

# A Legoland for miners? Adventures with modular builds

Kids love LEGO toys. Miners love LEGO mines. Modular mining builds are the LEGO blocks of mining.

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## Underground Mining > Operational- excellence

Prefabricated modules speed up construction of housing and mineral processing facilities in remote locations. Modular mining builds, as a construction approach, reduce time spent in site construction, and cost. The construction method improves safety and lowers site environmental waste impact as modules are built in factory conditions. Let's highlight and unpack some advantages of modular construction methods in mining.

Comments



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To stick-build a mine mineral processing facility is a time-consuming assembly process on site. By contrast, modular mine builds are snap your fingers fast. Matthew Cobbett, formerly of Fluor and now a consultant, sums up the difference this way: "90% of a facility can be pre-assembled and commissioned before transport to site...modular plants require smaller teams of workers on site and can reduce build times by up to 30%."

How fast can the assembly of a modular mine get? An early example of the time efficiency of this construction method was Teck's Red Dog Lead Zinc Mine, a modular built mine processing facility which was put in place 1,000 km northwest of Anchorage, Alaska, and 240 km north of Arctic Circle (See location Fig. 1). The key constraint was the construction season, which is three months in Alaska. Modular built mine processing units built off site enabled a way to build within this tight construction season window.

Modular site construction took 100 days. But there was prep work to make this rapid build happen. Initial development began 1986 for a port installation along Alaska coast, and a mine road build starting in 1987. A modular mill was mostly built in the Philippines, disassembled, large barges moved modules to the Alaska coast. In a mining industry first at the time, Self-Propelled Modular Transporters (SPMTs) were used to move heavy modules from to the Alaska coastal port, and then 84 km along the Delong Mountain Transportation System to the mine site. Full production was achieved in November of 1989. (See Fig. 1, mine location, and Fig. 2, SAG Mill, and Fig. 3. Flotation Module on road move from port).

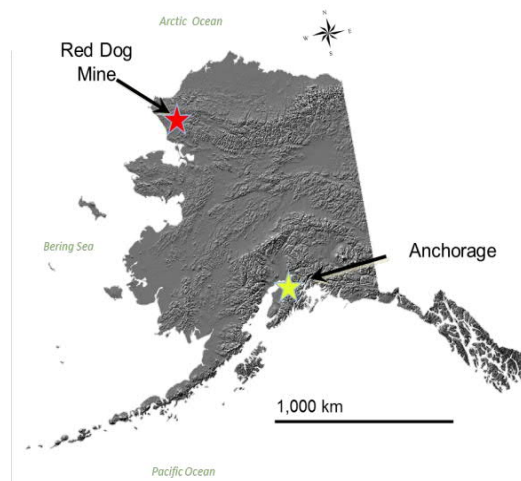


Figure 1 Red Dog Mine Remote Location and mine site overview





*Figure 2 Red Dog Mine Modular Build, began operations in 1989, Courtesy of Mammoet. Note the two Self-Propelled Modular Transporters (SPMTs) carrying a large module containing what appears to be a Fuller 22 foot diameter by 8.5 foot 1500 kw, 2000 hp SAG Mill and ATCO offices. Photo Courtesy of Mammoet.*



*Figure 3 Red Dog Lead-Zinc Flotation module on the move. 114' x 64' x 75' high, weight 1,600 tons, Courtesy Red Dog Mine.*

## Are modular-built mines safer?

Modular builds tend to be a safer method of construction. Factory design and build process in a controlled environment is safer. Assembly on a flat factory floor work surface, improves safety for the trades. Exposures to dust, vibration and noise are better controlled in a factory setting. As a generality, a well-lit factory floor, is better than doing a stick-built assembly in seasonally limited construction windows where for six months of the year sites are dark in places such as Canada's arctic areas, and Alaska.

A controlled factory setting for module built enables precise fitting of parts, which means complex assembly is subject to rigorous quality control. The better tested fit of parts assembled into larger components, the higher the QA/QC of parts, means reduction of shake down time to bring a mineral processing facility into full production.



Site construction waste control tends to be better with modular built mine processing facilities. Modular mining builds reduces the environmental footprint of disposal of site construction wastes by design. The majority of waste material generation is at an industrial park: a factory build approach produces wastes at an industrial park location that is cheaper for waste removal and reuse than on a remote mine location. It is easier to identify reuse opportunities in an area designated for industrial use as opposed to carrying out these activities in remote mine areas. Modular mining build conforms with industry's growing commitment to responsible mining operations, including the construction of the mine.

## Challenges and considerations

However, despite the advertised efficiency of modular builds on remote site, there are limitations. Some remote mine sites can experience high winds, and modular build construction has a limitation for heavy lift crane work that is exposed to high winds. Operations are shut down above a certain wind speed, a rule of thumb for crane operations is to shut down operations at wind speeds that exceed 20 kilometers per hour. Seasonally, logistics for modular build crane work should aim for construction during the lowest anticipated wind conditions.

While modular mining offers significant advantages, it also presents a bid challenge. In a bid situation there are a limited number of bidders that generally are seen for modular builds, there are only a few dominant players such as Fluor, Bechtel, Hatch, and Stantec for larger modular mine builds. Mammoet appears in almost to be a default modular mine transporter. This limits the number of bidders on larger projects, which makes bid situations less ideal for a mine client shopping for lower pricing. The lack of pool of modular experienced heavy constructors may impact corporate sole sourcing policies. It is often the case during construction, that sole sourcing can produce escalating costs, as a service provider knows they have sole sourcing leverage over a client mining company.

Engineering Challenges: design of modular units for intermodal to oversized level shipping is complicated. Consultant engineering firms such as Hatch have taken a 3D engineering and logistics require a higher level of skill and coordination for modular built mine. Engineers must ensure compatibility and interoperability between the units, a plug and play aspect where care must be taken in fit and measure of modular connections.

As noted by Steve McAlister of Seppro Systems:

"We pre-assemble and then disassemble interfacing modules before shipping to the site. This practice saves money in the long run because we are sure everything will fit."



Engineer analysis includes a careful review of ore characteristics and process requirements that places these modular facilities in an ideal spot for ore processing, locationally, but also in terms of modular mine processing specs that meet site conditions. One challenge is to spec mine site pilot process characteristics in clear fashion to distant factories. Engineering at a distance demands effective communication skills to the factories producing the modular mine parts.

Another challenge with modular mine builds is lining up road permits, and logistics, well before modules are moved along public roads. In the USA, for instance, some states may require an environmental assessment be done on modular transport for mine, to obtain road permits.

This work is done well in advance of the movement of modules. Significant lead time may be required an environmental assessment. Route assessments carried out by Mammot will also lead up to various road improvements that need to be carried out to accommodate oversized module during road movements.

For instance, one of the most convenient entry areas for oversized modules that can be moved into Western Canada, and the Western US, is in Lewistown, Idaho, which we will discuss later. Generally, there is a need for road improvements that well precede projects that has to be carefully assessed as to financial impact, as part of a modular built mine moves.

## Logistics Planning

Transporting large and heavy modular units is logistics brought to an art. This process requires a range of specialized equipment. Equipment such as ships, cranes, trailers, transporters, and lifting systems. Logistics planning and optimization for module movement is crucial for successful modular mining projects.

Moving from Point A and B is a massive interplay and dance of modules movements and transport costs. For instance, rising fuel costs for sea transport of oversized modules today has shifted focus of module component transport on oceans to very fuel-efficient ships, such as Zeamarine ZEA 14k-900 tween decker. This fleet of vessel was used to transport 450,000 freight tons of mine modules for South Flank Mine in Australia. These vessels are most fuel-efficient and technologically advanced multi-purpose tonnage ships on the water today.





Figure 4 Nine Eco Lifter Zeamarine ZEA 14k-900 vessel multipurpose vessels Sold to United Heavy Lift (UHL) Post South Flank Mine contract, expanding UHL's fleet to 19 vessels of this type. Ships carry two 450 tonne cranes. Image Credit UHL.

Land movement of modules: to get from Point A to B on land by road, requires equipment such as previously mentioned STMPT trailers, conventional trailers, and modular trailers. A complete set of equipment seen in modular moves can be seen in Figure 5.

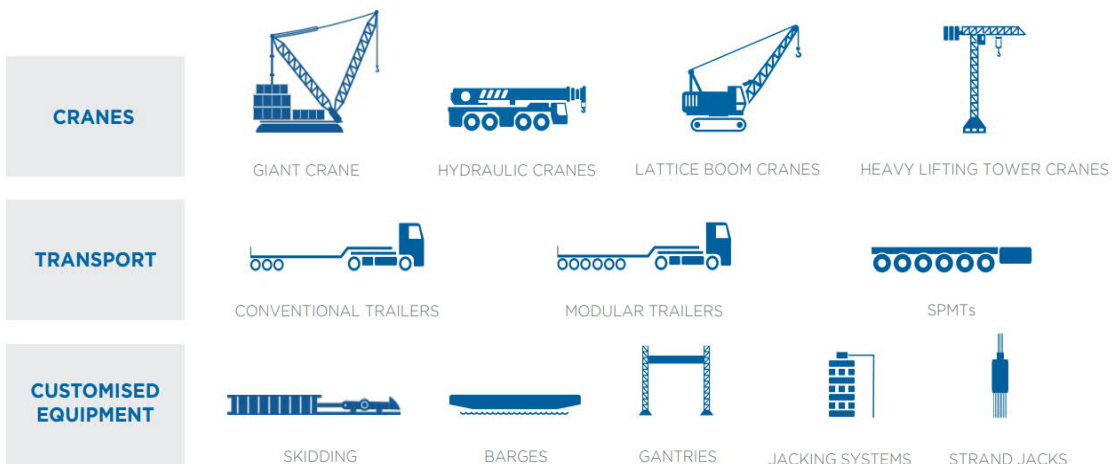


Figure 5 Typical types of Equipment used for Modular Moves and Component Builds. Image courtesy of Sarens



## Notable builds

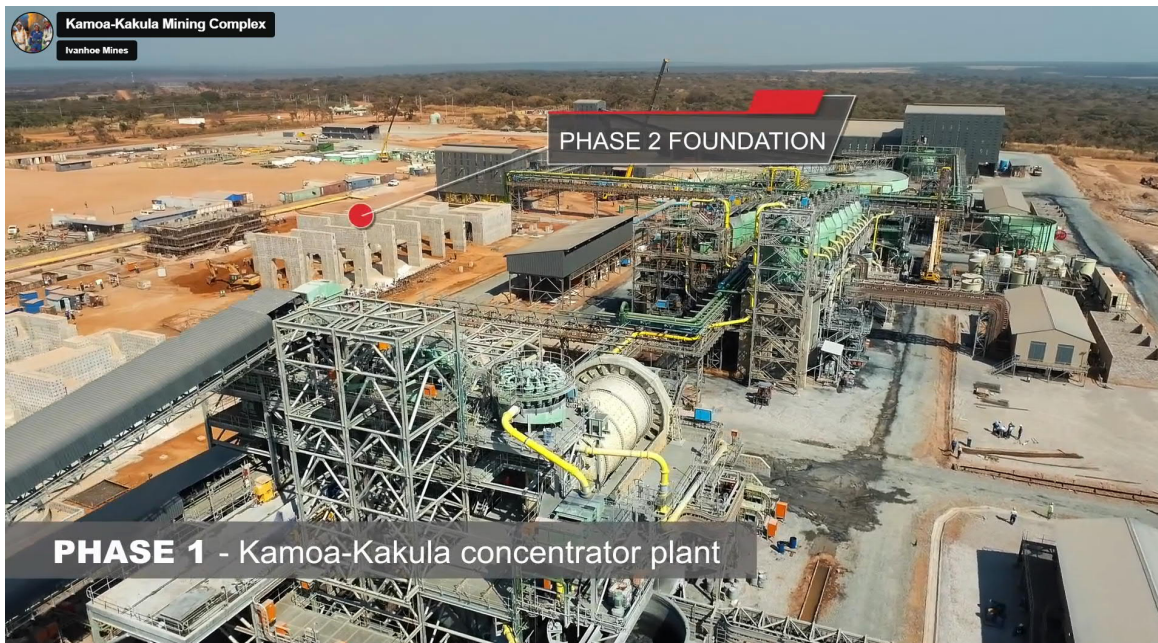
Kamoa-Kakula Mining Complex is an example of a recently build modular copper mine processing facility that places emphasis on the ramp-up possibilities of a modular build design assembly. Ramp-up of production by phase is a subject of foremost importance as critical metals facilities need to match growing production demand for critical metals.

The Kamoa-Kakula Mining Complex in the Democratic Republic of Congo, a joint venture between Ivanhoe Mines (39.6%), Zijin Mining Group (39.6%), Crystal River Global Limited (0.8%) and the Government of the Democratic Republic of Congo (20%), has become one of the world's largest copper producers since it started commercial operations on July 1, 2021. The complex, which consists of four ore bodies located in the Central African Copperbelt, a very large, near-surface, flat-lying, stratiform copper deposit with adjacent prospective exploration areas within the Central African Copperbelt, 25 kilometres west of the town of Kolwezi and about 270 kilometres west of the provincial capital of Lubumbashi.

The mine uses a modular design for processing plants. The processing plants were built off-site by contractors such as FLSmidth, Outotec and CITIC Heavy Industries and then transported and assembled on-site using cranes, trucks and trailers. Kamoa-Kakula began producing copper concentrates in May 2021 and began commercial production on July 1, 2021.

Modular phased expansion is projected to make Kamoa-Kakula the second largest copper complex globally. Kamoa-Kakula is powered by clean, renewable hydro-generated electricity and is projected to be among the world's lowest greenhouse gas emitters per unit of metal produced, as confirmed by a 2020 independent audit performed by Hatch Ltd., of Mississauga, Canada. Phase 1 of the Project consists of a 3.8 Mtpa mine and concentrator. The concentrator is designed using a modular approach with the second 3.8 Mtpa stream to be constructed as the mine ramps up. This phased approach using modular-built components, is evident in the two processing trains shown in the figure below (See Fig. 6).





*Figure 6 Image Credit: Kamo-Kakula Phase 1 Modular Built Processing Stream, Ivanhoe Mines Ltd.*

## BHP's South Flank Iron Mine

A recent exemplar modular-built mine is BHP's South Flank Iron Ore Mine in Pilbara region, Western Australia. The mine first entered production in May 2021. Annual production capacity is 80 Mt/y.

Dutch company Mammoet again played a key role in moving roughly 1900 modular components for the South Flank build (Typical component bracket moved along Fig. 7).





*Figure 7 South Flank Mine Modular Bracket part being moved out of factory. Courtesy of Civmec*

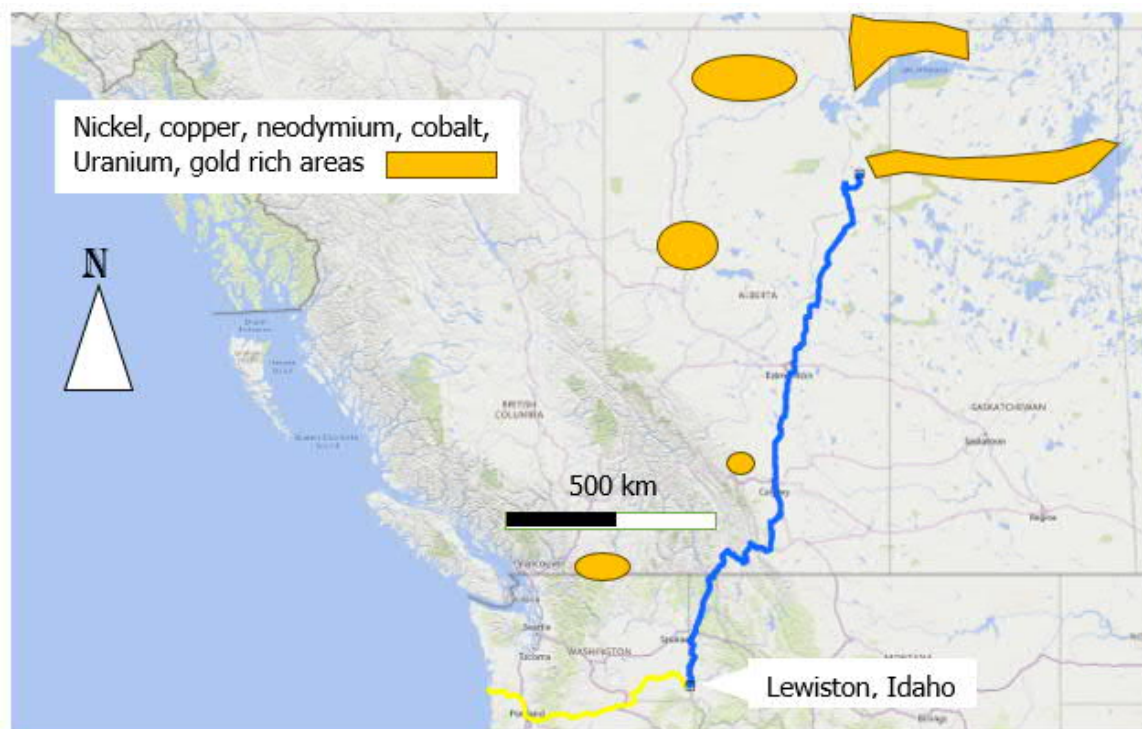
It will form the largest operating iron ore hub in the world, producing 145 Mt/y of iron ore each year. The heaviest modular build component move was a 349-t module comprising the train load out bin gate and HPU module. It was the heaviest object ever sent along a 340 km stretch of Western Australia's Great Northern Highway. Fluor was the EPCM provider on the project. Customer satisfaction with big top modular built style mines has been high. As noted by Steve Campbell, General Manager of South Flank Mine, in regard to the South Flank modular mine build: "Capital cost efficiency using a modular build was one half of what it cost BHP on its previous iron ore project."

### **A modular way for critical metals**

In Western Canada, historically oversized modular construction has been used for processing facilities for oil sands. Modular built heavy oil mines processing facilities has improved previously as transportation route into Western Canada for oversized modules transported by Mammoet. This proven route for entry of modular build mine components can also benefit the critical metals mining industry as a proven transport route. Oversized modular cargoes importing or exporting from the Port of Portland or Port of Vancouver utilize the Columbia Snake River System option by navigating through 8 locks and dams, traveling 465

river miles over an average three-day period to reach the Port of Lewiston. The Port of Lewiston is the most inland seaport in Western US. The port, with its 275-foot dock, allows offloaded oversized modules to road travel into Western Canada via the route marked in blue in Figure 8.

The key insight: metal mine areas are next door spatially to existing oil sands processing facilities. A proven route for modular builds for the heavy oil sands industry, now can now be used to develop critical metal rich areas in mine friendly Saskatchewan and Alberta.



*Figure 8 Modular module build entry route already proven by another industry: Oil Sands Modular Builds Have Proven Route (Yellow is inland river route for oversized modules to be offloaded in Lewiston, Idaho, blue route is oversize route improved by Heavy Oil Sand modules, which can also be used for metal mine modular transport to critical metals rich areas noted in orange. Author's Figure.*

This already proven routes bypass most hindrances to large modular transport. Hindrances such as tunnels, power lines, and turning radius limitations. It is a cost-effective route for metal mining companies to transport modular units for more quickly built critical metals mines.



# Conclusion

Modular mining factory-designed and prefabricated units offer many advantages. This includes cost savings, time efficiency, improved safety standards, and reduced environmental impact. Successful examples such as the South Flank Iron Ore Mine demonstrate quite amazing capital efficiency. Modular mining methods provide a compelling solution for rapid mine creation in places such as Western Canada for rapid mine development in critical metal-rich areas.



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