

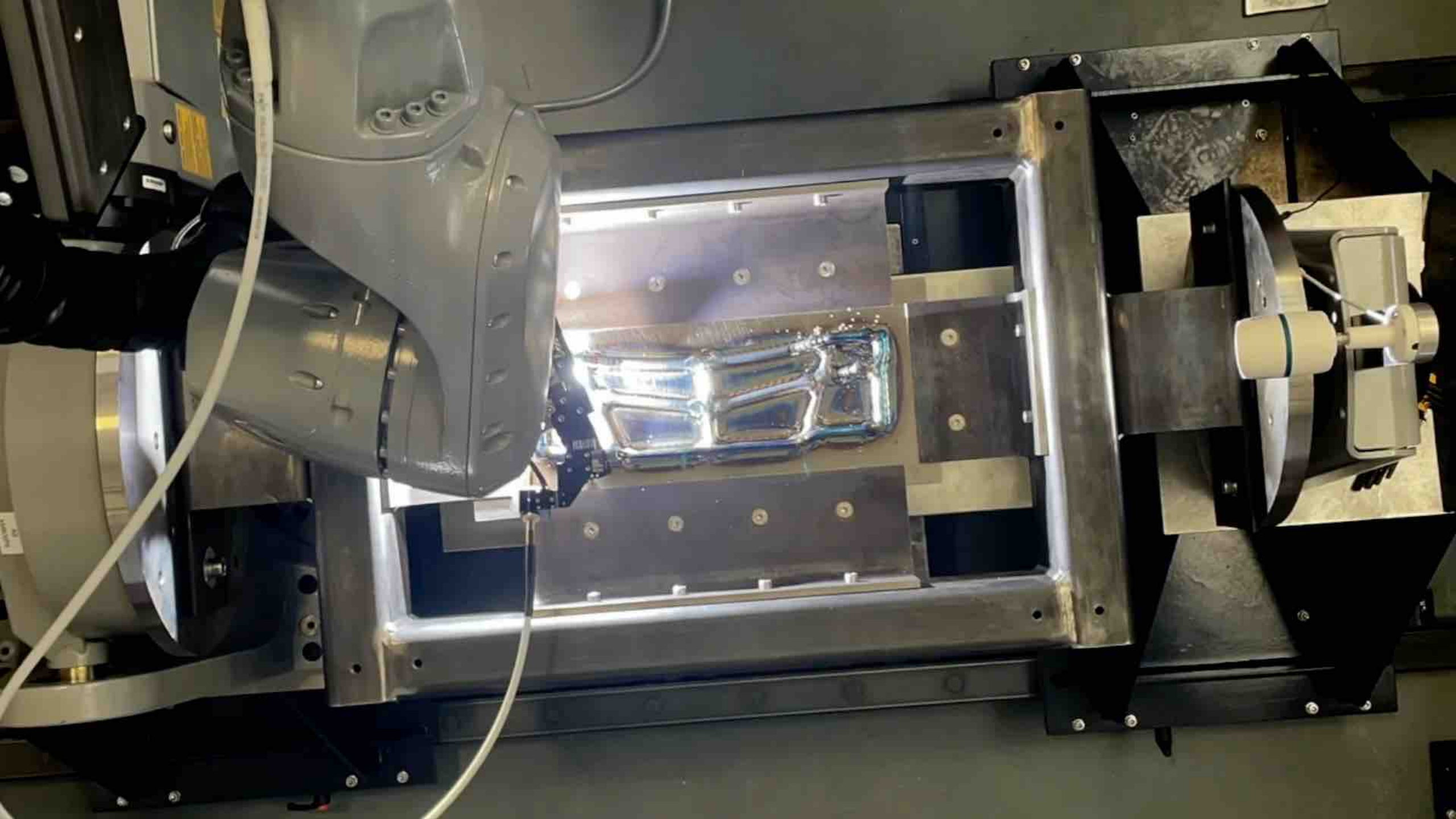


# COMPARATIVE LIFE CYCLE ENVIRONMENTAL ASSESSMENT OF ALUMINIUM, STEEL AND TITANIUM COMPONENTS MADE BY WAAM

Dr Filomeno Martina, Dr Emanuele Pagone  
January 2023







# PROCESS VIDEOS

0.5-metre frame structure in titanium <https://youtu.be/QgL6EQDDTqo> (on RoboWAAM Mk2)

0.5-metre propellant tank in titanium <https://youtu.be/7So03b9m5Al> (on RoboWAAM Mk2)

6-metre cantilever beam in steel [https://www.youtube.com/watch?v=LKj08zHMv\\_k](https://www.youtube.com/watch?v=LKj08zHMv_k) (on Cranfield Uni prototype XL system)

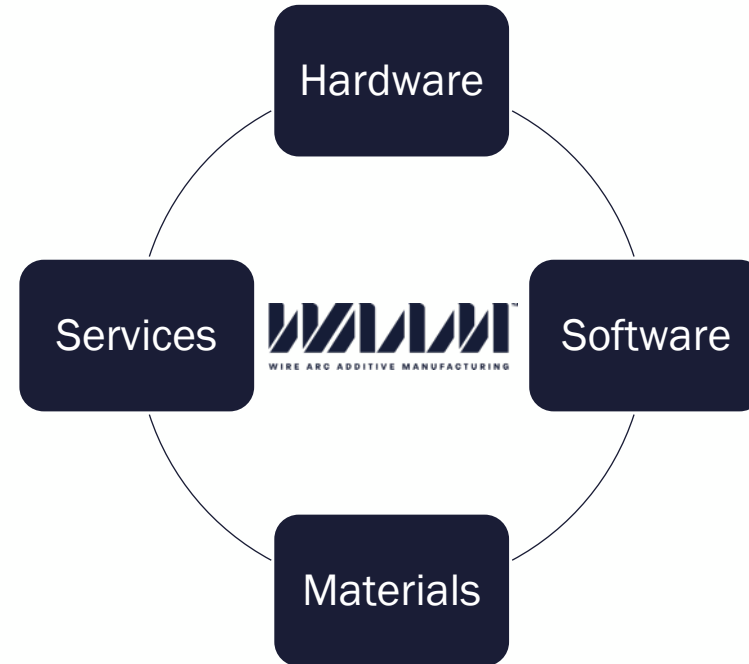
6-metre spar in aluminium <https://www.youtube.com/watch?v=oekfyLhkSgo> (on Cranfield Uni prototype XL system)



# WAAM3D

- RoboWAAM SE**
  - Entry level
- RoboWAAM Advanced**
  - Best-in-class platform
- RoboWAAM XP**
  - Featuring new high productivity WAAM (11/2022)

- WAAMCost**
  - Cost estimation
  - Life Cycle Assessment
- WAAMPlanner**
  - Slicer
  - Multidimensional sectioner
  - Tool path planner
  - Post-processor
  - Multi-material / process capability
- WAAMKeys**
  - Custom and / or automatic calculation of WAAM process parameters
- WAAMSim**
  - Kinematic simulation
  - Tool path plan visualisation
  - Collision detection
  - Debugger
- WAAMCtrl**
  - Operator's dashboard
  - Machine management
  - Data logging
  - Auditable quality file / report

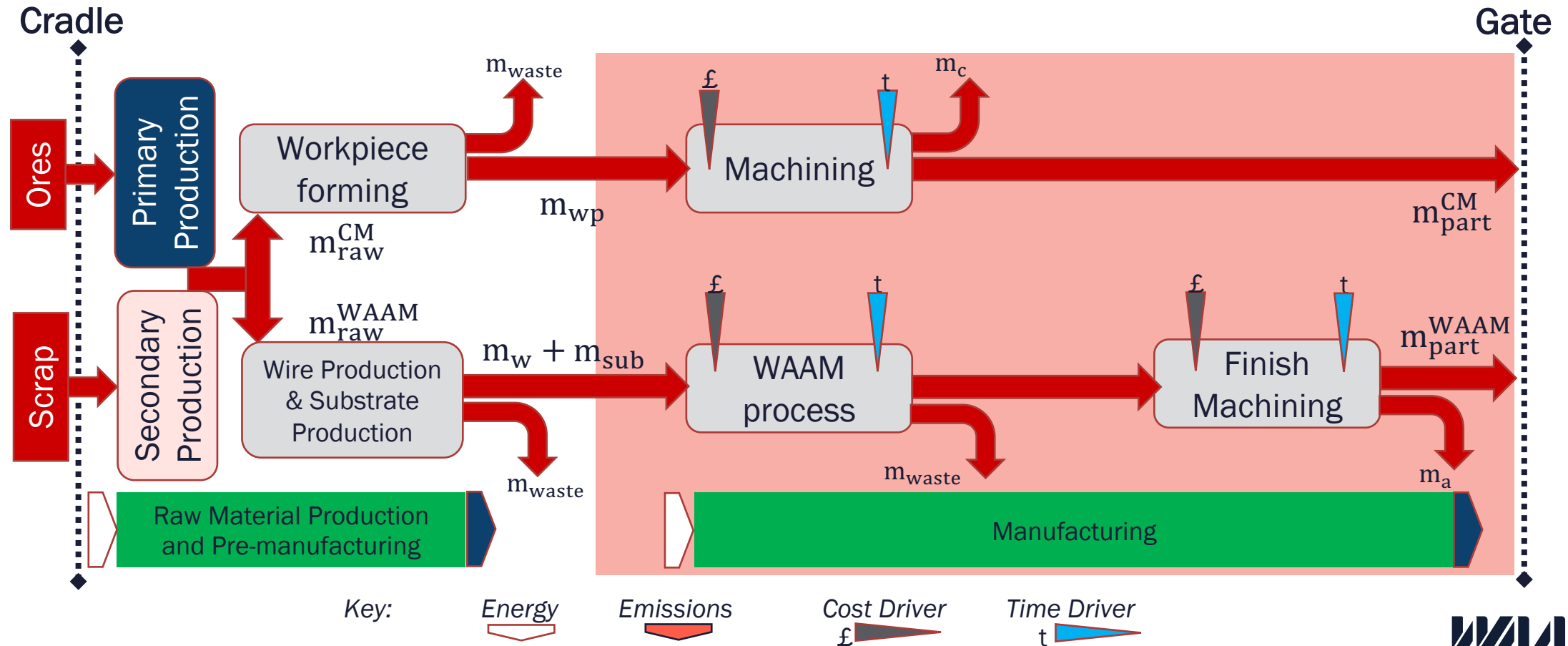


- Business case development**
  - Cost estimations
  - Life Cycle Assessment
- Training**
  - Foundational
  - WAAM Operator
  - WAAM Engineer
  - Advanced techniques
- Part building**
  - First-right-part
  - Proof of concept
  - Demonstration
  - End-use
- Special projects**
  - Custom hardware
  - New materials
  - Next complexity challenges

- Premium aluminium wire and rods**
  - 2319
  - 4043
  - 5183
  - 5356
  - Magnesium Scandium



# LCA FRAMEWORK



# ALUMINIUM BULKHEAD FOR SPACE APP.

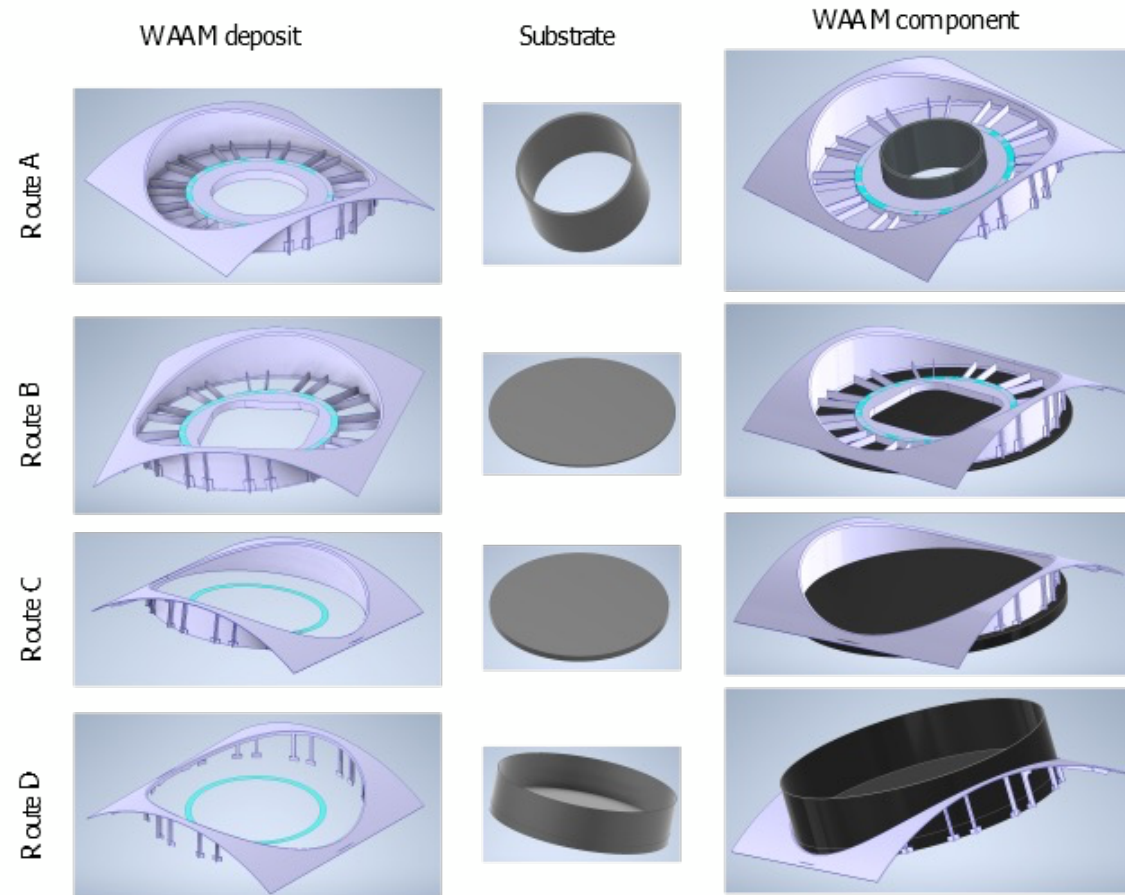
Final mass: ~230 kg

WAAM: 4 alternative routes:

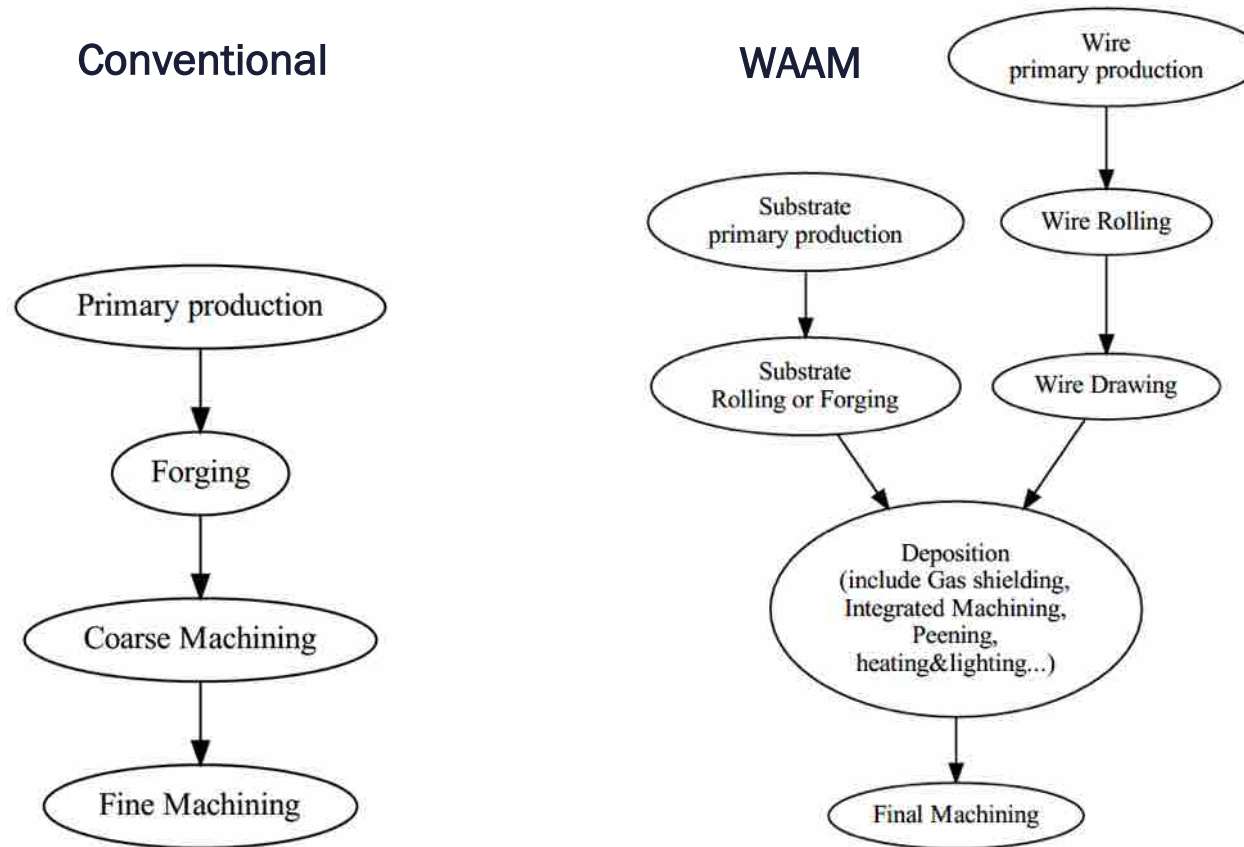
- Different starting feedstock geometries
- AA 2219, AA 6082
- Substrates: A&D rolled, B&C forged

Traditional: subtractive route

- Forged and machined
- BTF = 22.5
- AA 2219

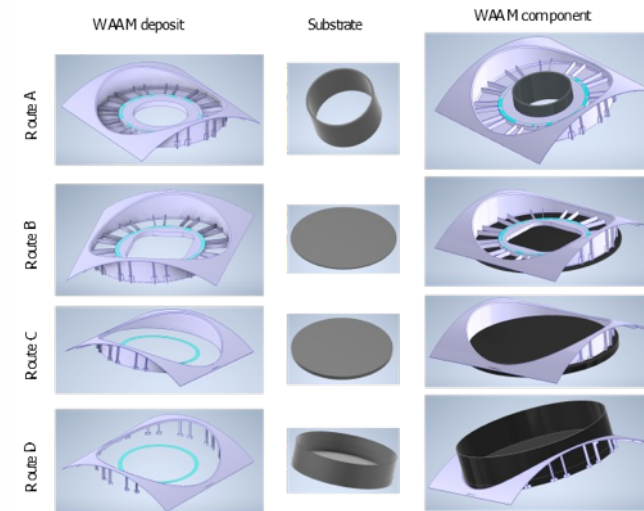
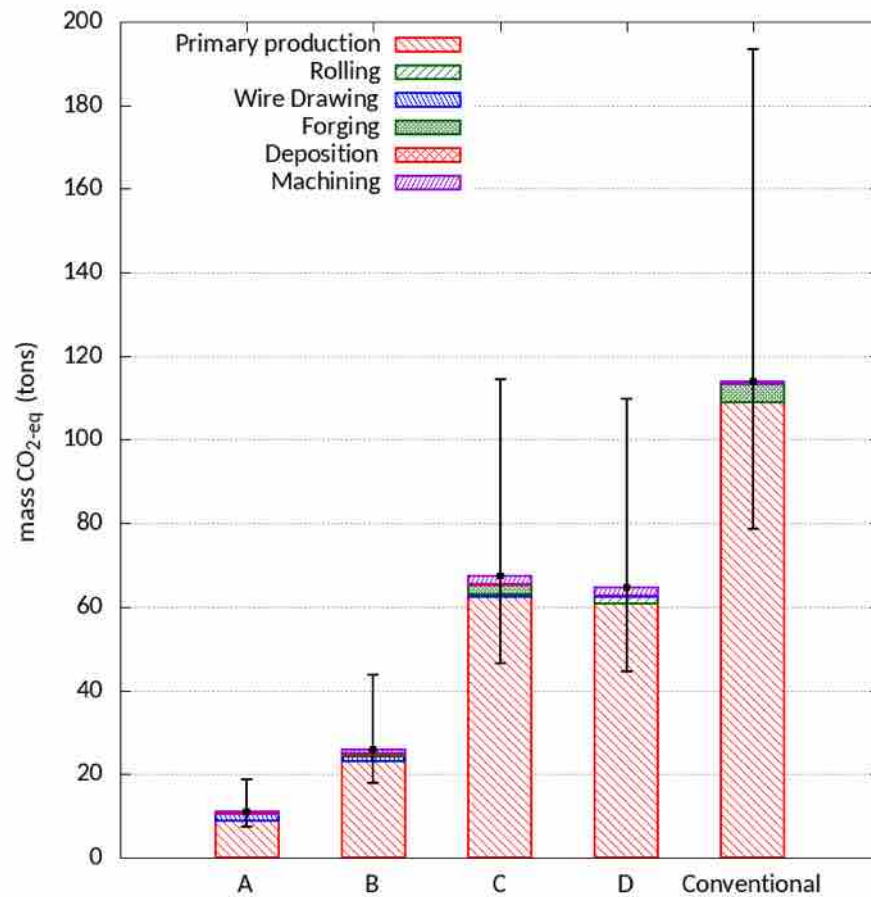
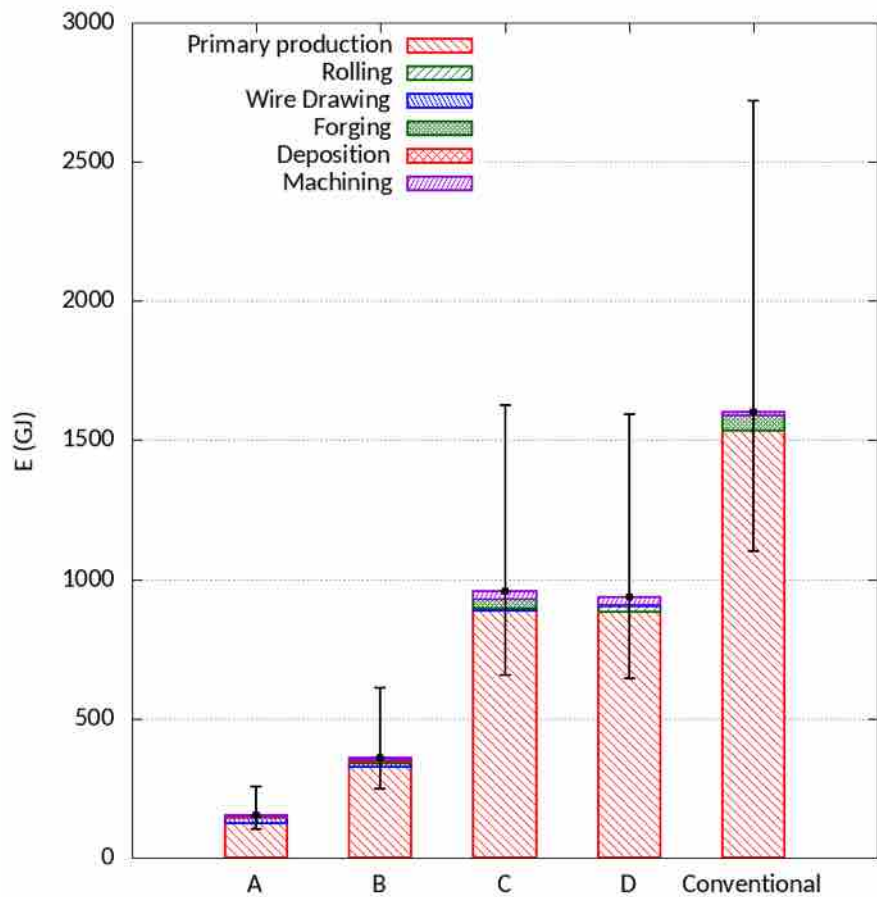


# ALUMINIUM BULKHEAD FOR SPACE APP.



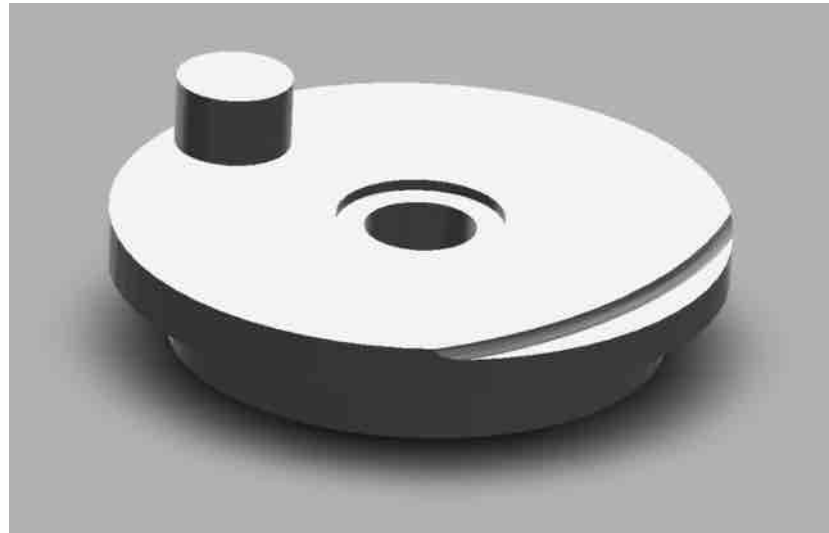


# ALUMINIUM BULKHEAD FOR SPACE APP.



# STEEL PART: NEW, AND REPAIRED BY WAAM

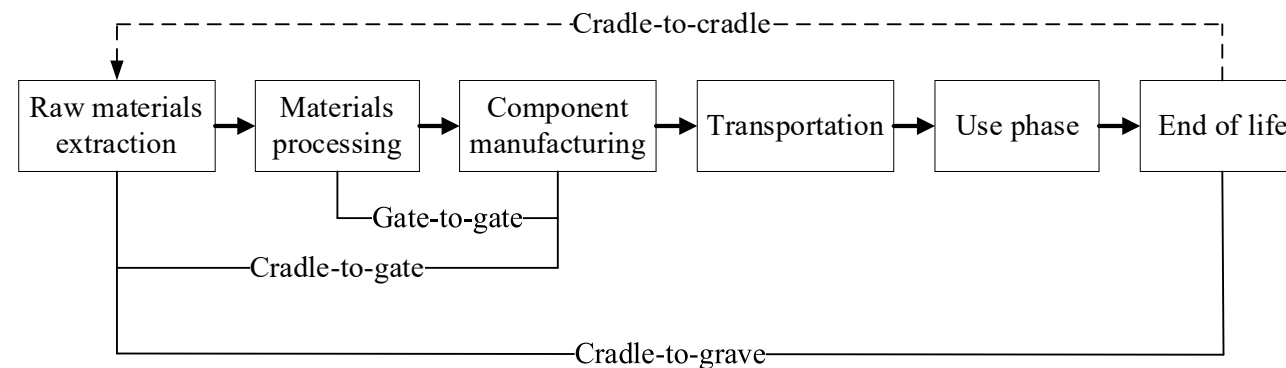
Part	Material
Conventional disc	34CrNiMo6
WAAM wire	ER70
WAAM substrate	YS600



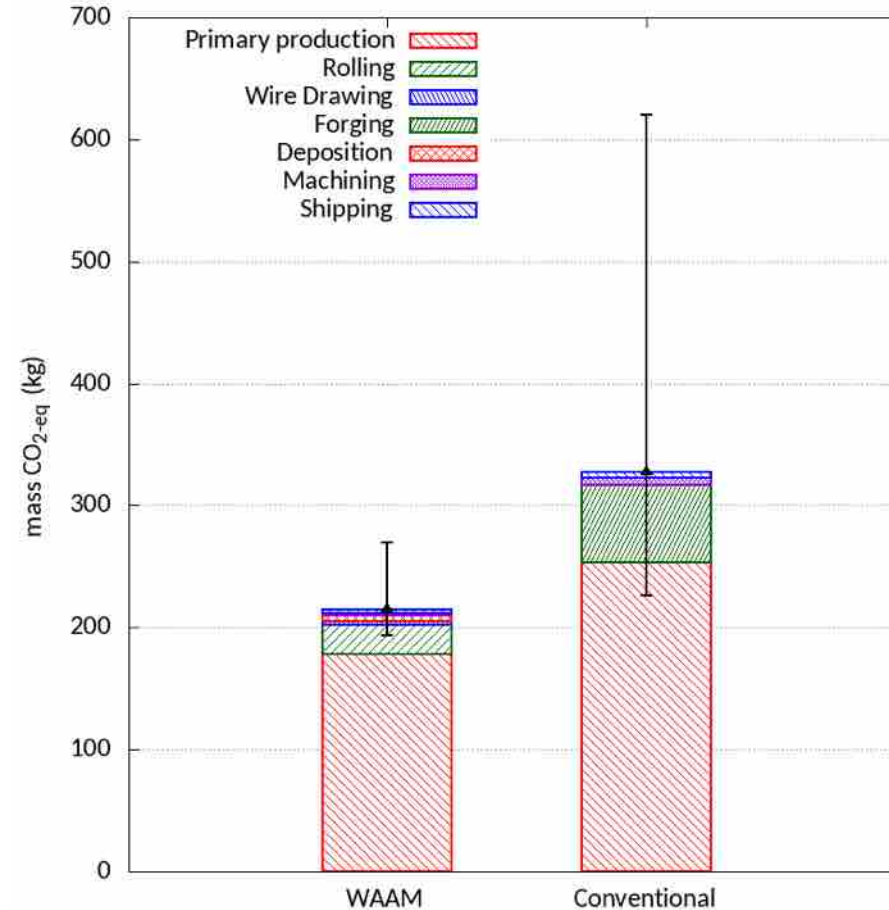
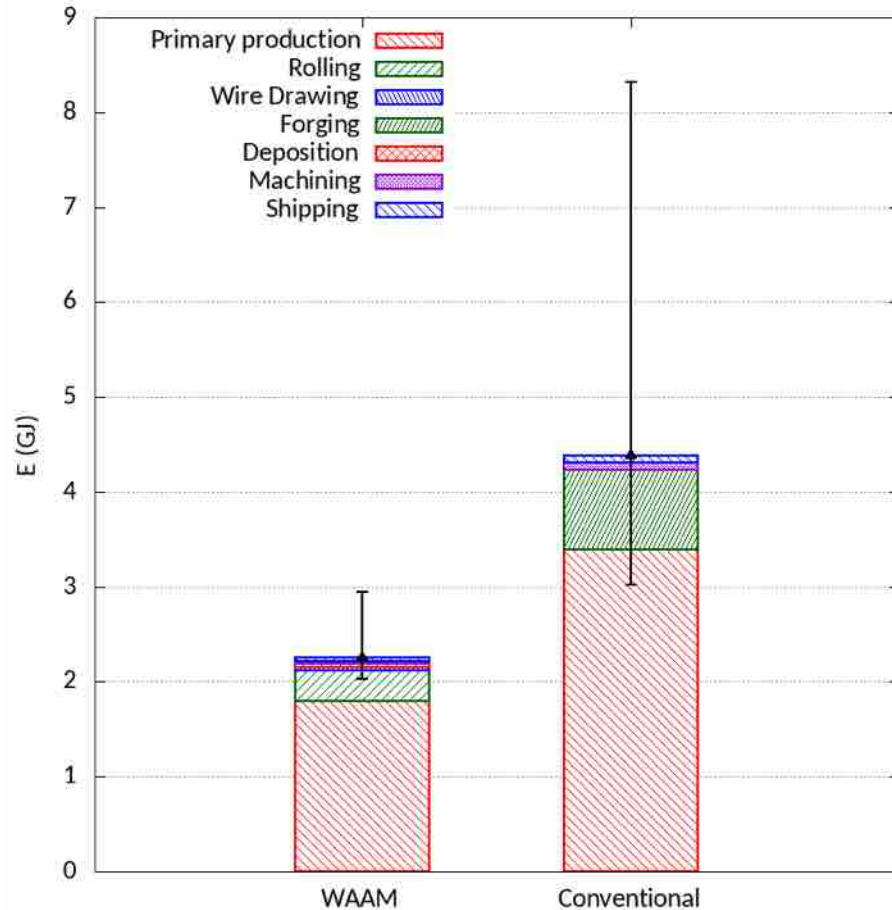
**Cradle-to-gate+**: i.e. shipping to customer.

Scenarios:

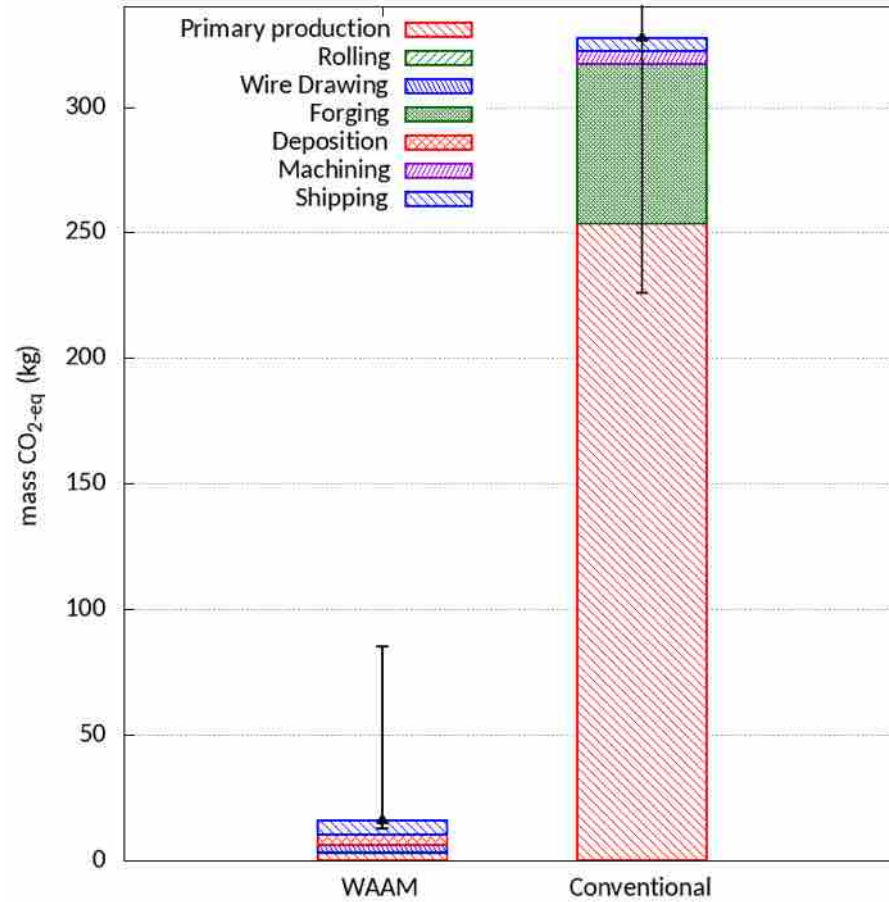
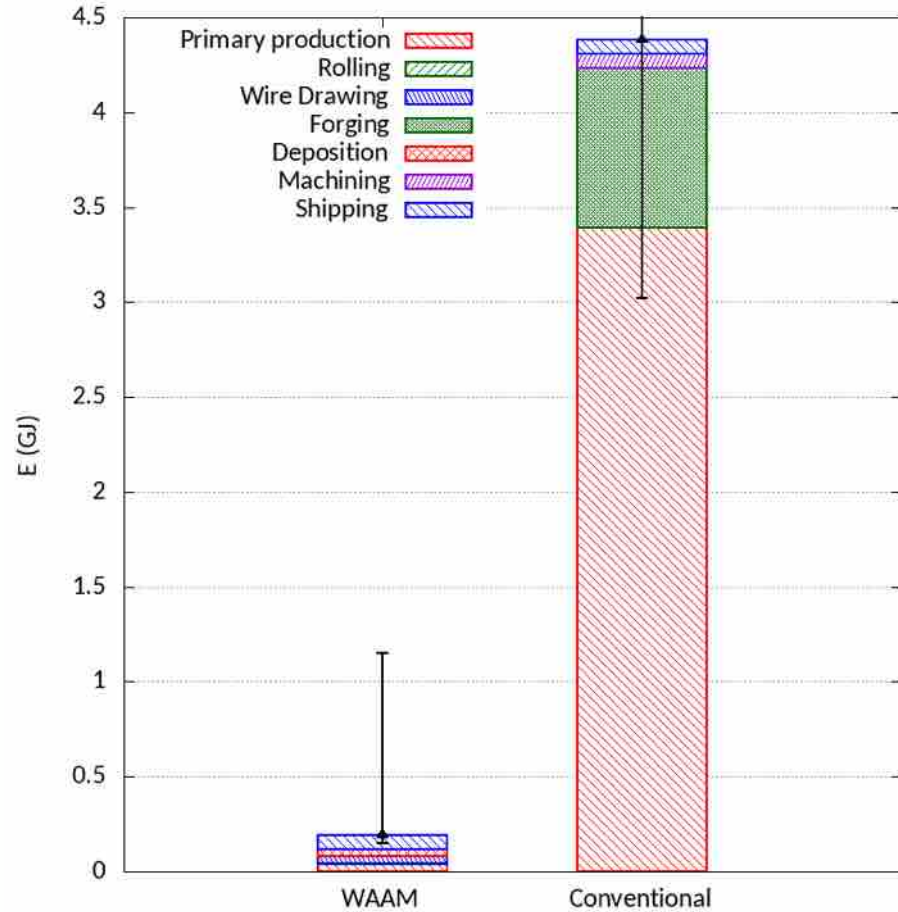
- "Mostly by air"
- "Mostly by sea"
- "Mostly by road"



# STEEL PART: NEW



# STEEL PART: REPAIR



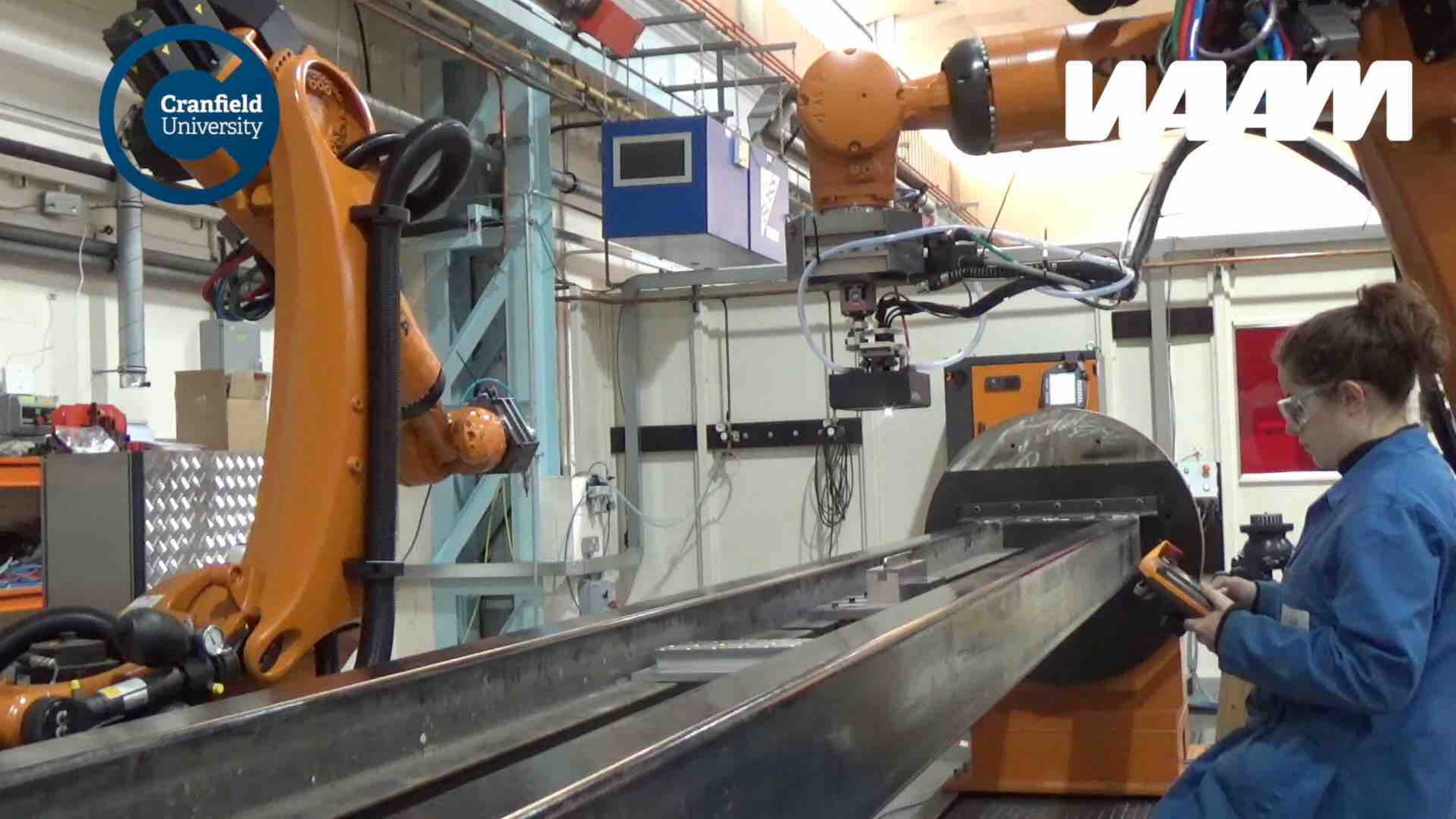






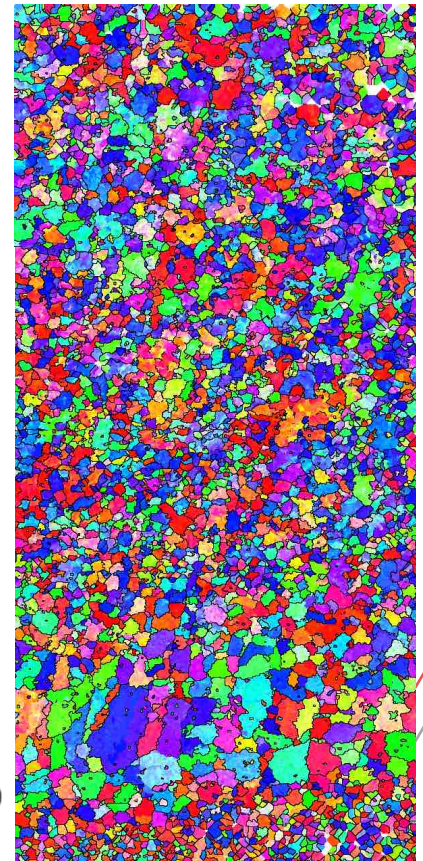
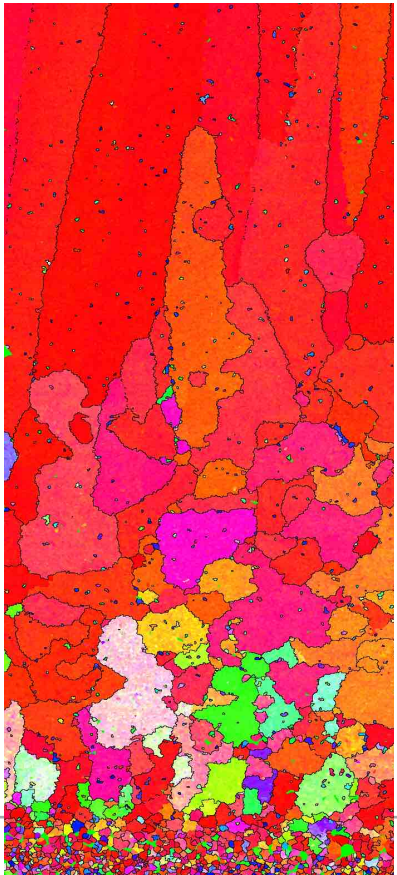
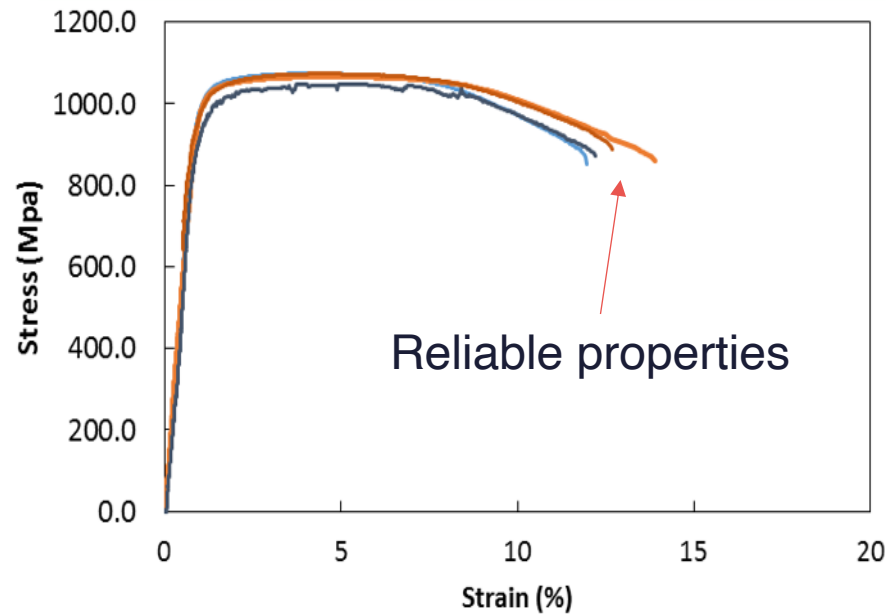
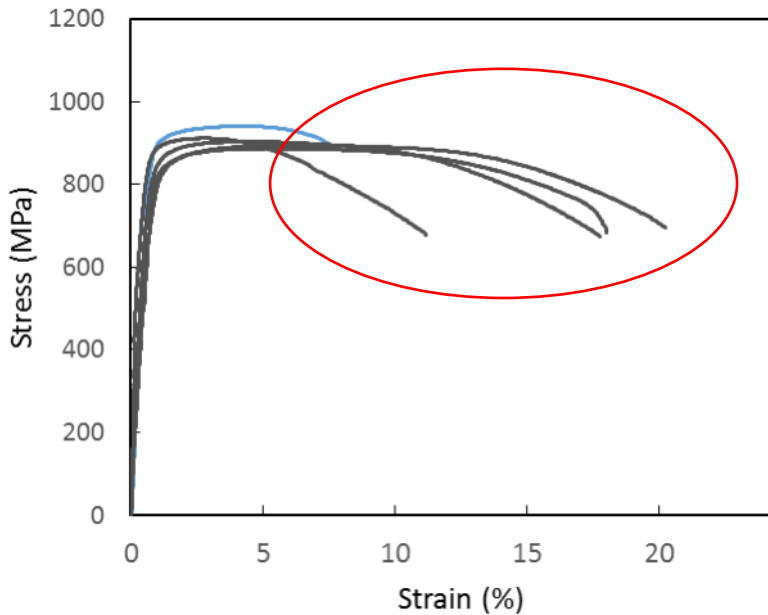
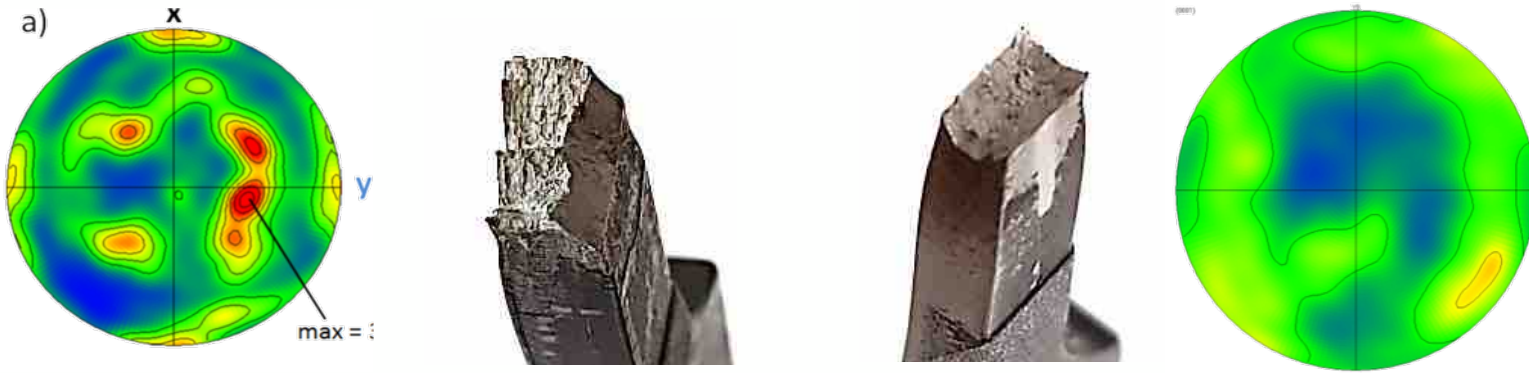


# WAM

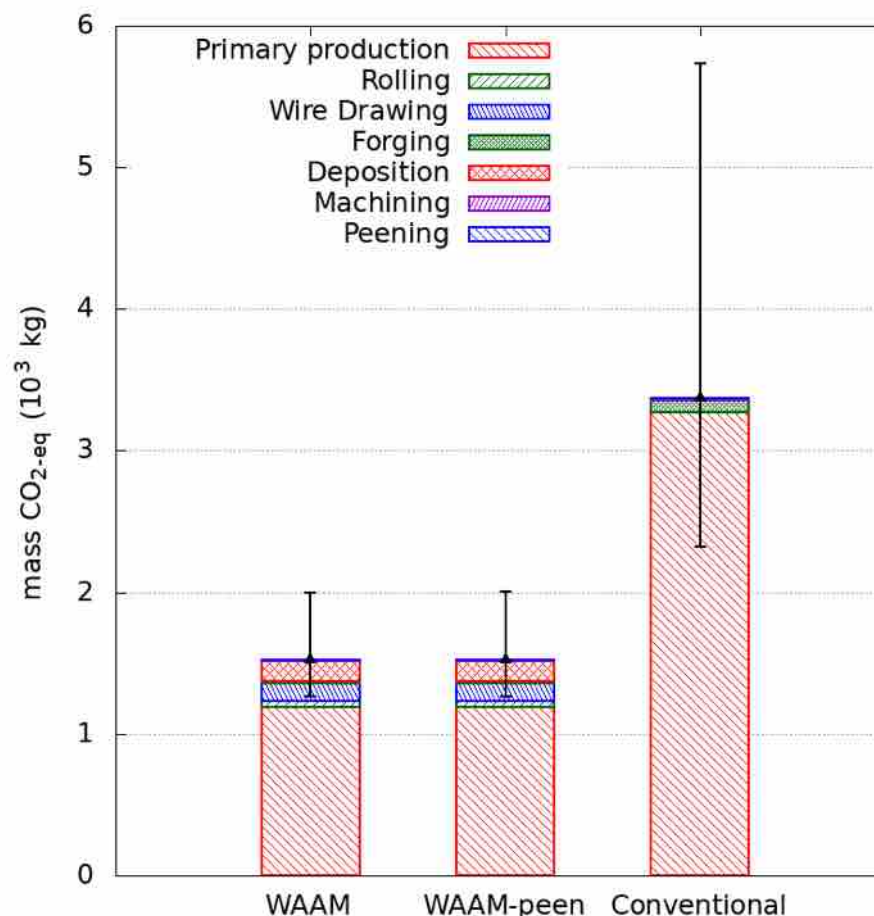
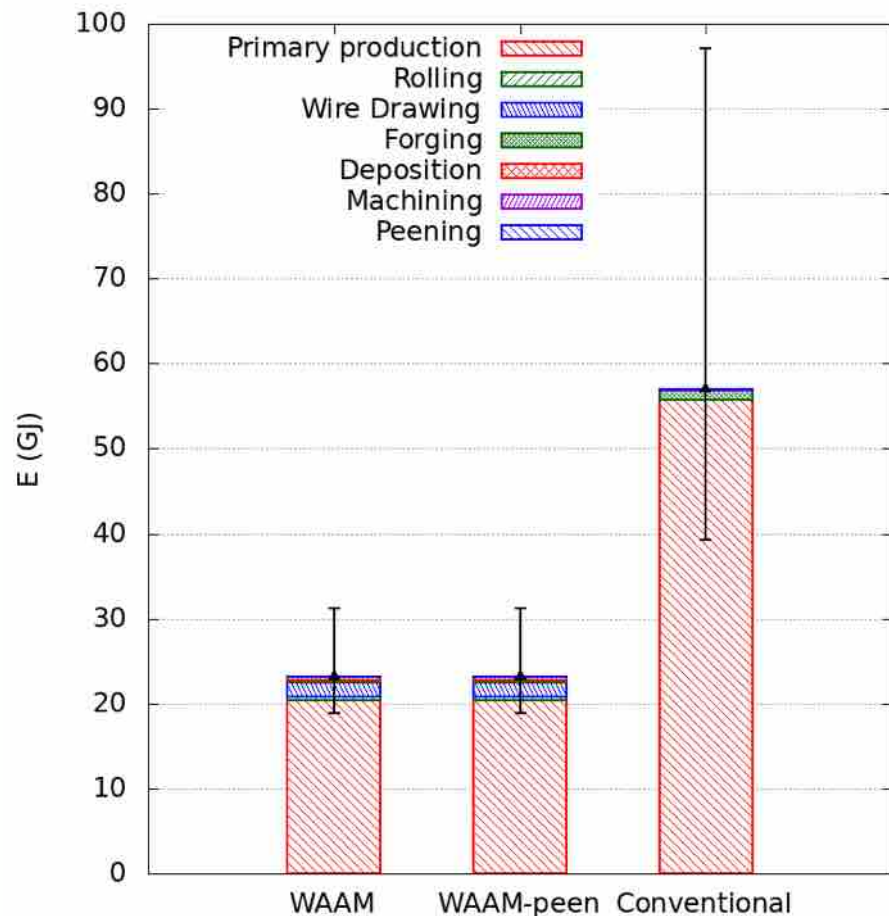




# A NOTE ON IN-PROCESS COLD-WORK

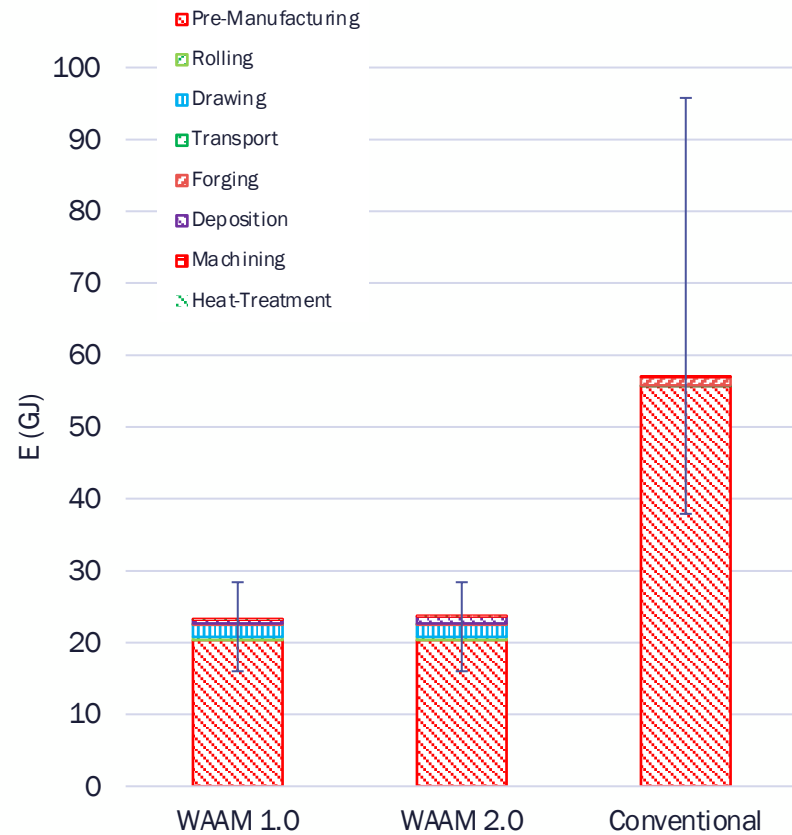
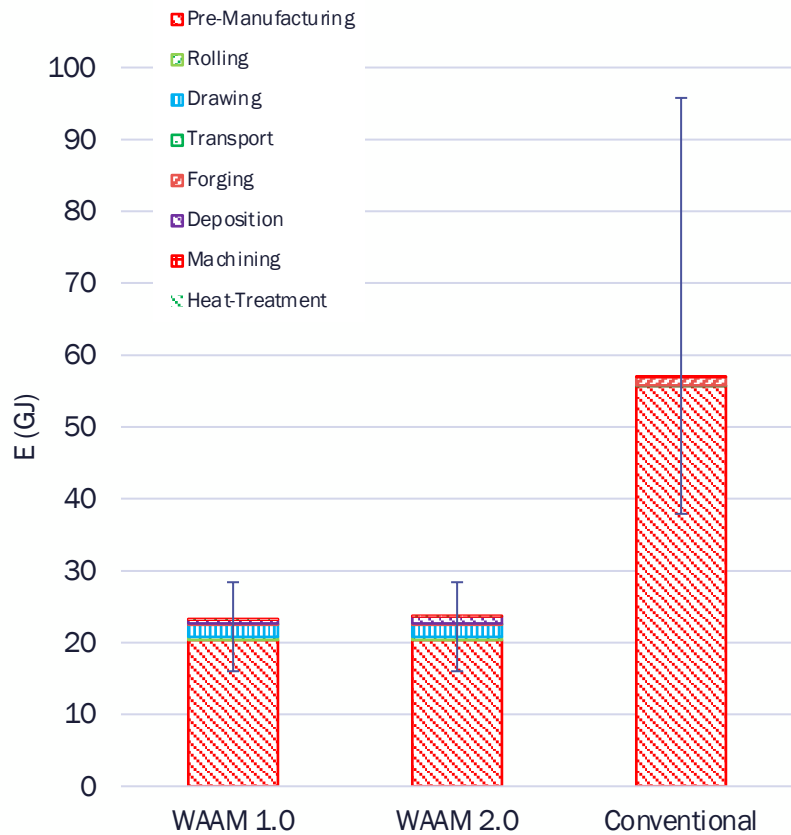


# AEROSPACE Ti64 PART WITH PEENING





# AEROSPACE Ti64 PART WITH WAAM 2.0



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