21st Century Societal Megatrends – 
Al centric perspective

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Entered the 20th Century with 1.6 billion
Exited the 20th Century with 6.1 billion
In a nutshell… as we look back

- Since 1700’s the volume of goods traded
  
  *Increased 800 fold*

- 1910-2010: the World’s industrial production
  
  *Increased 100+ fold*

- 1900-2000: global consumption of fossil fuel
  
  *Increased by 50 fold*

Source: T.E. Graedel
### Megatrends in the Aluminum Industry

<table>
<thead>
<tr>
<th>Category</th>
<th>Trends</th>
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40% REAR UNDERBODY COST SAVINGS

MODEL Y GIGA CASTING

Model 3 rear underbody: 70 pieces of metal.

Model Y rear underbody: 2 pieces of metal (eventually a 1x9)

-79 PARTS PER CAR

-
DIGITAL MANUFACTURING
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### Industry 4.2 – AI
- Machine Learning
- BlockChain/Quantum
- Process Cognition
- Supply Chain
- The need? Alleviate thermal processing
- Strengthening mechanisms
- New paradigm - HEA
Grand Challenge:
Develop foundational interfacial science for CCMs.
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CHALLENGING BUSINESS AS USUAL

High Value Cast & Wrought

Low Value Cast

DOWNCYCLING

• High value material is blended into low value bins when scrap is not sorted into alloy classes
• Increases need for consumption of primary aluminum
• Increases costs in the industry and reduces sustainability

EXPORT of MIXED COMMODITIES

• Increased restrictions limit scrap processors’ opportunities for export
• Limitations will increase as international consumers continue to raise standards
• Creates need to meet growing standards both for domestic and international consumers

U.S. Exports of All Scrap Commodities to China (incl. Hong Kong)
1994-2018 (metric tons)
Sources: Census Bureau/USITC

- 1994-1998: 7 million tons
- 1999-2003: 30 million tons
- 2004-2008: 71 million tons
- 2009-2013: 104 million tons
- 2014-2018: 76 million tons
NEEDS OF THE INDUSTRY

Scrap Processor
- Maximum Profitability
- Security During Market Fluctuations
- Access to Domestic Customers

Scrap Consumer
- Reduction in Melt Losses
- Guaranteed Known Scrap Composition
- Reduction in Primary Consumption
Types of Processing Approaches to Produce Upgraded Scrap

- Hand Sortation: Still Big in China and other nations
- Mass migration / Minerals Beneficiation Techniques
- Magnetic Separation
- Screening
- Air Classification
- Eddy Current Separation
- Froth Flotation
- Heavy Media Separation
- Automated Computer & Optics
- Color Sortation
- Visual Recognition
- Optoelectronic Sortation (LIBS/XRF)
CREATING OPPORTUNITY THROUGH AI

VALue Intelligent Sorting (VALIS) by:

Industry Data

Optimizing Metal Recycling
Extracting intelligence from industry data streams to maximize decision making power

Database and Optimization Models

Scrap Material Data

Operator & Sales User Interface

Optimal Sorting Criteria
Scrap Stream Monitoring
Contract Monitoring

The Customer
Decision Makers at Recycling Plant

PROFITABILITY • STABILITY • SUSTAINABILITY
SAUSAGE

Strategy: ZERO WASTE; CREATE VALUE FROM WASTE
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## Process Cognition
- Supply Chain
The Future of Work and the Worker
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<td>Advanced robots</td>
<td>Autonomous, cooperating industrial robots, with integrated sensors and</td>
</tr>
<tr>
<td></td>
<td>standardized interfaces</td>
</tr>
<tr>
<td>Additive manufacturing</td>
<td>3D printers, used predominantly to make spare parts and prototypes</td>
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<tr>
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<td>Decentralized 3D printing facilities, which reduce transport distances and</td>
</tr>
<tr>
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<td>inventory</td>
</tr>
<tr>
<td>Augmented reality</td>
<td>Digital enhancement, which facilitates maintenance, logistics, and SOPs</td>
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<tr>
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<td>Display devices, such as glasses</td>
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<tr>
<td>Simulation</td>
<td>Network simulation and optimization, which use real-time data from</td>
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<tr>
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<td>intelligent systems</td>
</tr>
<tr>
<td>Horizontal and vertical system</td>
<td>Data integration within and across companies using a standard data transfer</td>
</tr>
<tr>
<td>integration</td>
<td>protocol</td>
</tr>
<tr>
<td></td>
<td>A fully integrated value chain (from supplier to customer) and organization</td>
</tr>
<tr>
<td></td>
<td>structure (from management to shop floor)</td>
</tr>
<tr>
<td>The Industrial Internet of Things</td>
<td>A network of machines and products</td>
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<tr>
<td></td>
<td>Multidirectional communication among networked objects</td>
</tr>
<tr>
<td>Cloud computing</td>
<td>The management of huge volumes of data in open systems</td>
</tr>
<tr>
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<td>Real-time communication for production systems</td>
</tr>
<tr>
<td>Cybersecurity</td>
<td>The management of heightened security risks due to a high level of networking</td>
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<tr>
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<td>among intelligent machines, products, and systems</td>
</tr>
<tr>
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<td>The comprehensive evaluation of available data (from CRM, ERP, and SCM</td>
</tr>
<tr>
<td>Big data and analytics</td>
<td>systems, for example, as well as from an MES and machines</td>
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<td>Support for optimized real-time decision making</td>
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Source: BCG analysis.
Note: SOP = standard operating procedure. CRM = customer relationship management. ERP = enterprise resource planning. SCM = supply chain management. MES = manufacturing execution system.
“Hell is a Place Where Nothing Connects with Nothing” - T.S. Eliot
Old Paradigm: Transistors designed around binary units 1 or 0 bits

New Paradigm: QUANTUM BITS; exist in superposition; quantum algorithms creating probabilistic shortcuts
Digital information (the “block”) stored in a public database (the “chain”)

As each transaction occurs – and the parties agree to its details – it’s encoded into a block of digital data and uniquely signed or identified.

Each block is connected to the one before and after it — creating an irreversible, immutable chain.

Blocks are chained together, preventing any block from being altered or a block being inserted between two existing blocks.

DISTRIBUTED LEDGER - TRUST - ELIMINATE INTERMEDIARIES THAT DO NOT CREATE VALUE
WHAT ARE THE TWO KEY REQUISITES FOR A SUCCESSFUL MANUFACTURING ENTERPRISE?
WHAT are the two most important products of a successful consortium or a University Center?

KNOWLEDGE & PEOPLE
- Almex USA
- Aluminum Association
- American Foundry Society
- ATEK Metal Technologies
- California Metals Coalition
- Can-Eng Furnaces
- Collins Aerospace
- Consolidated Metco
- CPC
- Eck Industries
- FCA – Fiat Chrysler
- Foseco
- General Aluminum
- General Motors
- Harley-Davidson
- Hazelett Corporation
- H.C. Starck
- Inductotherm
- Kunshan Liufeng
- KYOWA Japan
- MAGMA
- Magma
- Mercury Marine
- Linamar Light Metals
- NADCA
- NEMAK, S.A.
- Nikkei MC Aluminum
- Oshkosh Corporation
- Persimmon Technologies
- Pratt & Whitney
- QuesTek
- Rio Tinto Aluminum
- RUSAL
- Sakthi Automotive Group
- Shiloh
- Tesla/SpaceX
- Terves
- VJ Technologies
- ACRC Members
“In the 4th Industrial Revolution it is all about Talentism; not capitalism nor socialism”

Klaus Schwab - WEF