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Camp Roberts: Tactical Network Topology (TNT) / Mission-Based Experiments (MBE) / Concept-Based Experiments (CBE)

QuickLook Report

Observations of Humanitarian Infrastructures: Power, Water, Lighting, and Cooking. Facilitated by the TIDES Project (Transportable Infrastructures for Development and Emergency Support):

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Background

The TIDES[1] project is an international, knowledge-sharing research effort to encourage sustainable, affordable support to stressed populations in post-disaster, post-war, or impoverished environments. These environments include missions such as Stabilization and Reconstruction (SSTR), Humanitarian Assistance-Disaster Relief (HADR), and Building the Capacity of Partner Nations (BPC). By and large, TIDES is used to refer to specific projects which can draw on the world-wide assets of the STAR-TIDES (ST) network. TIDES is a part of a broader effort called STAR (Sustainable Technologies, Accelerated Research).

TIDES addresses domestic and foreign situations, for short- or long-term operations, with or without involvement of the military forces. Its intent is to promote unity of effort among diverse organizations where no unity exists. As such, TIDES seeks to build bridges of interoperability across the boundaries of business, civil society and government stakeholders who are working toward common goals. The principal means to accomplish this mission are: (1) social network development, (2) trust building within and among social networks, (3) sharing information and "sense-making" approaches, and (4) cost-effective logistic solutions.

Goals

The February TNT/MBE[2] tests were TIDES's first opportunity to participate in the Naval Postgraduate School (NPS)/Special Operations Combatant Command (SOCOM) field tests, where Dr. Ray Buettner, Naval Postgraduate School, advised the TIDES team to devote time at Camp Roberts to achieving two goals:

1. To acclimate to the unique environment that Camp Roberts provides for observing packages/systems of products in the field, building relationships with key people, creating mashups between products, and studying the human and physical terrain in preparation for future MBE tests.
2. To establish procedures and experimentation designs for future testing of infrastructures that support stressed populations, such as shelter, water, sanitation, power, ICT, cooking, and heating/lighting/cooling. Since this type of testing has not been tried in this context, many lessons could be learned by conducting procedures within specific experimentation venues in the field.

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[1] TIDES = Transportable Infrastructures for Development and Emergency Support

[2] Tactical Network Topology (TNT)/Mission-Based Experiments (MBE) are conducted quarterly by the Naval Postgraduate School (NPS), Monterey, California and the US Special Operations Command (US SOCOM).

Based on these goals, the TIDES team limited the scope of observation to four of the seven infrastructures on the TIDES research agenda:[3]

1. **Power**: an exploration of the core metrics and procedures to measuring the performance of solar and wind generators, as well as hybrids, combining these systems with fossil fuel generators.
2. **Water:** an exploration of how to compare a wide range of purification techniques, from pills to large ultra-filtration water closets and portable reverse-osmosis purifiers.
3. **Lighting**: an exploration of how to measure the performance of solar and hand-generator (shaken, cranked, or squeezed) lights, with the goal of finding inexpensive systems to extend the hours of usable light in the developing world.
4. **Integrated Cooking**: an exploration of how to measure ways to combine solar ovens, high efficiency combustion stoves, and retained heat baskets to reduce fuel consumption compared with traditional cooking instruments.

The primary objectives of the TIDES team were to learn how to design experiments for future rounds of MBE tests, and to assess how the integration of the infrastructures for implementation, training, and social effects.[4]

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[3] TIDES examines low-cost approaches to shelter, water, power, integrated cooking (combustion, solar, retained heat), heating/lighting/cooking, sanitation and information and communication technologies (ICT).

[4] DISCLAIMER: All information produced by the STAR-TIDES project is intended to be in the public domain. All intellectual property right claims should be clearly identified by contributors prior to submission.

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Observations

The team observed qualitative and quantitative results at both the individual and experimentation design levels. The observations from the quantitative experiments were not considered necessarily repeatable, nor did they meet the high mark of standardized testing criteria, but they were considered a method for the TIDES team to train on and observe different types of infrastructures that could be used in disaster relief and development operations. The qualitative results gained from the use of the equipment were the key goal of TIDES' participation with the overarching TNT/MBE group. These qualitative assessments appear below.

Qualitative Results: Experimentation Design

The TIDES team explored best practices to measure the performance of tools from the perspectives of both responders and members of the affected population.

Based on discussions within the TIDES team, with Ray Buettner, and experiments in the field, three possible frameworks for experimentations of humanitarian infrastructures emerged:

Framework 1: Measuring water purification performance

For any purifier that requires water to flow through a unit (i.e., almost all purification techniques beyond those which add tablets/chemicals), the most important metrics involve the condition of the water as it relates to the filtration or purification system involved. Water temperature and total dissolved solids (TDS) affect the flow rates of water through membranes and filters; i.e., cold, salt water flows more slowly than warm, fresh water. Based on an exploration of pumps and water flows, the team devised the following set of metrics for assessing purifier performance:

Water Condition Metrics

- Total Dissolved Solids (TDS) Pre-purification (ppm)
- Water Salinity Pre-Purification (ppm)
- Water Temp (C)
- Turbidity (visual assessment)
- Source of Water (fresh, brackish, salt, contaminated)
- Taste (sweet, sodium, hard minerals, etc.)

Power Consumption/Generation Metrics

- Power source (solar, wind, microhydro, fossil fuel generator)
- Voltage (V)
- Amp Hours Consumed (Amp-hours)
- Amp Hours Generated (Amp-hours)
- Run Time (minutes)
- Watts Consumed (W)
- Watts Generated (W)

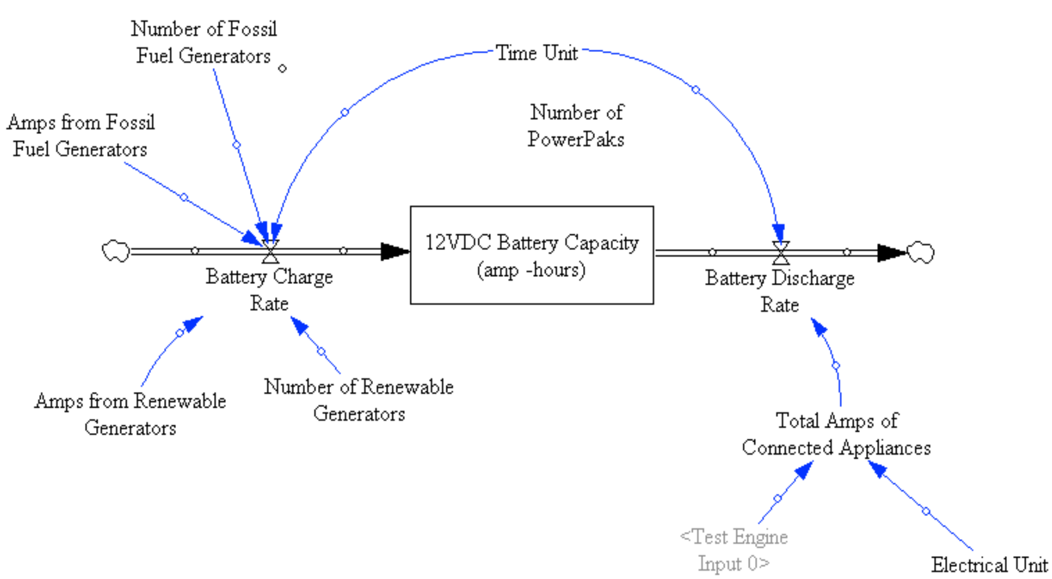
Purification Metrics

- Total Dissolved Solids (TDS) Post-purification (ppm)
- Water Temperature Post-purification (C)
- Time per gallon/liter created (liters/gal per minute)
- Watts/Gallon (W/gal) or liter (W/l), this is computed as (W/hr) / (l/hr)
- Total Product Generated (liters/gal)
- Total Product Flow (flow rate over time)

Framework 2: Measuring power generation

As the TIDES team discussed rural power generation and power generation for military Forward Operating Bases (FOBs), it was observed that power generation for the field has traditionally emphasized methods that provide continuous power output, such as fossil fuel generators. In this model, a portion of the fuel is converted to electric energy, which is available while the generator is running. However, the energy that is not immediately used is typically lost. Since most electrical devices do not draw continuous power (such as laptops and other ICT equipment), gasoline generators consume far more fuel by keeping their engines running than would be needed if only electrical power demand was required.

Since wasted fuel can force supply chains to bring unnecessary and heavy consumables to remote locations—putting people and equipment at risk—the TIDES team sought to remove the assumption of continuous power flow from the model. Instead, the team postulated that battery storage could create a stockpile of the majority of generated electricity using renewable energy sources (such as solar). Devices could run off this stock while one or more generating devices "top off" the battery during periods of peak sun. The TIDES team developed a system dynamics model of the stocks and flows of this framework:



In this model, the generators charging the batteries could be from any energy source, opening the possibility of hybrid systems which link (1) renewable generators (solar, wind, microhydro, biomass) with (2) gasoline or diesel generators for redundancy and energy security with (3) storage devices that can be drawn from as demand requires. Note: the *test engine input* variable in the model (on the discharge side) is a randomizing variable modeling the uneven power requirements of a set of electronics.

Key variables include:

- Amps generated per system (amps)
- Number of systems in array (count)
- Rate of battery charging (amp–hours)
- Capacity of battery (amp-hours)
- Rate of battery discharge (amp–hours)
- Total amps demanded by connected appliances (amps)

Framework 3: Building system tests of village-level infrastructures
Based on conversations between the NPS and TIDES teams, several sites at Camp Roberts were identified as ideal testing environments for two forms of infrastructures for emergency support:

1. **RESPONDER INFRASTRUCTURE**. SOUTHCOM has proposed partnering with TIDES to design Prepositioned Expeditionary Assistance Kits (PEAK), which aim to provide basic infrastructures for teams of emergency responders for the first two weeks of an international disaster response operation. Camp Roberts would provide an ideal environment to test various human system integration venues around a system of products that could provide ICT, water purification, shelter, power generation, cooking, heating/lighting/cooling, and sanitation to a team of responders over 10 days.

2. **AFFECTED POPULATION INFRASTRUCTURE**. The May (or August) experiments may offer TIDES an opportunity to set up an entire village in a remote part of the base. Based on ideas from NPS and others teams of volunteers perhaps college students from the local area could be invited to learn how to build shelters from supplied materials, testing the ease of training and difficulty of construction of various forms of shelter. The TIDES team hopes to gain an understanding of the variables at play when mentoring a static refugee population in establishing the basic infrastructures for short-term disaster response.

In particular, it would be possible to study the interoperability of components from SOUTHCOM's PEAK responder kits (above) with the ICT and power generation tools packaged for affected populations. Such interoperability could (for example) ensure that ICT dropped into a village could help responders ascertain the public health of the affected population from a remote location. Such experimentation could provide excellent interoperability opportunities for STAR-TIDES vendors, researchers, and operators working on both the responder and response side of the problem, as well as the study of human interoperability and human system integration.

Lessons Learned

I. Experimentation Design

Since Camp Roberts was STAR-TIDES' first experience in field experimentation, the TIDES team learned several key lessons about the design approach for future field experiments that could be transitioned to other types of efforts such as PEAK:

Limit the scope of work.

It is more effective to choose a relatively small number (about three) products and observe their independent and integrated uses over several contexts than to use many products within one context. The team learned that more time needs to be allotted for gathering information, as the operation of products has a learning curve and tests often need to be repeated due to minor problems, such as a faulty battery or miss-set timers.

It was sometimes necessary to replace instrumentation in the field, which was not readily on hand, delaying the experiment while a replacement was sought. Round trip to commercial stores from Camp Roberts site can take as long as hour an a half.

Think about staffing to enable time to learn and explore ideas

Understanding the context around a device takes time and study. Social, cultural, and technical conditions can radically alter the experimental set-up time and outcomes. For instance, an operator setting up a camera used to capture data might need to connect the device to a computer and require rain protection, causing a delay in experimentation and changing the outcome of the experiment in cases where photos are used or the photography is an important part of the test. In future testing, the TIDES team will need to include the cognitive-social-cultural factors as part of the experimentation design.

Implement opportunities for vendor "hands-off" experiments

In the future, people should be engaged who have not used a particular technology or have tacit knowledge of the technologies being assessed. It is important to show that a layperson can quickly learn a technology rather than a vendor demonstrating what the tool can do. Vendors are not a scalable resource in an emergency, but responders are.

Explore systems and integration

It is hard to make many kinds of infrastructures interoperable with people or as "human integrated systems." Future testing should provide insight on individual components, how those components integrate as systems and how individuals understand and apply those systems.

Focus on Human Factors

Camp Roberts provides a unique environment in which to assess the traditional human factor aspects of TIDES-related products, including the simplicity of use, ease of maintenance, and ruggedness.

Don't try to build apples-to-apples comparisons; instead, create case studies

It is very difficult (if not impossible) to create pure apples-to-apples comparisons in field experiments. Instead, case studies should be created that put the devices into plausible scenarios that field operators might encounter, and report on the results under known circumstances.

II. Relationship Building

Create "Charrettes" (for brainstorming sessions) on humanitarian gear

The STAR-TIDES model is not a governmental process-driven project, but a community-driven initiative. At MBE tests, the opportunity exists to bring people together around the challenge of humanitarian infrastructures. STAR-TIDES could challenge everyone in its community—from universities to vendors, NGO to government entities—with building humanitarian infrastructures that meet or exceed certain performance parameters. In an event or campaign similar to the DARPA Challenge for robots, the resources of the STAR-TIDES network could help create a competition of ideas that center on expanding the capacities and efficiencies of humanitarian infrastructures.

Engage in problem solving not just solution testing

The unique capacity of the STAR-TIDES network is its convening power. The TIDES team can draw on this to bring together experts from a range of fields to solve systems problems that involve multiple products interoperating in a specific context. While each individual product should be tested and vetted for use, this is not the task of the TIDES team. The TIDES team focuses on the MBE testing and on the problems that emerge when products are placed into juxtaposition in difficult field environments.

III. Infrastructure Tests and Findings

General

Finding culturally appropriate devices and methods is critical for adoption of new tools and for understanding how the tools will disrupt longstanding economic and social relationships in an affected community. The technology must be *their* choice, must be sustainable by them, and should minimize reliance on external sources of supply or maintenance.

Water
Test Water Conditions. To choose between water purification techniques and to site water purification devices, one must understand the conditions, pathogens and solids being removed from the water and those methods that work for best for that type of purification.

Cooking
Conversations with the Marines on the base (who had been deployed to Djibouti) led the TIDES team to believe that military cooks could also be trainers. Cooks have the knowledge to build integrated cooking. For example, the military has the manpower and skills to teach local artisans how to build rocket stoves from metals (including large 55-gal drums), as well as from other materials, such as masonry. For such an approach to succeed, the military would need to buy into such a training process, which was not immediately accepted within the one regiment queried by a Marine CWO.

Lighting
Luminance metrics are important for comparing apples to apples; however, what is most critical is the usability of the light. Can one accomplish a task with a given light, and for what period of time before the light wears out? Can the light be put into a culturally appropriate form factor? Can the light be so simple that it becomes a part of another system of the home? For instance, a designer recently created a venetian blind made of a material that radiates light after charging in the sun; users need do nothing more than close the blinds during the hottest part of the day to get several hours of usable light at night.

Conclusion
TIDES should continue its inventory assessment of humanitarian relief and development-focused products and find ways to evaluate them in integrated ways that relate to the cultures and people who will be using them.

Lessons Learned from use of hybrid power generators

Gasoline generators are designed to provide temporary power. They are not a permanent 24x7 solution, because they require a great deal of maintenance and consumables to continue running. If the gasoline generators are used for extended periods, they will experience numerous maintenance issues, which could include destruction of critical components. For example, a generator left running by an academic research institution last cycle threw a rod after running for several days solid.

Important considerations:

1. Gasoline generators can run a fixed number of hours on a given amount of fuel.
2. After a low number of refills (approximately 10 fuelings or alternatively about 250 running hours), generators must go through a maintenance cycle that includes lubrication and gasket replacement. This repair requires skilled labor and several hours of downtime.
3. Every few maintenance cycles, generators must go through a complete overhaul, requiring shipment to an authorized dealer and several days of downtime.
4. The fuel and other consumables must be brought into theatre, leading to each unit of fuel costing far more than the purchase price per liter.[5]

That said, gasoline generators currently are a trusted source of power during crises and outdoor events. Solar, wind, microhydro, or even local geothermal should be explored as hybrid solutions, which in some cases, may be able to serve as a primary modes of generation.

Future exploration of hybrid generation models

Gasoline generators could be started at different times to maintain uptime. In this sense, they form an aging chain in which one would wear out a generator, take it offline, and replace it with another. With battery backups preventing downtime (like a UPS), it might be possible to use gasoline generators indefinitely. The key would be to find a system with the right number of generators to allow for 250-hour maintenance cycles and complete rebuilds of generators in the aging chain. A system dynamics model of this system would be intriguing to build, particularly considering the price of gasoline, cost of shipping gasoline, and the expenses associated with maintenance cycle consumables and rebuilds endogenous to the model. The TIDES team hopes to answer the question: how much does a generator really cost?

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[5] See the recent papers of the Science Boards' Josh Free in the Department of Energy Strategy, "More Fight – Less Fuel," February 2008, specially section 2.2.3 in "Understanding and Managing Fuel Demand," and the need to use the true cost (in "Fully Understanding Cost") of fuel as actually delivered to operational units.

Future Tests on Battery Charging

It would be useful to conduct testing on power storage devices and their capacity to charge battery packs for field use, particularly for use with communications gear.