



Microreactor Factory Fabrication

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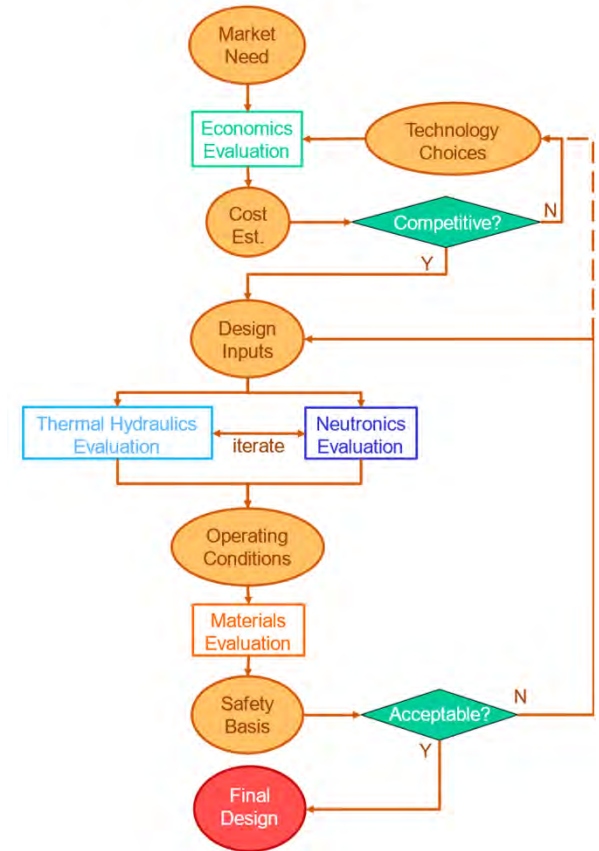


Scope Overview

- Collaboration between Microreactor Program (MRP) and Systems Analysis & Integration (SA&I)
- Objective was to take a deeper dive into factory manufacture considerations for microreactors
- Within the scope of ‘economics-by-design’
- Mass production of microreactor expected to be primary factor that will determine economic competitiveness
- Understand potential cost reductions, manufacturing challenges/best practices, where to prioritize R&D efforts to achieve highest economic impact
- Quantify order of magnitude investment costs for microreactor factory
- Upcoming journal article:

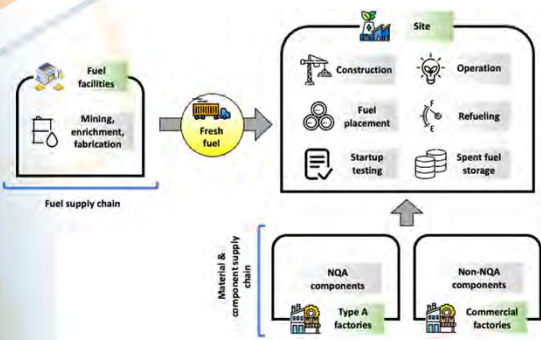
A. Abou-Jaoude, et al., “Assessment of Factory Fabrication Considerations for Nuclear Microreactors”, *Nuclear Technology*, under review

Economics-by-Design

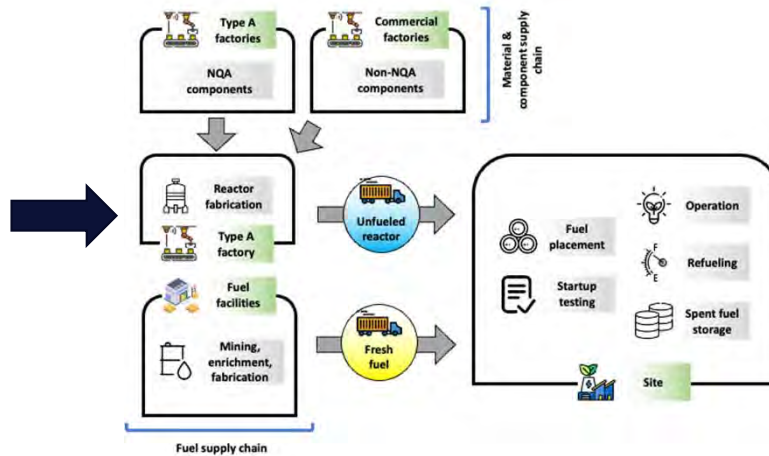


Microreactor Factory Considerations

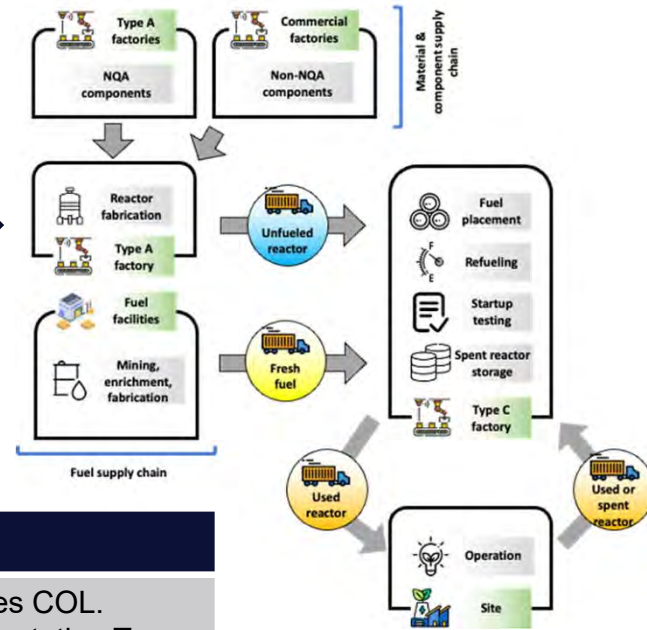
Current Layout



Near-term Configuration



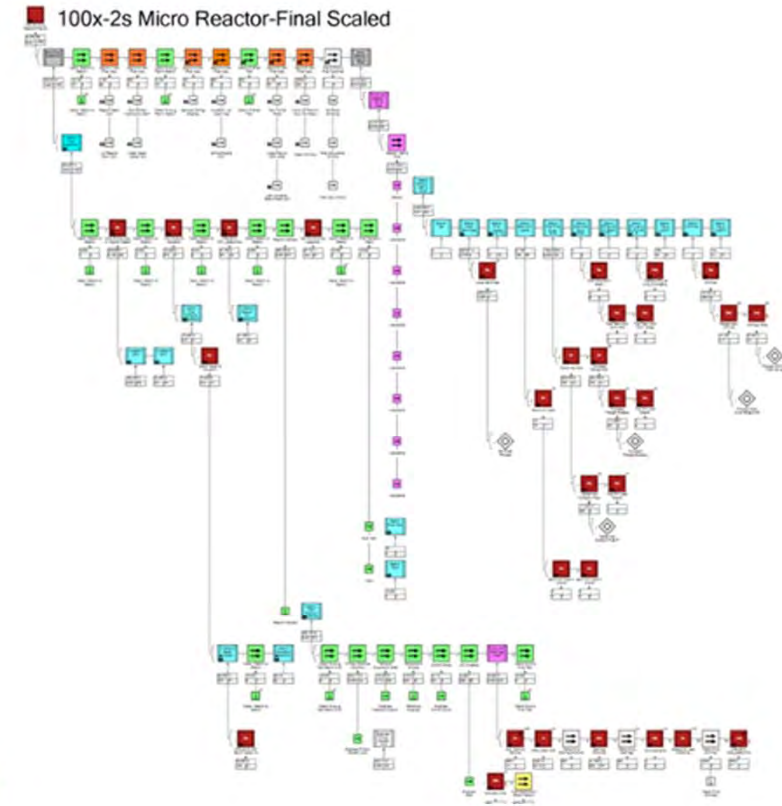
Long-term Configuration



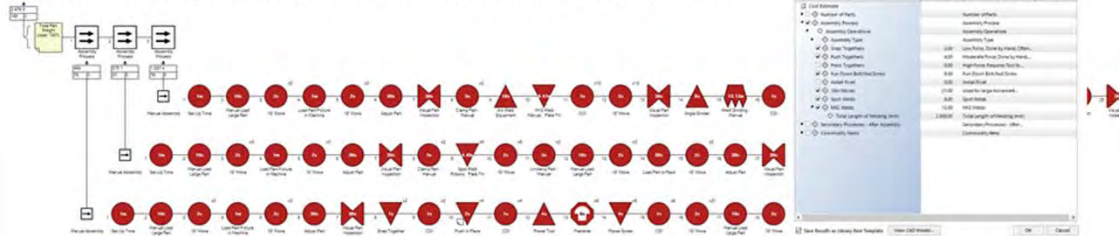
| | Current | Near | Future |
|------------|---|--|---|
| Regulatory | Most regulations designed for this scenario: COL based on 10 CFR Part 50/52 | Reactor fabrication: NQA-1 and possibly 10 CFR Part 52 subpart F | Factory requires COL. Reactor transportation Type B standards |
| Economic | Limited standardization/modularization | Mass production of assembly. Fueling/startup/D&D at each site | Larger factory costs, but reduced end-user costs |

Evaluation of Microreactor Factory Fabrication Model

- Subcontract awarded to Munro & Associates Inc. (experience in defense, aerospace, automotive)
- MARVEL reactor used as a usecase
- Design Profit leveraging CAD assemblies to evaluate 10-100 unit/year production of microreactor at factory

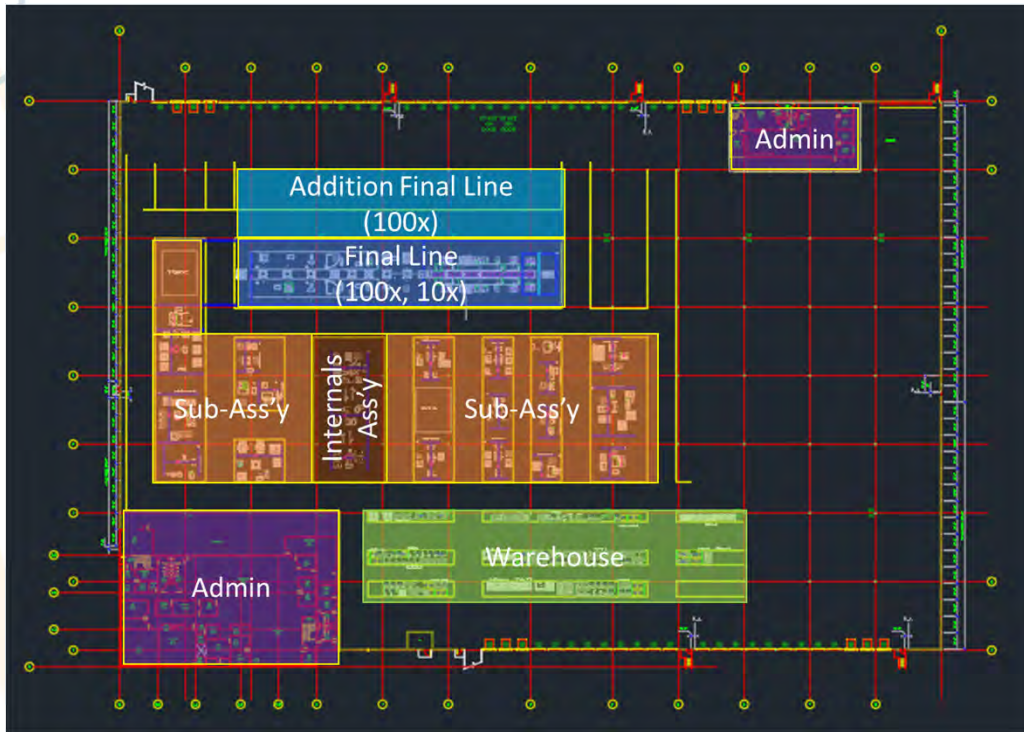


BRACKET, REFRIGERANT LINE MOUNTING, STAI

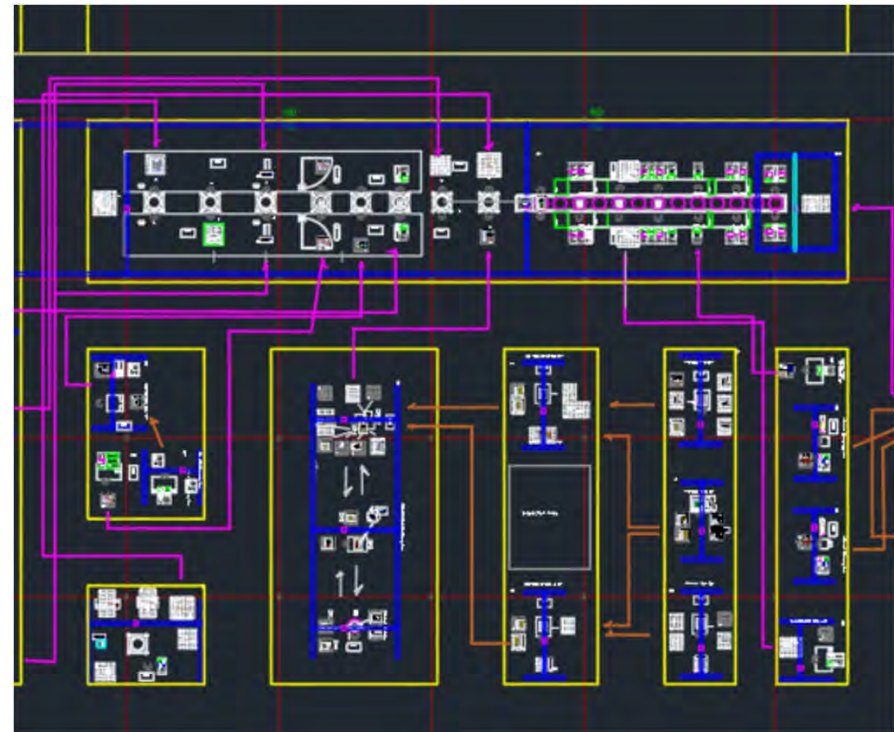


Detailed Microreactor Factory Layout

Factory layout and organization

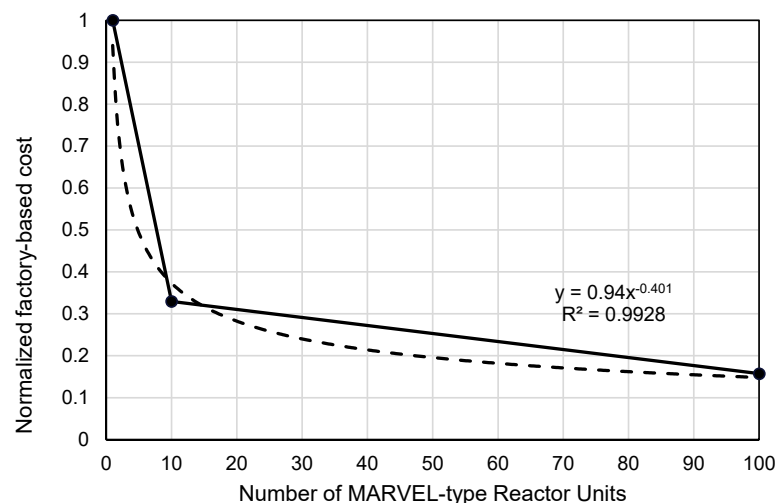


Detailed flow of components to final assembly line



Main Findings

- 36 assembly modification recommendation via ‘Design for Manufacturability’
- Line layout : Asynchronous Indexing assembly line primarily
- 22 Workstations +1 final assembly (10x) or +2 (100x)
- Takt time: 10x = 400 hr, 100x = 40 hr
- Equipment costs: \$6M (10x) to \$10M (100x)
- Building cost (without land, etc.): \$72M
- 10x: 36 staff/shift; 100x: 51 staff/shift
- 10x to 100x: same facility + 1 final assembly + 2 shifts + less downtime
- 1x to 10x → 70% cost drop in factory costs
- 10x to 100x → 50% cost drop in factory costs



| | 10x Costs | 100x Costs |
|----------------------|--|---------------|
| Capital | | |
| Equipment | \$5M-\$6M | \$9-10M |
| Building | \$72M | \$72M |
| Not included: | Land costs, regulatory costs, governmental costs, etc. | |
| Operating | | |
| Staff | \$6M-10M/year | \$15-20M/year |
| Utilities | \$1M/year | \$1M/year |
| Not included: | Administrative staff, transportation, etc. | |





MRP Microreactor
Program