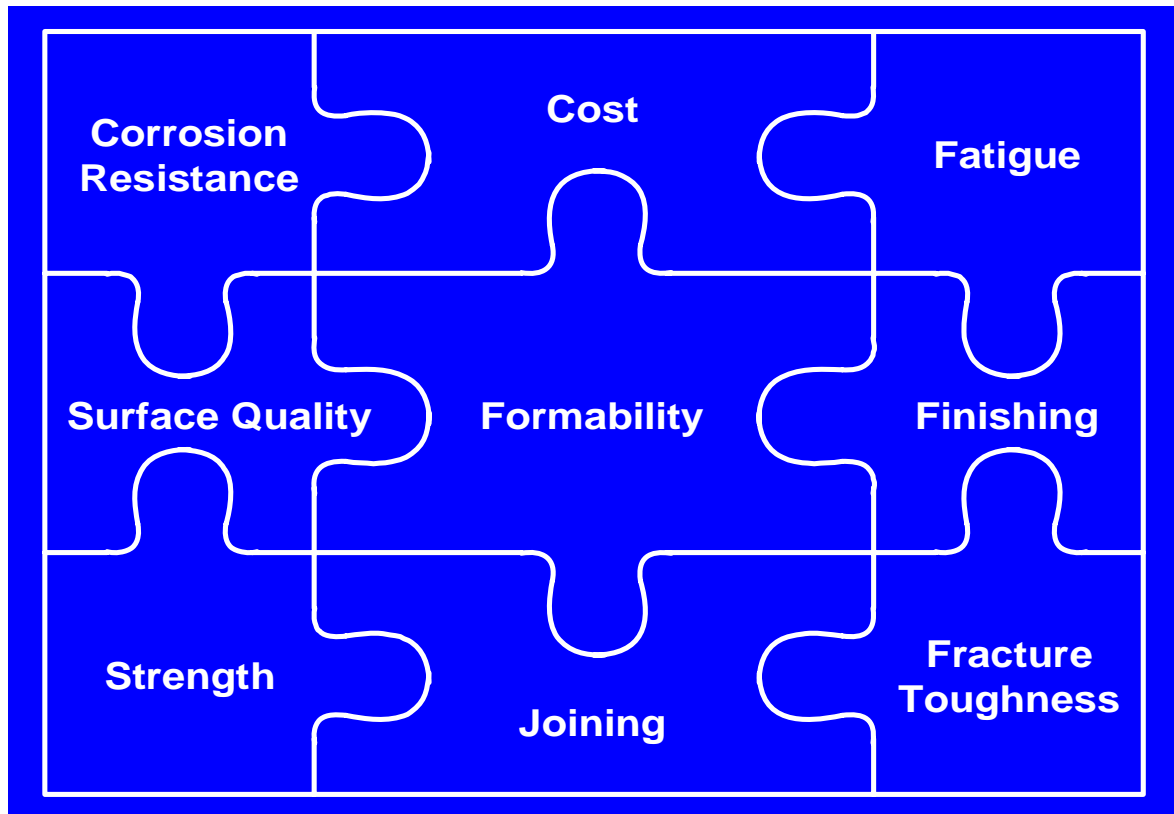


The Complexity of Aluminum System Design



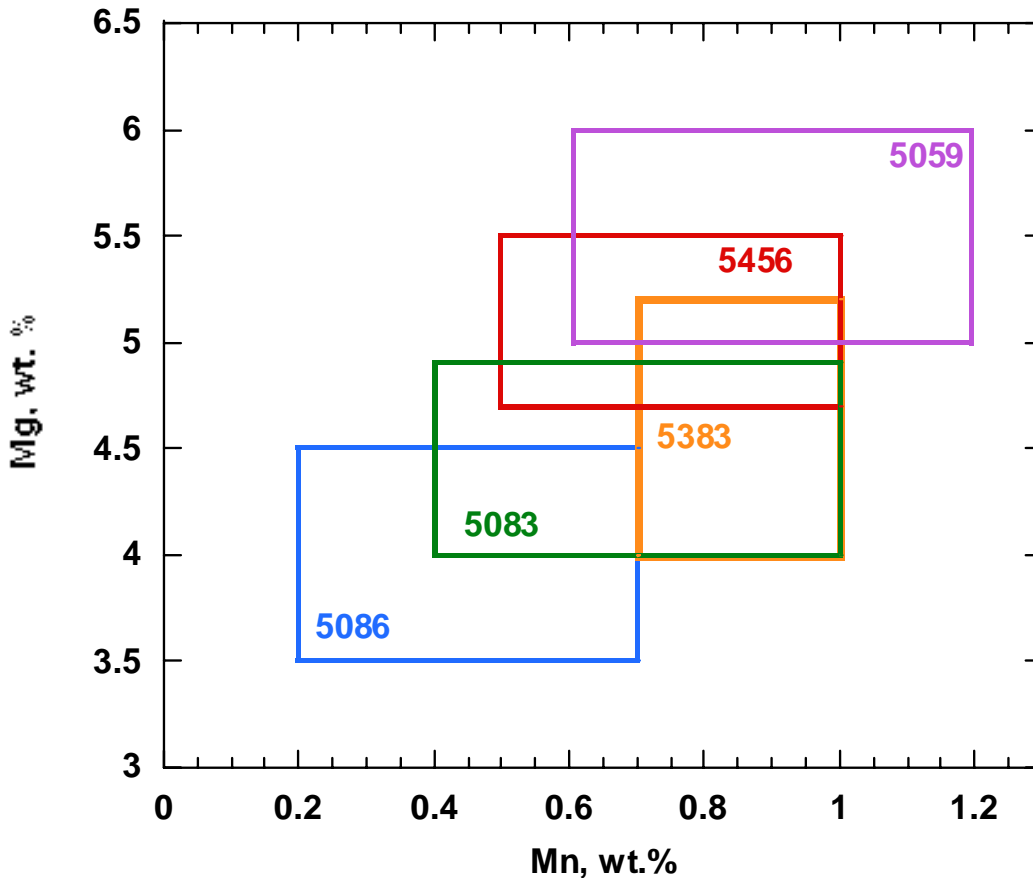
All aluminum products must function in a variety of ways to meet the customer's needs

Some attributes may trade off against each other in marine applications we focus on joining (welding), corrosion resistance, and strength.

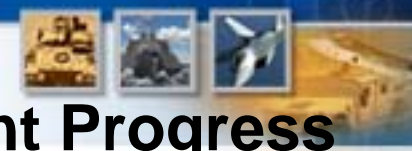




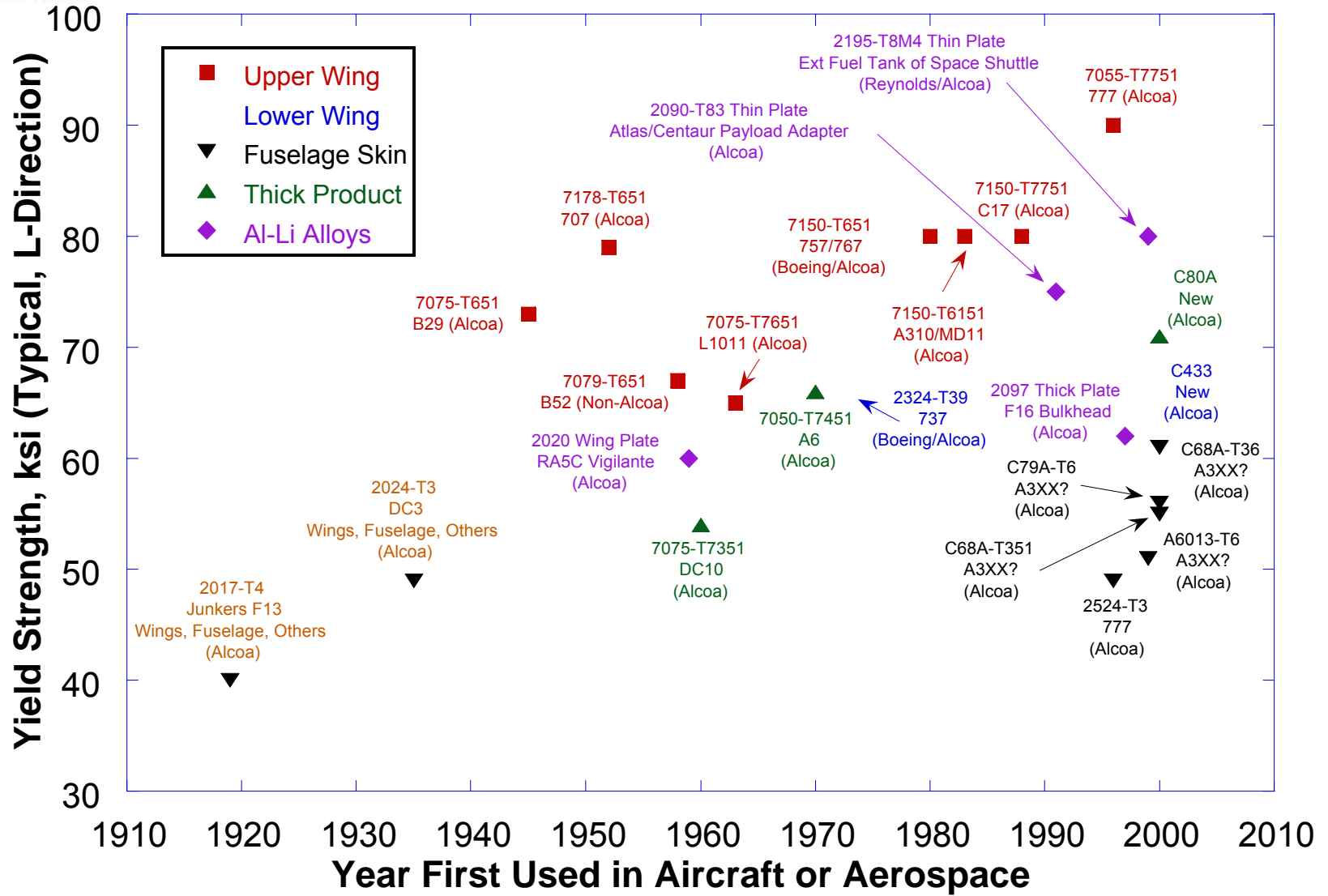
High Strength 5XXX Alloys



1. The 5000 series aluminum alloys used in marine applications trace their lineage to the 1950(s).
2. Automotive, aerospace, trucking, and army ground vehicle platforms design with newer materials and favor the use of multiple aluminum alloys in their systems.
3. Aerospace alloy development was largely driven by the needs of the product designers working in close collaboration with Alcoa.



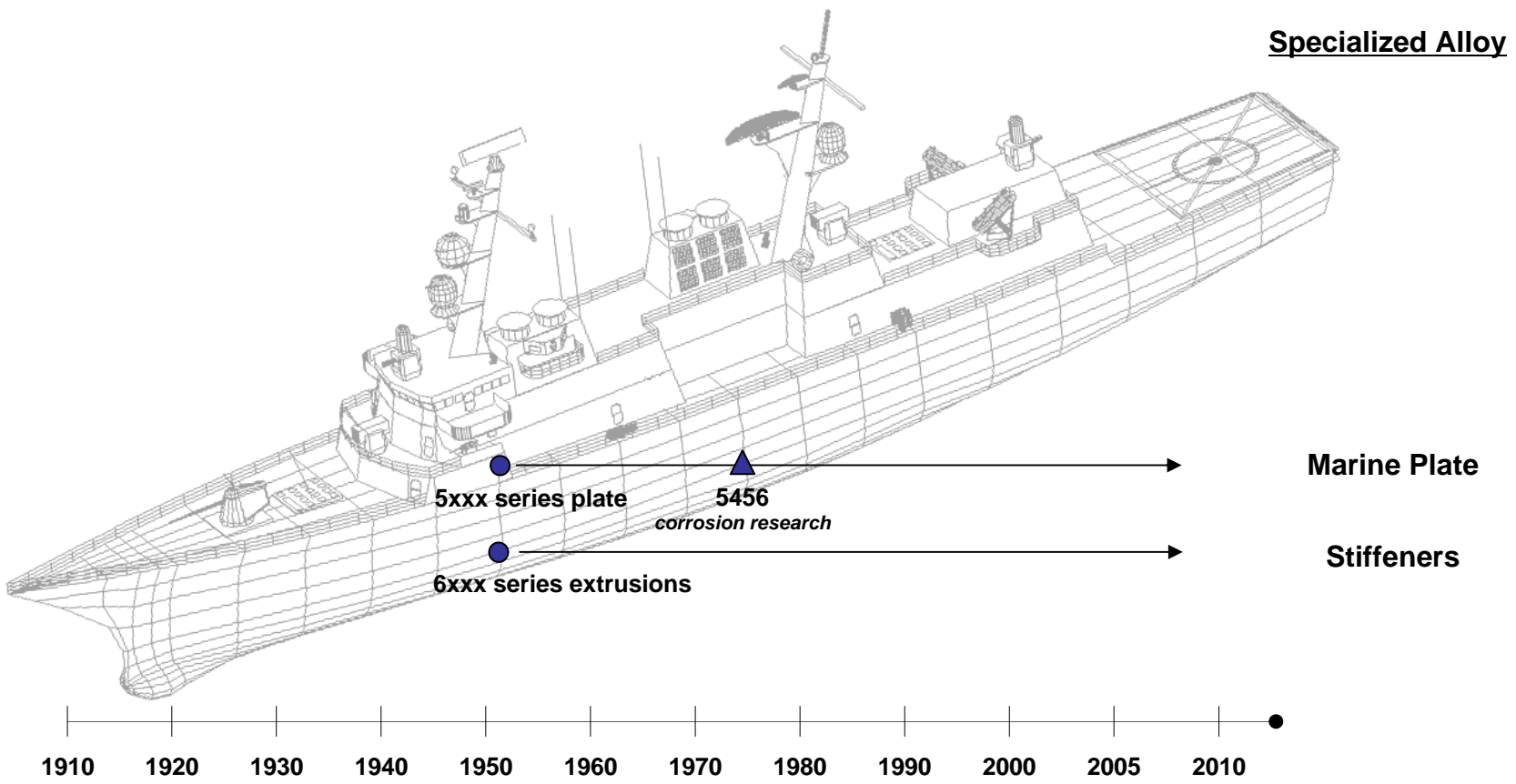
Aerospace Alloys Have Made Significant Progress





Alloy Development for the Navy

Since the 1950s, there has been nearly no innovation in aluminum alloy development for maritime systems and limited interaction with Navy leadership



With Navy inputs, Alcoa believes it can achieve the same level of alloy customization that it has for the aerospace industry



Innovation Leadership

Maritime Objectives

Technology Innovation

Alloy Development

Joining Technologies

Structural Design

Coating Systems

Opportunities for Collaboration



Alcoa Competencies

- Unmatched materials expertise
- Unparalleled data base led to the development of design tools
- The design tools are predictive
- Alcoa embedded on multiple design teams in multiple industries
- Using these design tools in multiple industries led to a lightweight structural design competency
- Alcoa's competency demonstrated in aerospace, automotive, trucking , rail cars, tactical wheeled vehicles, ground combat vehicles, ground combat systems (M777), and numerous other industries

Maritime Situation

Maritime Situation:

- Use limited set of alloys
- Does not avail themselves of material data base
- Does not use design tools
- Alcoa funded to change that
- Alcoa will work with multiple Navy primes

Maritime Program Objectives:

- Develop marine technologies
- Structural design using technologies (product and manufacturing) commercialized in other market



1

Achieve a Leadership Role

Maximize the potential of Alcoa's role as a national center of excellence for future Maritime-specific aluminum applications

2

Innovate to Face Challenges

Address legacy challenges of aluminum alloys through breakthroughs that address fire protection, corrosion, and fatigue requirements for the maritime segment

3

Build Partnerships with the Navy

Establish new partnerships with Navy, their shipyards, and defense primes and their technical experts to ensure that next-generation Navy requirements fundamentally shape Alcoa's research objectives



- **Support the development of lightweight and cost-efficient structural designs**
- **Develop specific and identified material and product solutions in defined thrust areas where validation is necessary for the use of aluminum and titanium, including:**
 - Aluminum Alloy Data and Design Base
 - Optimization of Existing Aluminum Alloys
 - Advanced Welding and Inspection Processes
 - Surface Modification Techniques
 - Aluminum Corrosion Properties, Detection and Prevention
 - New Weldable Aluminum Alloys
 - Manufacturing Technologies for Titanium



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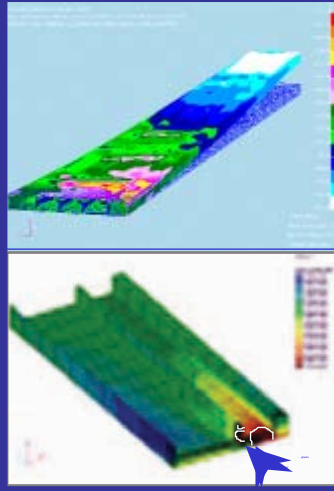
Coating Systems

Opportunities for Collaboration



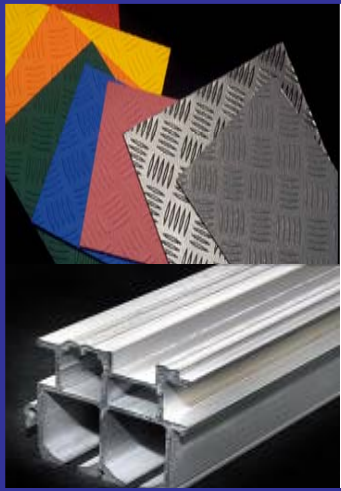
1 Alloy Development

Alcoa is a leader in aluminum alloy research and development and has led in custom breakthroughs in close cooperation with industry partners



2 Design Capabilities

Alcoa is a proven industry partner in providing design solutions for aluminum structures and draws on a wealth of propriety tools and models



3 Marine Coatings

Alcoa's coatings expertise promises to address critical fire resistance, friction and non-skid issues and can be delivered as a systems solution to the Navy



4 Joining Technology

Alcoa's advances in next-generation joining technology has made it an industry leader in Friction Stir Welding and related process tool development



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Alcoa is a national leader in Alloy Development focusing on three core areas



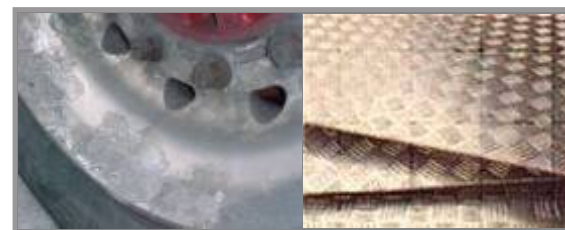
Alloy Development

- Physical Metallurgy
- Mechanical Metallurgy
- Product Manufacturing



Material Characterization

- Optical Metallurgy
- Scanning & Transmission Electron Microscopy
- Microprobe
- Guinier
- Orientation Imaging Microscopy
- Auger



Corrosion

- Electrochemistry
- Immersion Testing
- Cabinet Testing
- Product Specific Testing
- Atmospheric Testing



Alcoa Collaborative Opportunities

- **Next generation naval alloys are a significant enabler of aluminum for lightweight ship designs such as LCS and J-HSV as well as other ship applications where weight reduction is important**
- **Alloy Technology and Materials Research Division has significant resources and expertise for alloy product development**
- **Conventional 5xxx marine sheet and plate alloys have good as-welded strength and corrosion resistance but improved properties desired:**
 - Parent and as-welded strength
 - Thermal stability
 - Fatigue and corrosion fatigue
- **Achieving next-generation breakthroughs in alloy development for maritime applications will require customer pull.**



Innovation Leadership

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Alcoa is a leader in cutting-edge joining research, cover a broad gamut of technologies and applications

Alcoa Joining Process Research Areas



Friction Stir Welding (FSW)



Gas Metal Arc Welding (GMAW)

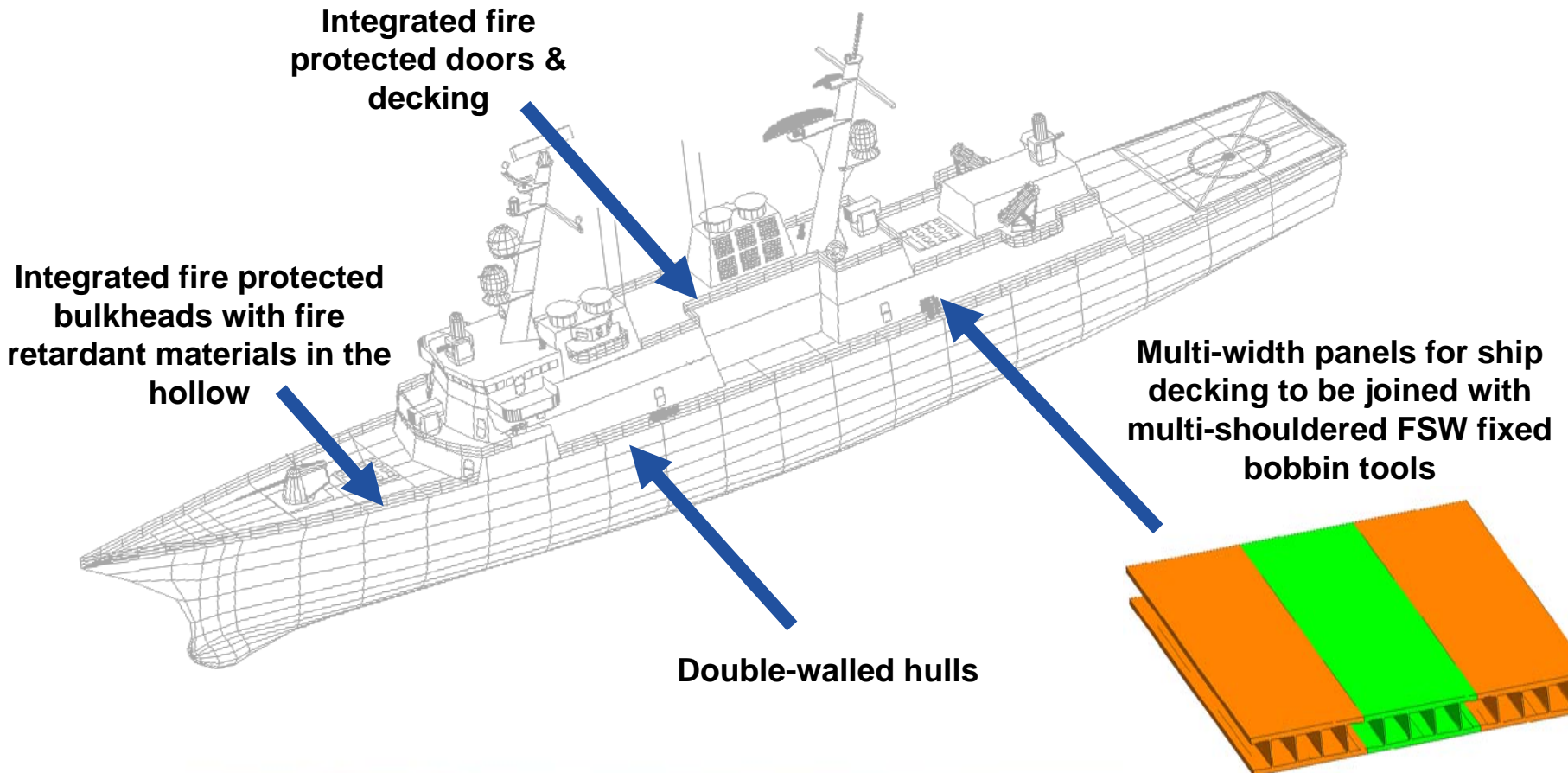


Magnetically Impelled Arc Butt Welding (MIAB)

- High frequency induction resistance welding
- Low and high temperature brazing
- High temperature soldering
- Magnetically impelled arc butt welding (MIAB)
- Gas metal arc welding (GMAW)
- Flash welding
- Resistance Spot welding with and without adhesives
- Riveting (eg., Riv-bonding, blind rivets, self-piercing rivets, etc.)
- Friction stir welding
 - Conventional
 - Fixed Bobbin tools
- Friction welding
- Laser beam welding with and without wire
- Laser-Stir welding
- Hybrid GMA/Laser welding
- Hybrid Plasma/Laser welding
- Cast joining
- Double-wire gas metal arc welding
- Cold wire assisted plasma welding
- High frequency resistance welding



Alcoa envisions a number of ready joining and FSW applications for next-generation ship building





Alcoa Collaborative Opportunities

- **Alcoa is at the cutting-edge of next-generation joining technology innovation and is a leader in Friction Stir Welding development which promises high joint strength over traditional aluminum welding methods**
- **Alcoa's FSW innovations, such as the multi-shoulder fixed bobbin tool, can provide the Navy and its industry partners with proven joining technologies that offer relative simplicity, constant quality, ease of operations, and repeatability**
- **FSW is an enabler for the introduction alloys that are non-weldable by current means**
- **Moreover, Alcoa's innovations represent a collection of new processes and fabrication tools that can not be easily replicated by the Navy's existing supplier base**



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- **Alcoa's design technologies have been successfully leveraged across multiple commercial and defense market segments**
 - Rail cars
 - Transportation systems such as bulk trailers and intermodal containers
 - Cars and trucks
 - Commercial aerospace
 - Defense aerospace and land systems

- **Design is driven by customer performance requirements and standards**
 - Alcoa has found that its design competencies and toolkits are fully transferable to other market segments once we learn a customer's performance requirements and standards
 - Alcoa is not as deeply immersed in maritime design requirements and needs guidance on the community's performance standards

Ferrari 360 Modena Spaceframe

Designed And Assembled By Alcoa

Components of Spaceframe:

- 58 extruded components
- 18 castings
- 85 Stamped sheet components
- 42 meters of MIG welding
- 313 Self-piercing rivets
- 316 Riv-nuts
- 77 Inserts

153 kg frame weight

Vehicle Performance

- +44% in torsional stiffness vs. steel predecessor
- +42% in bending stiffness vs. steel predecessor



Advanced Aluminum Aerospace Initiative (A³I)

Objective: Cost reductions up to 50% over current aero-structure designs while maintaining all performance requirements.

Boeing C-17



Boeing F/A-18



Boeing UCAV



Lockheed Martin C-130

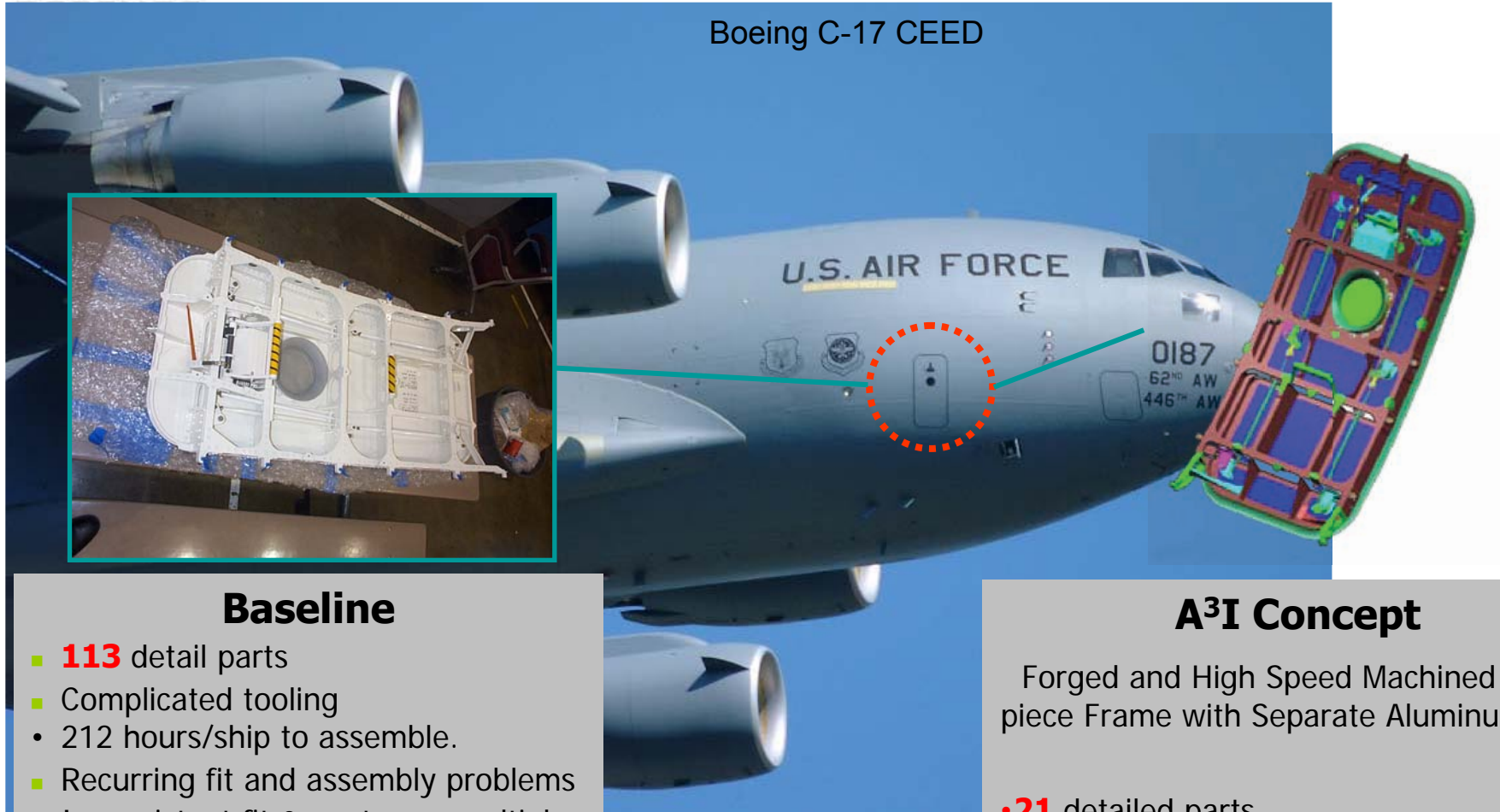


Lockheed F-22

Air Force estimates Cost Savings from A³I Program: 48% ROI, \$200M NPV



Boeing C-17 CEED



Baseline

- **113** detail parts
- Complicated tooling
- 212 hours/ship to assemble.
- Recurring fit and assembly problems
- Inconsistent fit & contour – multiple shims required
 - 15-20 shims required per door
- Each Door Custom Built

A³I Concept

Forged and High Speed Machined One-piece Frame with Separate Aluminum Skin

- **21** detailed parts
- Existing Assembly Jig Used
- Fit and Assembly problems eliminated
- Reproducible



Requirements

Lightweighting continues to be a critical driver as the primes and Army implement rigorous weight reduction initiatives to get closer to program weight targets

Changes to transportability requirement caused elimination of modularity requirements and structural configuration changes

Transportability requirements were also based on increased survivability enhancements which required weight allocation for additional armor

Alcoa's Role

Proven the ability to cost effectively reduce the weight gap between actual and required weight targets for vehicle concept demonstrators

Application of commercial technologies including mechanical fastening and bonding, Friction Stir Welding, and multi-material solutions

Developed successful prototypes the primes once considered "unbuildable"



"Bottom line is that we still have hundreds of kilograms to pull out of the vehicles – and [the Alcoa-led] ALSI has been, and should continue to be, a great tool for achieving cost effective weight reductions for our structures"

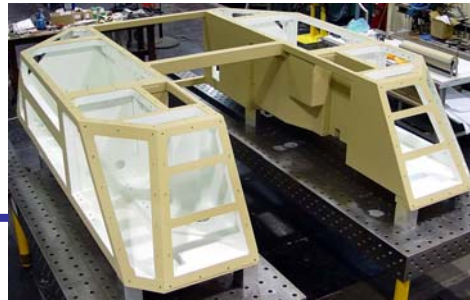
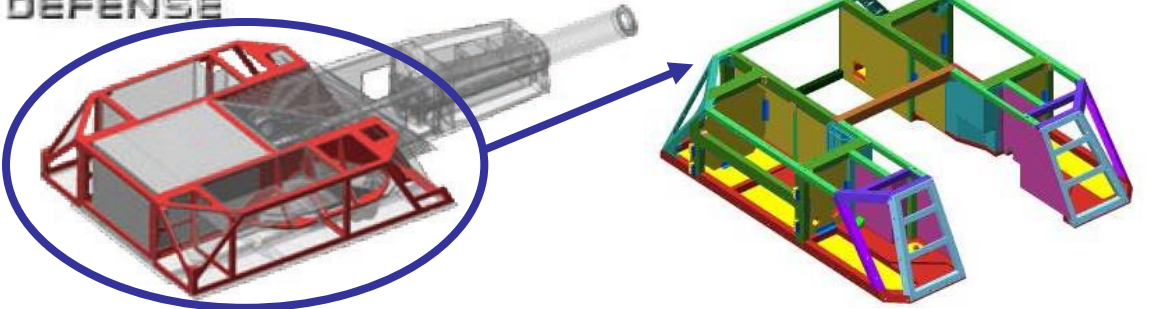
– BAE Systems Structures Manager



ALCOA

 DEFENSE

ALSI - Platform Life-Cycle Cost Savings and Field Repairability



NLOS-C B-Module

118"L x 100"W x 30"H (1276 lbs-current)

Major Milestones

- **September 19th:**
Delivered prototype with surrogate armor panels and ballast and brackets
- **Jan to June 2007:**
Prototype testing on-going
- **3rd Quarter 2007:** Firing Platform testing in Yuma, Arizona

- Alcoa's breakthrough design is **51% (649 lbs)** lighter than the baseline OEM aluminum design
- Design portends **significant life cycle cost improvements** through enhanced readiness and **field repairability**



Marine Design Applications

- **Optimize performance of lightweight aluminum maritime structures for high speed vessels through its deep expertise in aluminum structural design and internally developed design tools**
- **Leverage its proven integrated design approach to optimize aluminum designs from the material microstructure through fabrication and assembly to lifecycle management**
- **Address aluminum maritime design challenges such as stiffness and buckling, fatigue crack initiation and propagation, structural health monitoring, fire protection, corrosion, and fabrication while maintaining performance benefits**
- **Design optimized aluminum structures enabled by new technologies such as FSW, coatings, and alloys**



Alcoa Collaborative Opportunities

- **Aluminum structural design competencies and design tools are a significant enabler of aluminum for lightweight ship designs such as LCS and J-HSV as well as other ship applications where weight reduction is important**
- **Alcoa has significant resources and expertise for developing optimized aluminum structures**
- **Achieving next-generation breakthroughs in aluminum structural design with potential maritime applications will require pull from the Navy**
- **Alcoa stands ready to be a full partner in bringing its cutting-edge research capabilities to bear on current and future Navy structural design requirements**



Innovation Leadership

Maritime Objectives

Technology Innovation

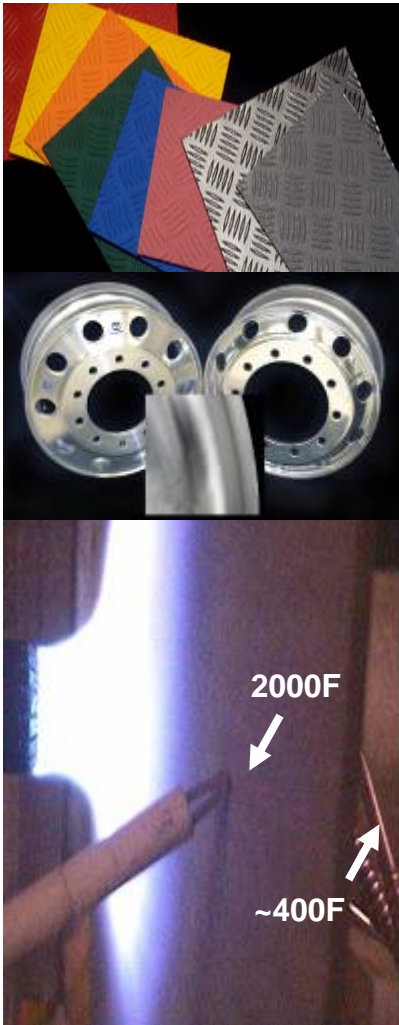
Alloy Development

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Opportunities for Collaboration



1 Coated Tread Plate

- Low cost improvement to tread plate that is customizable and has reduced maintenance as well as corrosion prevention

2 Wear Resistant Coatings

- Low cost wear resistant coatings for aluminum (AlcoSlide and Dura-Flange) which reduces fretting wear conditions from friction, vibration, and environmental conditions
- Corrosion resistant and has demonstrated service life improvements of greater than 3X

3 Fire Barrier Hard Coatings

- Composite coating comprised of a refractory ceramic and a high melting point alloy applied by Thermal Spray
- Coating possesses fire barrier resistance as well as good thermal shock properties, adhesion, corrosion resistance, and wear resistance

4 Intumescent Coatings

- Provides protection from fire and heat at temperatures in excess of 2000 F (1093 C) whether used as a primer coat or finish coat



Marine Coating Applications

- **Address non-slip decking requirements with proven COTS aluminum coating systems that offer improved durability and performance**
- **Design coating systems that reduce aluminum structural fatigue problems for high wear structures such as hangar doors, mission bay side and rear doors, other doors and hatches**
- **Address fire and burn concerns via innovative coatings which will allow the Navy to obtain the lightweight properties of aluminum without sub-optimizing design**



Alcoa Collaborative Opportunities

- **Coating Systems are a significant enabler of aluminum for lightweight ship designs**
- **Alcoa has significant resources and expertise for developing aluminum coating systems for non-skid, wear resistance, and fire protection**
- **Some coating applications are readily available off-the-shelf for immediate development of maritime-specific aluminum systems**
- **Achieving next-generation breakthroughs in aluminum coating systems with potential maritime applications will require pull from the Navy**



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Opportunities for Collaboration

- Aluminum is a significant enabler of lightweight ship designs such as LCS, JMAC, and J-HSV, as well as other ship applications where weight reduction is important
- Alcoa has significant resources and expertise for developing optimized aluminum structures
- Achieving next-generation breakthroughs in aluminum structural design with potential maritime applications will require pull from the Navy and prime contractors
- Alcoa is funded by the Navy to change the current maritime aluminum situation and will work with multiple Navy prime contractors
- Alcoa stands ready to be a full partner in bringing its cutting-edge research capabilities to bear on current and future Navy requirements



Ready to Come Aboard.

Alcoa Defense optimizes cost, weight and performance to meet mission requirements.

Proven Design Capabilities Advanced Materials Product and Process Know-How

ALCOA

DEFENSE

LIGHTER, FASTER, STRONGER