K-TOWN: PORTRAIT OF A THOUSAND-PERSON COLONY ON MARS. J. B. Greenblatt[1] and A. Rao[2], [1]Emerging Futures, LLC, 2726 Eighth St., Berkeley, CA 94710, jeff@emerging-futures.com, [2]Department of Economics, Warner Hall, 303 College St., Middlebury College, Middlebury, VT 05753, arao@middlebury.edu.

Introduction: For our submission to the Mars Society's 2019 Mars Colony Prize designing the first human settlement on Mars, we combined engineering analysis, urban design, detailed mass and energy flow modeling, aesthetics, and a unique set of economic, political and social considerations to develop a bold vision for the future of permanent human settlement on the Red Planet. Here we present the high-level results of this multi-month project, touching on settlement demographics, physical layout, major industrial activities, key economic drivers, and political principles that will have strong influences on positive outcomes. The analysis is not of a static outpost, but a dynamic, growing settlement that is passing *through* the 1,000-person mark on its way to a much larger population, eventually numbering in the millions.

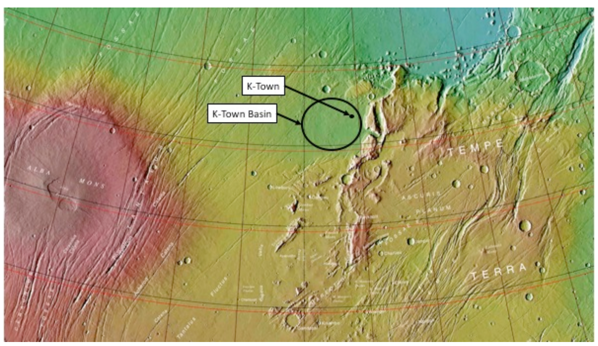

Fig. 1. Location of K-Town on Mars

Fig. 1 shows the chosen location of K-Town at 47°N, 274°E in a flat region of western Tempe Terra adjacent to a number of beautiful and scientifically interesting natural features. In 2049, during K-Town's hypothetical 10^{th} Mars year (M-year) of existence, its population is envisioned to have 607 permanent residents and 393 visitors, broken down into 204 professionals (business, medical, scientific, etc.), 96 tourists, 44 spacecraft crew on furlough, 26 guests from other Martian settlements, and 23 visiting college students. In addition to the temporary visitors who arrive every synodic period, K-Town welcomed 209 immigrants, and said "bon voyage" to 50 people permanently returning to Earth, bringing the net immigration rate down to 159 per synodic cycle. This represents a very rapid net growth rate of 13.7% per M-year.

Physical layout: K-Town is arranged as a set of semi-buried airtight structures providing radiation and micrometeorite protection for residents, while allowing ample interior space for multi-story buildings and open-air parks, gardens and fields. Domes are mainly composed of thick glass supported by periodic structural steel members. Fig. 2 shows structures within the heart of K-Town, which include a central region containing several interconnected open spaces for recreation. Arranged in a ring around the central region is a 50 m dia. curved half-cylinder containing the urban region, divided into 16 blocks each approximately 85 m long with a 5 m wide pedestrian and vehicle path in between each block. The maximum height of the half-cylinder is 25 m, sufficient to accommodate five to six stories, and an underground area exists down to 10 m below the entire urban ring, providing an additional two stories of habitation, storage and facilities space.

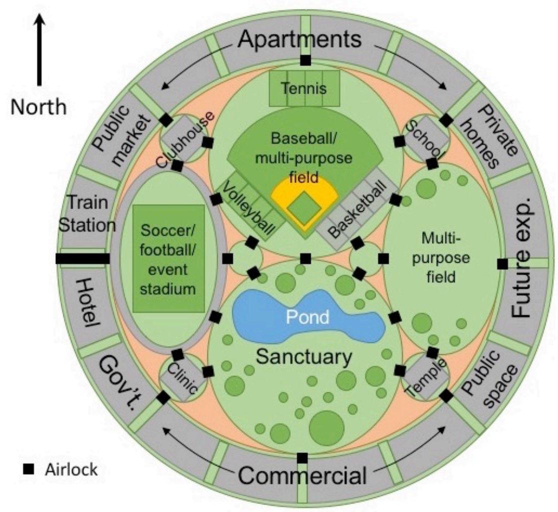

Fig. 2. Detail of K-Town central region.

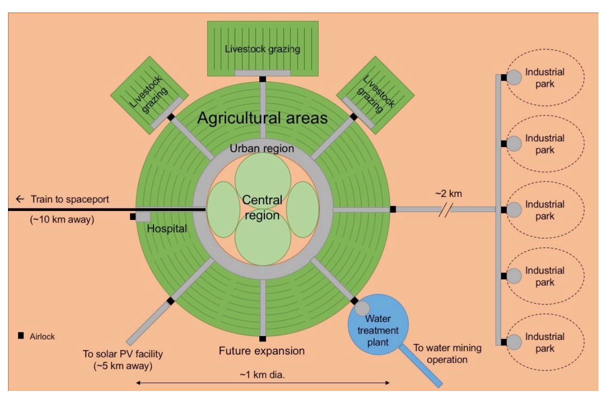

Fig. 3. Map of K-Town and vicinity

Fig. 3 shows the full town layout, revealing large agricultural areas surrounding the urban ring. Coverings are again mainly glass in order to minimize the use of artificial lighting and efficiently utilize the available area for production. (During dust storms, however, such lighting is essential to maintain crop production.) Although they are thinner, conferring less radiation protection as a result, all aspects of farming are highly automated, minimizing human exposure.

The design of K-Town is highly modular, so that multiple "copies" of the basic layout can be replicated across the K-Town Basin (an ellipse of approximately 225 km x 190 km, or 33,600 km^2, about 38% of the area of Greater Los Angeles) as population expands.

Industrial activities: Physical flows of materials in K-Town are nearly closed-loop, as making things completely closed would require exorbitant amounts of time and/or energy to realize. Designs strive for ≥95% reuse of materials, and is expected to improve over time as technologies mature. Emerging Futures used a computer model it developed called ASTER (Analysis of Space Technologies, Economics and Resources) to provide estimates of the total flows of critical resources and energy throughout K-Town, its surrounding operations, and trading partners. Trade with other, smaller settlements on Mars as well as orbital locations in Mars orbit, nearby asteroids, the Moon, Earth orbit and, of course, the Earth's surface, are carefully considered from the perspective of necessary imports and exports that are likely to be economically competitive. Maximal self-sufficiency in the context of practical technical and economic limitations is a guiding principle. Because of Mars' abundant water, carbon dioxide, nitrogen and other minerals necessary for life, full food production including some animals appears feasible.

Economics: K-Town's economic system was designed with five interrelated goals in mind:

1. To provide citizens with economic freedom;
2. to minimize distortions and maximize allocative and productive efficiencies;
3. to minimize rent-seeking and economically unproductive activity;
4. to encourage savings, and therefore investment, for largely self-sustaining economic growth;
5. to prevent labor shortages or surpluses.

The first goal is achieved through a universal basic income (UBI). By ensuring citizens access to a source of funds, they are free from anxiety over their ability to live (particularly important in an environment like Mars, where even air is economically scarce) and free to pursue activities which they believe are valuable, even if they are not financially lucrative. The second goal is achieved by using depreciating licenses and a land value tax as the main sources of government revenue, rather than other, distortionary, taxes (such as on income or labor). Depreciating licenses contribute to the third objective, as does the cooperative ownership structure of many K-Town enterprises. The fourth is achieved by the Central Bank of K-Town as part of their mandate, and is critical to the self-sustainability of K-Town's economy. The fifth is achieved through a combination of immigration policy and the use of UBI to offset the need for living wages.

At a high level, K-Town's economy was approximated using a Solow model of economic growth. The model describes a "bootstrapped" economy: an initial infusion of resources from outside its economy is provided, after which the economy grows using almost entirely its own resources. The key idea is that a substantial amount of the output produced in each time period is reinvested in additional capital stock, with which to produce more output in the future. Similar models have been used to study space colonies at Sun-Earth L5 and on the Moon, where an initial infusion of resources from Earth is used to springboard a mostly self-sustaining space colony.

Exports: While Earth has superior manufacturing and supply chain capabilities, its deep gravity well makes it more expensive to ship anything into space if it can be made reasonably cheaply elsewhere. The lower gravity of the Moon and asteroids, however, present in some cases challenging economics for Mars to compete against. The main advantages Mars has over other space locations are twofold: 1). superior manufacturing capabilities in some areas, due to a larger human presence and more developed infrastructure, and 2). abundant carbon and nitrogen, two elements that are very limited on the Moon. Examples for #1 include metal alloys and equipment, and platinum group metals that, if discovered in sufficient concentrations on Mars, could be exported competitively, while for #2 include food, fiber, plastics, organic chemicals, carbon-based fuels, fertilizers and inert gases (N_2/Ar) used for breathing air and industrial processes. Moreover, water and oxygen, while not cost-competitive with the Moon, may be convenient to export to Mars orbital locations and some nearby asteroids. Finally, some materials are valuable simply because they're Martian, such as homegrown K-Town products and perhaps even Mars gold. We estimate an export flow of >4,000 t/M-year and revenues of nearly $1 billion/M-year.

Conclusions: Although 1,000 people may be on the low end of what is needed for industrialization, automation would presumably also be high, and there would be a significant diversity of jobs, social roles and activities, with a robust tourist industry as well as a steady stream of guest professionals (including college students) from Earth, smaller settlements on Mars, and nearby orbital locations that could make K-Town a viable concept. Come dream with us about the largest human settlement on Mars!