Med*inas Partner Environmental Spotlight Series No. 1*

Harmony Medical Solutions Medbays

By Daniel Brian

1. About the Environmental Spotlight Series

At Medinas, we believe that all businesses should be stewards of the environment. That's why we streamlined our operations and sought (and received) third party validation of our sustainability efforts from the Green Business Bureau, which provided Medinas with its Platinum certification. It's also why we always rigorously analyze and optimize our own services to maximize their environmental benefits to our partners. In our recent pilot study, for example, we determined that Medinas's remarketing platform can provide huge upstream and downstream environmental benefits for our partner hospitals.

We found the study so helpful in making business decisions that we decided to take our analysis a step further. Why only study our own operations, we decided, when lessons could be learned from our partners, many of whom are pushing the envelope on sustainability with their own businesses? That decision to study and learn from our partners is how the Environmental Spotlight Series was born. The goal of the spotlight series is to identify, analyze, and highlight products and services provided by our partners that are on the cutting edge of environmental innovation. We plan to bring the same rigor to analyzing the human health and environmental lifecycle benefits of those innovations as we do our own operations. By quantifying the environmental and human health benefits of our partners, we hope to catalyze an industry-wide transition towards sustainable operation.

If you know of a company, service, product, or other innovation that you think should be featured in the next Medinas Environmental Spotlight, please email our green team at green@medinas.com.

2. About Harmony Medical Solutions Medbays

For our first spotlight series, we chose Harmony Medical Solutions, a Tennessee company founded by industry veterans Shirin Charkhkar and Ed Petrovskis. Combined, Ed and Shirin have over 40 years of experience in the diagnostic imaging sector. Harmony was founded to offer high-quality installation, refurbishment and repair services for diagnostic imaging systems. But they quickly realized that those services could only be provided feasibly in a limited number of developed countries, despite the fact that developing countries have a much greater need for diagnostic imaging services, particularly affordable services carried out through reuse of refurbished equipment. Their solution: Harmony medbays.

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Harmony medbays are prefabricated, modular medical facilities created at Harmony's Goodlettsville, Tennessee facility within standard 40 foot long, high cube shipping containers. The medbays are turn-key medical facilities that come fully insulated and shielded, with LED lighting, self-contained HVAC and backup power. Harmony primarily outfits them with refurbished diagnostic imaging equipment, including X-ray, Mammography, Ultrasound, and CT. They are customizable enough, however, to be used as primary care facilities, pharmacies, or surgical centers.

By making the medbays highly transportable and largely self-sufficient regardless of infrastructure and grid conditions in their target area of deployment, Harmony's goal was to create a flexible, affordable tool that would be ideally suited to bringing diagnostic imaging to developing countries and disaster areas. And by using modular fabrication methods, standard shipping containers, and refurbished equipment, they hoped to reduce costs and the environmental impacts of providing diagnostic imaging services as compared to the status quo.

In this spotlight, we focused on quantifying both the human health and environmental benefits of Harmony's medbays.

For **human health impacts**, we analyzed the:

- Benefits of increased access to radiology services; and
- Benefits of deploying diagnostic imaging quickly to disaster areas.

For **environmental impacts**, we considered:

- Upstream and downstream benefits of using refurbished equipment and shipping containers, as compared with new products;
- Efficiencies and cost savings of modular construction; and
- Lifecycle benefits of shipping container construction

3. High-Level Conclusions

In brief, we found significant, across-the-board environmental benefits from utilizing Harmony's medbays when compared with the option of building facilities in situ using traditional construction methods as well as upstream and downstream environmental benefits from utilizing pre-owned equipment and materials when constructing the medbays. Harmony's Medbays reduce:

- construction waste by up to 70%;
- greenhouse gas emissions from construction by up to 86%;
- Greenhouse gas emissions from equipment procurement by up to 60%;
- usage of metals, semimetals, and rare earth elements by between 42% and 50%;
- construction costs by up to 20%; and,
- equipment procurement costs by up to 50%.

Harmony, by refurbishing equipment, will also divert from landfills and recycling facilities in developing countries thousands of pounds of electronic equipment containing PCBs, heavy metals, and radioactive materials.

The environmental benefits are dwarfed, however, by the dramatic human health benefits of the medbays. The prevailing literature indicates that a lack of diagnostic imaging is one of the leading causes of premature mortality in developing countries. And it is also essential for optimizing triage in disaster areas. To be effective, however, diagnostic imaging equipment requires a stable power source and highly controlled operating conditions. Those conditions simply do not exist in most third world countries and disaster areas. Which means that medbays aren't just the more sustainable option for saving lives in these circumstances, they're the only option.

4. In-Depth Analysis

The below analysis analyzes the human health and environmental benefits of Harmony's medbays. It utilizes third party, NGO, and academic studies wherever they are available to provide baseline and reference metrics.

a. Human Health Impacts of Harmony Medbays

i. Access to diagnostic imaging services in developing countries

Lack of access to diagnostic imaging in developing countries is one of the leading causes of improper or inadequate diagnosis, and early mortality, in developing countries. "According to the World Health Organization (WHO), approximately 3-4 billion people are at risk for widespread losses and deaths that can be avoided or treated if radiology were available."[1] That is because:

> . . . in some 20%-30% of cases worldwide, clinical considerations alone are not sufficient to make a correct diagnosis. A child with severe cough and fever, for example, is often diagnosed to have pneumonia, although an X-ray examination

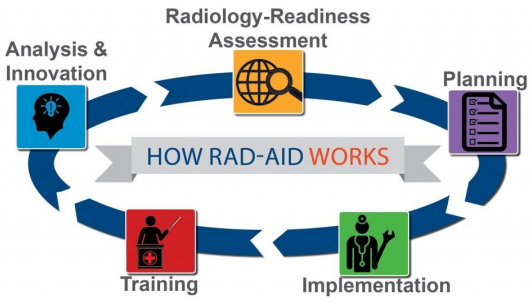
[1] RAD-AID 2016-2017 Annual Report, Page 12 (available at https://www.rad-aid.org/wp-content/uploads/2016-2017-RAD-AID-Annual-Report-Web-Version.pdf).

may uncover information to indicate a different condition and avoid the expensive and potentially dangerous antibiotics that would otherwise be prescribed.[2]

The challenge of creating an environment conducive to provision of diagnostic imaging services is best described by RAD-AID. RAD-AID is a nonprofit founded in 2008 with "one simple mission: to increase and improve radiology for poor and resource-limited countries and communities of the world.[3] Since its founding, RAD-AID has grown to include more than 6700 volunteers from 100 countries, 45,000 web visitors per year, 55 university-based chapter organizations, on-site programs in 25 countries, and an annual conference on global health radiology."[4]

RAD-AID realized that providing diagnostic imaging services wasn't as simple as simply shipping ultrasounds or x-rays overseas. "Closing the radiology gap also means overcoming many non-medical challenges: a lack of electricity, roads, or an information system to store the images."[5] In order for healthcare providers to be able to make effective use of the machines, RAD-AID identified a bundle of essential prerequisites that had to be in place. They boiled those prerequisites down into a "radiological readiness checklist" that they use to assess whether a given location is ready to receive diagnostic imaging equipment.[6] Many of those prerequisites fall into the category of infrastructure requirements, which are evaluated in the "Structural, Electrical, Climate Control, and Transportation Infrastructure" section of the survey.[7] They seek to assess:

- How reliable the power grid is;
- How stable the power grid is;
- Whether backup power is available at the facility;
- Whether they have voltage stabilizers in place;
- How the facility is built (materials);
- Method of flooring construction;
- Facility weight-bearing capacity;
- Indoor temperature range and humidity; and
- State of roads leading up to the facility.[8]



[2] "Essential Diagnostic Imaging," Published by the World Health Organization, available at https://web.archive.org/web/20121023154427/http://www.who.int/eht/en/DiagnosticImaging.pdf.
[3] RAD-AID 2016-2017 Annual Report, Page 2
[4] RAD-AID 2016-2017 Annual Report, Page 12
[5] "Most of the World Doesn't Have Access to X-Rays," published in The Atlantic 9/27/16, available at https://www.theatlantic.com/health/archive/2016/09/radiology-gap/501803/.
[6] *See* Introduction to the RAD-AID Radiology-Readiness(™) Survey (2013), available at https://3ymebab1r2y1lmyvx5km8q19-wpengine.netdna-ssl.com/wp-content/uploads/Radiology-Readiness-2013-RAD-AID.pdf.
[7] Introduction to the RAD-AID Radiology-Readiness(™) Survey (2013), PDF Page 30.
[8] Introduction to the RAD-AID Radiology-Readiness(™) Survey (2013), PDF Pages 30-33.

If too many of these questions are answered in the negative, RAD-AID will deploy diagnostic imaging equipment elsewhere "so that resources are not wasted."[9]

Harmony's medbays solves every single one of these issues, ensuring that structural, electrical, climate control, and transportation infrastructure issues will not stand in the way of a facility providing diagnostic imaging services. The medbays have their own backup power and power stabilizers, which mitigate concerns about grid reliability, stability, and facility backup power. They are built to United States construction standards for hospitals, which ensures there is no concern about how the facility is built or it's ability to bear weight. The medbays also have their own HVAC system, so indoor temperature range and humidity are self-managed. And finally, they can be helicoptered into place, which obviates the need for high-quality paved roads leading up to the facility.

RAD-AID does not make available to the public statistics regarding how often facilities fail Radiology Readiness Assessments due to structural, electrical, climate control, and transportation infrastructure reasons, as opposed to the other reasons set forth in the radiological assessment. So we can't quantify a specific percentage of the underserved population that could be served by medbays but not by traditional diagnostic imaging setups. Given that the total unserved population may be as high as 4 billion people,[10] however, any increase in the number of locations where diagnostic imaging services are feasible will have a huge impact. If medbays expand the feasible diagnostic imaging population by only 10%, for example, 400 million more people would be able to receive those services. If it is higher, the impact would be even greater. We can assume, then, that medbays may be the only feasible method of providing crucial diagnostic imaging services to hundreds of millions of people.

Rad-Aid is constantly "work[ing] hard to find innovative solutions for medical imaging," because it is such an important and difficult problem. This analysis indicates that Harmony's medbays may just be the solution Rad-Aid is looking for.

ii. Access to diagnostic imaging services in disaster areas

Because medbays are self-contained, can operate in a wide range of weather and infrastructure conditions, and can be air-dropped in quickly via helicopter, they are uniquely suited to being deployed in disaster areas. Though it is logical that having diagnostic imaging services could be beneficial in disaster areas, how and when they would be used to mitigate man-made and natural disasters is uncertain. According to a study in the British Journal of Radiology, however,

[9] "What is Radiological Readiness?" available at https://www.rad-aid.org/resource-center/radiology-readiness.
[10] RAD-AID 2016-2017 Annual Report, Page 12.

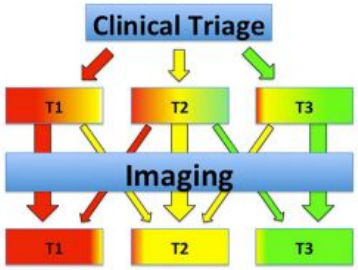
they will be exceptionally useful in two areas: (1) Eliminating constraints on limited diagnostic imaging resources, and (2) streamlining field triage of victims.[11]

In "Emergency Imaging after a Mass Casualty Incident: role of the radiology department during training for and activation of a Disaster Management Plan," the authors analyzed the role and impact of diagnostic imaging services in disaster areas. They noted:

> In a mass casualty incident (MCI), the number of casualties by definition overwhelms available resources. There is no specified number of victims to define a MCI, since the number of victims at which resources become overwhelmed depends on baseline capacity. In MCI events, the care paradigm shifts from the greatest good for each individual to the greatest good for the greatest number of victims, potentially resulting in focusing care only on the portion of the affected patients most likely to benefit.[12]

In these circumstances where medical resources are the limiting factor in providing care, figuring out the right level of care each victim requires becomes of the utmost importance. Medical personnel in disasters tend to mass triage patients by sorting them into three categories: T1 Red (those needing medical attention to survive), T2 Yellow (those with injuries, but who are able to wait), and T3 Green (those with minor injuries). Though there are best practices in place for doing so, all existing methods "produce a considerable rate of undertriage (falsely lower category) and overtriage (falsely higher category)." When the authors "analysed overtriage rates and mortality in several [disasters, they] found an almost linear positive correlation between the overtriage rate and mortality."[13] In other words, counterintuitively, the worst medical outcomes occur when medical professionals are over-cautious and place people in too high of a category (yellow instead of green, or red instead of yellow). That overtriaging uses up limited resources, which takes those resources away from the victims who need them immediately, leading to increased death among those victims.

The solution, the authors determined, was "in essence . . . to increase accurate triage, thereby reducing resource burden and mortality."[14] "Patients tagged yellow (T2) typically need at least some basic imaging to detect if they are under-triaged (correct to red, T1) or overtriaged (correct to green, T3). In patients tagged red, imaging should be limited if they need to be transferred quickly to the OR



[11] Berger, Ferco & Körner, Markus & Bernstein, Mark & Sodickson, Aaron & Beenen, Ludo & Mc Laughlin, Patrick & Kool, Digna & Bilow, Ronald. (2016). Emergency Imaging after a Mass Casualty Incident: role of the radiology department during training for and activation of a Disaster Management Plan. The British journal of radiology. 89. 20150984. 10.1259/bjr.20150984.
[12] *Id.* at 1 (internal citations omitted).
[13] *Id.*
[14] *Id.* at 5 (internal citations omitted).

(pericardial effusion, large hemothorax etc.)."[15] The above figure shows how diagnostic imaging can be used to reduce undertriage and over triage, thereby saving lives. "With appropriate availability," they concluded, "[diagnostic imaging] can consequently help to correct errors in prior triage and to prioritize need for further interventions and operations by reducing the overtriage rate."[16]

Medbays can be dropped quickly into disaster zones in large numbers, which would have the dual benefit of providing the "appropriate availability" of diagnostic imaging[17] and correcting errors in prior triage as discussed above. They are the only diagnostic imaging solution we analyzed that It is clear, therefore, that they can have a sizeable and unique role in responding to disasters.

b. Environmental Benefits of Harmony Medbays

i. Benefits of using refurbished equipment and shipping containers

Harmony uses refurbished diagnostic imaging equipment, purchased on the secondary market and refurbished in-house, to produce most of its medbays. The cost savings to end-customers of doing so are massive. "Often, refurbished machines cost 50 percent less than new ones."[18] And the lifespan of refurbished equipment is often not significantly shorter than that of new equipment. But there are also massive upstream and downstream environmental benefits of utilizing refurbished medical equipment that Harmony realizes by forgoing new imaging equipment.

1. Upstream environmental benefits of using refurbished equipment

In our pilot study white paper, we noted the significant upstream benefits of using refurbished equipment. Simply put, each piece of diagnostic imaging equipment that is refurbished rather than disposed of or recycled is a piece of new electronic equipment that does not need to be manufactured.[19] "According to prevailing environmental literature," we noted, "reuse is one of the only viable ways of reducing the lifecycle impact of electronics such as those used in hospitals, as recycling unfortunately does very little to reduce those impacts."[20] Using

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[15] *Id.*
[16] *Id.*
[17] *Id. (*"The maximum capacity of patients that can be examined simultaneously may be limited by the number of rooms, devices (such as X-ray generators, plate readers or printers) and technical staff." Medbay deployment can help solve the first two.)
[18] Jackson, Whitney, "Is Refurbished Imaging Equipment Right for You?" (6/12/2012), available at https://www.diagnosticimaging.com/vendors/refurbished-imaging-equipment-right-you.

[19] Brian, Daniel, "Environmental Benefits of Partnering with Medinas," (10/18/2019), Page 2, available at https://www.medinas.com/wp-content/uploads/2020/01/191018-Green-Writeup-Medinas-4.pdf.
[20] *Id.* (internal citations omitted)

refurbished equipment instead of new, we concluded, yields the following environmental benefits:

- An over 60% reduction in greenhouse gas emissions as compared to purchasing new equipment, which is especially notable because a full 59% of hospital greenhouse gas emissions come from equipment procurement;
- A 50% reduction in human health impacts from manufacturing processes using radioactive materials and toxic metals; and
- A 42-50% reduction in metal, semimetal, and rare earth element usage as compared to purchasing new equipment.[21]

By using refurbished equipment in its medbays, Harmony will realize the same sizeable upstream benefits.

2. Downstream benefits of using refurbished equipment

We previously noted that "When waste isn't recycled or reused, it usually ends up in landfills."[22] Diagnostic imaging equipment such as x-ray, CT scanners, and mammography units, is particularly problematic in landfills or recycling centers because "it contains multiple heavy metals, such as lead, that can lead to human health, groundwater, and soil impacts . . . with additional environmental impacts and human health risks caused by radioactive materials."[23]

By reusing hospital equipment, Harmony will divert from landfills and recycling centers thousands of pounds of electronic waste. Over 96% of the waste diverted is expected to contain "PCBs (Poly-Chlorinated Biphenyls), as well as heavy metals such as lead, mercury, and cadmium," and 25% is "expected to contain radioactive materials, including Cobalt 60, which has a halflife of over 5 years."[24]

ii. Efficiencies of using pre-owned shipping containers to produce medbays

In addition to the upstream and downstream benefits of using refurbished equipment, Harmony will recognize additional benefits by utilizing pre-owned shipping containers in the construction of its med bays. According to a study in Energy and Buildings, "[r]eusing shipping containers is the ultimate in sustainability, using far fewer materials and embodied energy than any kind of

[21] *Id.* (internal citations omitted)
[22] *Id.* at 1.
[23] *Id.* at 1.
[24] *Id.*

building construction.[25] Put another way, "building construction . . . consumes huge energy and emits large quantities of greenhouse gases," so "reuse of shipping container would help in reducing environmental impacts."[26] Specifically, studies indicate that, under a lifecycle analysis approach, "a reduction of 86% CO2 emission was obtained [by using shipping containers for construction as] compared to a benchmark" conventional construction methodology.[27]

While there are construction challenges when using pre-owned shipping containers instead of new, which the study identifies, the potential reductions in waste and greenhouse gas impacts Harmony will realize by using pre-owned containers are worthwhile.

iii. Efficiencies of using modular construction to produce medbays

Regardless of whether Harmony uses pre-owned or new shipping containers to create medbays, the cost savings and environmental benefits of modular construction, as compared to traditional construction, will be sizeable. According to a recent study by McKinsey & Company[28] modular construction such as the type utilized by Harmony can "realize more than 20 percent in construction cost savings" as compared to conventional construction. When considering the limited financial capabilities of the developing country hospitals who are Harmony's target medbay purchasers, a 20% reduction in construction costs is quite meaningful. Particularly when that savings can be aggregated with the up to 50% savings Harmony will experience by using refurbished rather than new equipment.[29]

5. Conclusion

Harmony's medbays have the potential to be a world-changing product. When deployed at scale, they have the unique potential to bring diagnostic imaging services to hundreds of millions of people who live in developing areas that are not conducive to traditional diagnostic imaging systems, with the potential to save millions of lives. The medbays are also perfectly suited for use in disaster areas, where they can save lives by increasing the accuracy of triage for medical personnel responding to both man-made and natural mass casualty events.

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[25] Islam, Hamidul & Zhang, Guomin & Setunge, Sujeeva & Bhuiyan, Muhammed. (2016). Life cycle assessment of shipping container home: A sustainable construction. Page 1. Energy and Buildings. 128. 10.1016/j.enbuild.2016.07.002. (internal citations omitted)
[26] *Id.* at 2.
[27] *Id.* at fn 38 (N. Jewell, Upcycle House: Lendager Arkitekter Unveils Incredible House Made Entirely from Recycled Materials. September 16, 2015, 2013 www.inhabitat.com/upcycle-house-lendager-arkitekter-unveils-incrediblehouse-made-entirely-from-recycled-materials/.)
[28] McKinsey & Company, "Modular construction: From projects to products," available at https://www.mckinsey.com/~/media/mckinsey/industries/capital%20projects%20and%20infrastructure/our%20insights/modular%20construction%20from%20projects%20to%20products%20new/modular-construction-from-projects-to-products-full-report-new.ashx
[29] See, infra, note 18.

Harmony's medbays are also much more sustainable, and affordable, than traditional construction of diagnostic imaging clinics. By using modular construction, refurbished equipment, and repurposing construction materials, Harmony can reduce:

- construction waste by up to 70%;
- greenhouse gas emissions from construction by up to 86%;
- Greenhouse gas emissions from equipment procurement by up to 60%;
- usage of metals, semimetals, and rare earth elements by between 42% and 50%;
- construction costs by up to 20%; and,
- equipment procurement costs by up to 50%.

Harmony, by refurbishing equipment, will also divert from landfills and recycling facilities in developing countries thousands of pounds of electronic equipment containing PCBs, heavy metals, and radioactive materials.

All in all, it would have been challenging to find a single product or service for Medinas's first environmental spotlight that offers more human health and environmental benefits than the Harmony medbays.