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MEMO TO: Tri-State University Energy Alliance Members

FROM: Gary Markovits

SUBJECT: TrUE Alliance Innovation Genotype™ and Regional Collaborators

Executive Summary

On February 28th, 2017, Innovation Business Partners (IBP) presented a workshop at the National Academies of Science, Engineering and Medicine, Government-Industry-University Research Roundtable on "Thriving in the Innovation Economy through Collaborations of Government, Universities, and Industry". At the end of the workshop we offered a free pilot of Innovation Network Based Economic Development for interested participants. Among others, we were approached by Cynthia Sweet Director of West Virginia University Central Corporate Relations Office, Professor Deborah Stine Associate Director for Policy Outreach Scott Institute for Energy Innovation at Carnegie Mellon University, and Dr. James McGuffin-Cawley Associate Dean of Research at Case Western Reserve University. During the discussion we learned that all three universities, along with the University of Pittsburgh, were members of the Tri-State University Energy Alliance which is focused on energy innovation in Ohio, Pennsylvania, and West Virginia. After additional discussion with Susan Sauer Sloan, Director of the Government-University-Industry Research Roundtable, it was decided that the energy alliance would make an excellent pilot.

The objective of the pilot was to demonstrate the potential of using IBP's Innovation Network Based Economic Development (INBED) model, and Innovation Genotype™ analysis, to identify industry partners to collaborate with the four universities in pursuing energy related innovations and economic development. Three of the universities wanted to focus on the tristate region, which was further constrained to the cities of Cleveland, Pittsburgh, and Morgantown. West Virginia University wanted to look for collaboration partners across the U.S.

The pilot began by defining the energy related Innovation Genotype of the four universities. This is essentially the collection of energy related technical domains of interest expressed as a collection of 69 US Patent & Trademark Office primary classifications. With this IBP conducted a series of searches and analyses that resulted in:

- Identifying 212 companies from the three cities that had one or more inventions in the 69 USPTO classes that defined the energy alliance Innovation Genotype

- Of these 212 potential collaborators 88 were from Cleveland, 117 from Pittsburgh, and 7 from Morgantown.

- The companies ranged in size from Fortune 500 companies to startups.

The INBED process goes beyond simply identifying potential collaborators at the university-company level, it identifies the technical domains and individual researchers that should be convened to collaborate. Further, using a process developed by IBP it analyzes the inventions from both the university and industry partners to identify combinatorial opportunities to generate more inventions.

To demonstrate the process the pilot focused on Carnegie Mellon and the city of Pittsburgh. For each we generated their energy related Innovation Genotypes, and examined the intersection between them to identify potential collaborations between Carnegie Mellon and Pittsburgh companies. Finally, we examined several companies in a technical domain, identifying the researchers and synergies between their inventions. The results were:

- For the periods examined Carnegie Mellon had 56 inventions spanning 35 energy related technical domains, and the city of Pittsburgh had 346 inventions spanning 52 energy related domains.

- There were 29 energy related domains in common between Carnegie Mellon and Pittsburgh companies.

- To examine the opportunities for collaboration with SMEs we selected the “surgery” domain and found 14 Pittsburgh companies that were potential collaborators.

- Carnegie Mellon had 2 inventions in the surgery domain related to ingestible electronic devices. The 14 Pittsburgh companies had 30 inventions in the surgery domain.

- We selected two SMEs, Body Media and CardiacAssist and in both cases were able to identify synergies between their inventions and Carnegie Mellon’s ingestible electrical device invention.

- Identified the specific industry and Carnegie Mellon inventors to convene and explore the synergies.

Carnegie Mellon is also interested in collaborating with large Pittsburgh based companies, to that end we selected Alcoa and examined the intersection of Carnegie Mellon’s genotype with that of Alcoa. The result was:

- Overlap between Carnegie Mellon and Alcoa in 7 energy related domains

- 10 inventions from Carnegie Mellon and 25 from Alcoa

- The Innovation Genotype analysis can serve as a guide to developing additional energy related collaborations between Carnegie Mellon and Alcoa

The same potential exists for Case Western Reserve and Pittsburgh University for collaboration with tri-city companies. Because a full analysis for every university was beyond the scope of this pro bono pilot we selected and explored one example each for Case Western and Pittsburgh University.

- Potential collaboration between Case Western Reserve and PPG Industries of Cleveland in high power super capacitors

- Potential collaboration between Pittsburgh University and Powercast of Pittsburgh powering and charging devices using RF energy

Finally, for West Virginia University we searched the last eight months of inventions from US companies in the 20 technical domains of the West Virginia University energy related genotype. The result was:

- 1,283 inventions in the 20 technical domains from US companies

- 678 companies as potential collaborators for University of West Virginia

- A range of companies from Fortune 500 to startups

- Explored the domain of converting waste into multi-phase fuel and found a synergy between University of West Virginia and KiOR of Texas.

The initial pilot has demonstrated how the use of Innovation Genotype™ analysis can identify opportunities for collaboration, innovation and licensing between universities and industry. A next possible step would be to explore conducting a more robust study that would identify and detail a significant number of potential collaborations and then pursue their realization using the Innovation Network Based Economic Development model.

Tri-State University Energy Alliance

The Tri-State University Energy (TrUE) Alliance is a collaboration between Case Western Reserve University (CWRU), Carnegie Mellon University (CMU), the University of Pittsburgh (PITT) and West Virginia University (WVU) to accelerate innovations by addressing challenges and opportunities facing the energy sector of Ohio, Pennsylvania, and West Virginia. Within the TrUE Alliance each university has a different focus: CWRU is focused on energy storage, PITT on the grid, CMU on energy efficiency, and WVU on fossil fuel technologies. By applying the Innovation Genotype model we demonstrate a systematic method of identifying and locating suitable organizations, and people to collaborate with and or license intellectual property.

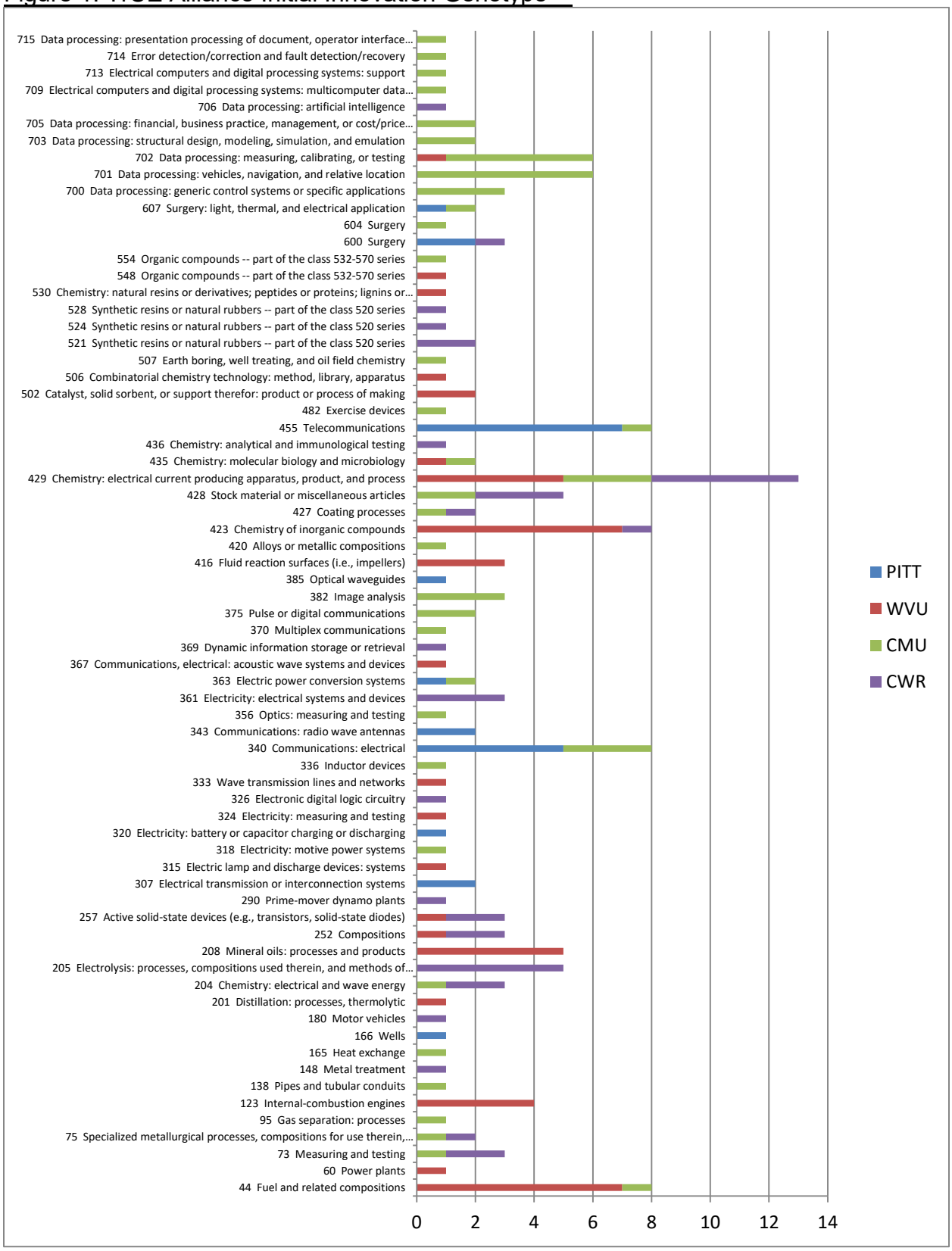
The TrUE Innovation Genotype™

The Innovation Genotype™ model, developed by Innovation Business Partners (IBP), is used to characterize an organization's capacity for innovation. It is based upon a biological analogy. Just as the genes of an animal's genotype express the proteins that combine to form the organs that determine the animal's characteristics, and therefore its chance to survive and thrive in the environment, so too, the inventors of an organization express the inventions that combine to form the innovations that determine an organization's ability to survive and thrive in the economy.

To determine the TrUE members "energy sector" genotype IBP first assembled a database of intellectual property (IP) granted or published for each university between 1/1/2000 through 4/5/2017. A spreadsheet containing that IP was provided to teams from each university who then identified a subset of their IP relevant to their energy sector focus in the TrUE collaboration. IBP combined the selected IP to create the "TrUE Alliance Initial Innovation Genotype™" which is shown in the Figure 1 below.

The left side of Figure 1 lists the U.S. Patent & Trademark Office (USPTO) classifications, the technical domains in which a patent examiner has determined the invention belongs to. The bars on the right side represent the number of inventions that the organization has in that USPTO class.

Figure 1: TrUE Alliance Initial Innovation Genotype™



USPTO Primary Classification vs. Number of Inventions

The TrUE Alliance Innovation Genotype™ analysis revealed 69 USPTO classifications considered relevant to each universities TrUE Alliance focus. The breadth of the TrUE Alliance genotype lends itself to a comparative genotype analysis to other organizations in the tristate region. In doing so it becomes possible to identify a significant number of opportunities for collaboration and/or licensing between the TrUE universities and industry.

CWRU, PITT and CMU wanted to focus on opportunities within the tristate region. Again, to contain the scope of the initial pilot the region was further constrained to opportunities with companies located in three cities: Cleveland, Pittsburgh, and Morgantown. With the TrUE Alliance Innovation Genotype™ as the guide we conducted IP searches in the 69 technical domains for commercial assignees in Cleveland, Pittsburgh and Morgantown. Searches were further limited to IP filed between 1/1/2012 and 5/18/2017.

Figure 2 below depicts the comparison of the TrUE Innovation Genotype and that of the three cities of Cleveland, Pittsburgh and Morgantown for the 69 USPTO classes. The TrUE Alliance is shown in blue while the three cities are shown in red.

The first thing to note is that in the majority of TrUE USPTO classes there is a significant amount of commercial IP for companies from the three cities. This means that there is ample opportunity for university-industry collaboration.

Second, referring back to Figure 1, the "TrUE Alliance Initial Innovation Genotype™", there are 17 classes[1] in which two or more TrUE universities have invented in. Looking at Figure 2, "Comparison of TrUE and Tri-City Innovation Genotypes™", we find that for 16 of the 17 classes[2] there are companies in the three cities that have also invented in these technical domains. That means there are sixteen domains in which it should be possible to structure collaborations involving multiple members of TrUE and multiple companies from the three cities.

Third, there are five TrUE USPTO classes in which there were no inventions from companies in the three cities. TrUE will have to reach beyond the three cities to find collaboration partners in those technical domains.

[1] USPTO classes: 702, 607, 600, 455, 435, 429, 428, 427, 423, 363, 340, 257, 252, 204, 75, 73, and 44.
[2] The only USPTO class in which multiple TrUE members invented and where there were no commercial inventions from the three cities was class 44 "Fuel and related compositions".

Figure 2: Comparison of TrUE and Tri-City Innovation Genotypes™

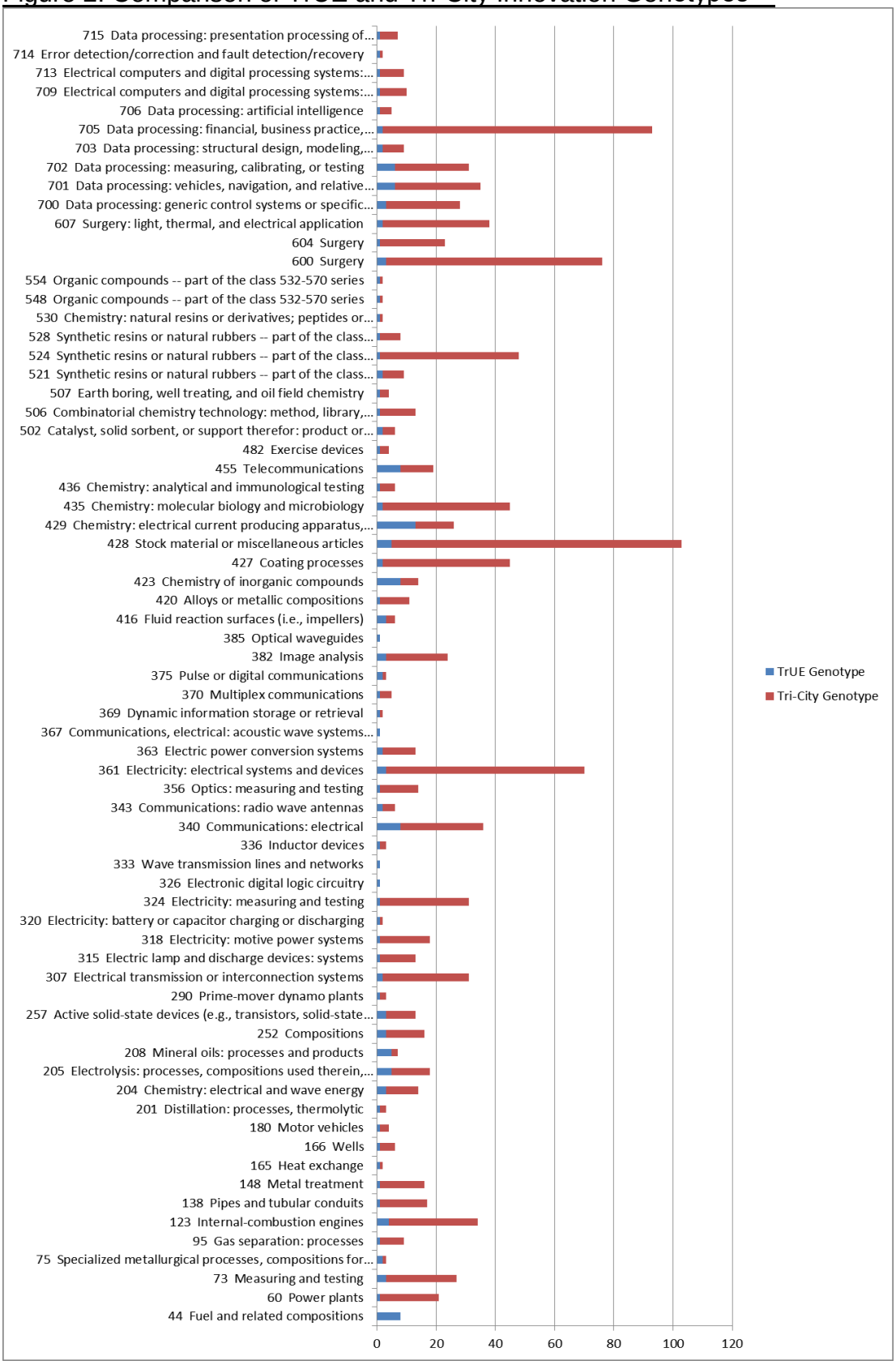
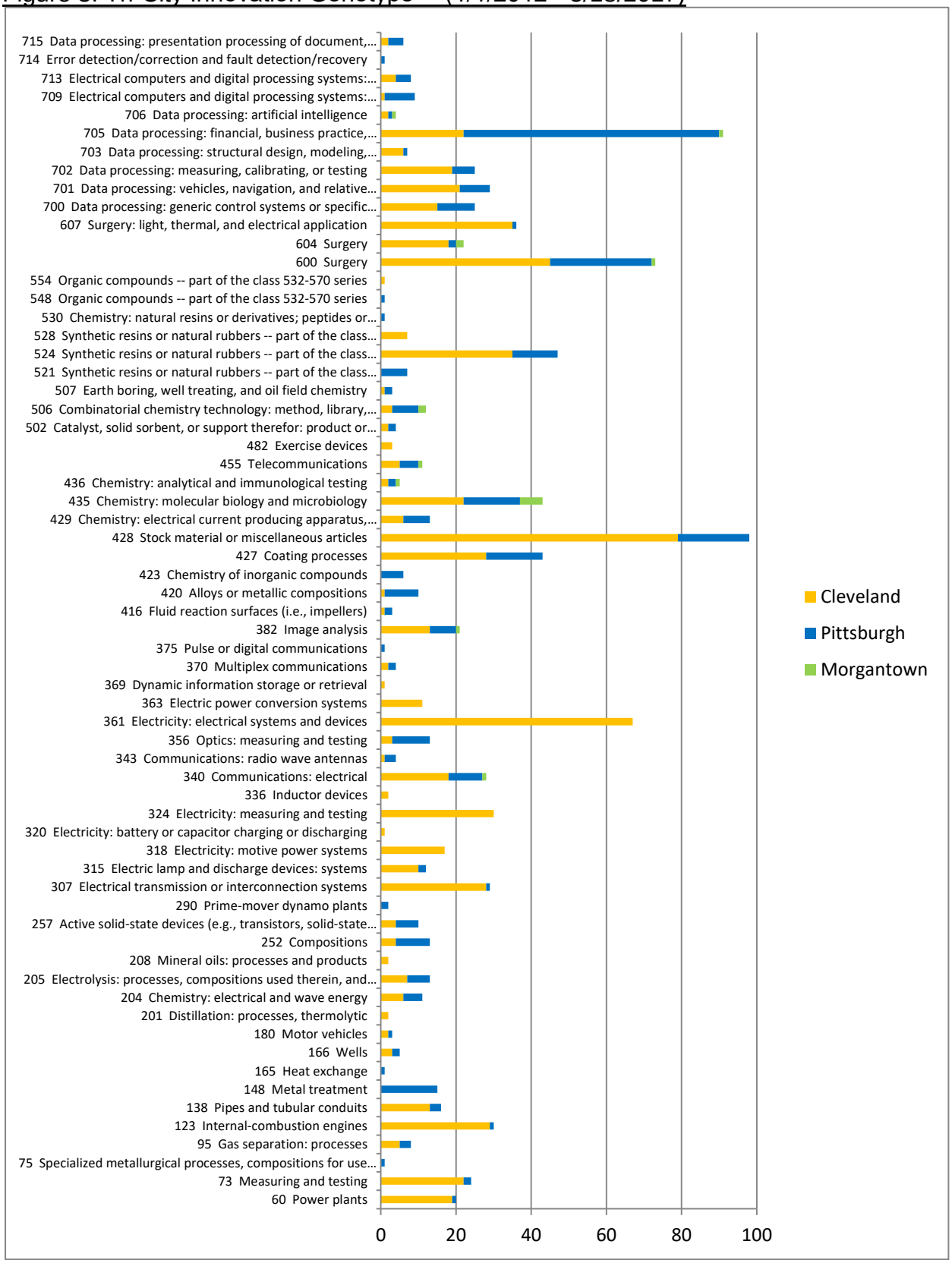


Figure 3: Tri-City Innovation Genotype™ (1/1/2012 - 5/18/2017)



USPTO Primary Classification vs. Number of Inventions

In Figure 3 above, “Tri-City Innovation Genotype”, we break out the commercial inventions by city. In total there were 1,071 inventions from companies in the three cities. For the roughly 6-1/2 year time span there were 708 in Cleveland, 346 in Pittsburgh and 17 in Morgantown.

When looking at specific collaborators by region Cleveland had 88 assignees across 54 of the 69 USPTO classes comprising the initial TrUE energy Innovation Genotype™, Pittsburgh 117 assignees across 52 classes, and Morgantown with 7 assignees across 10 classes. For Cleveland and Pittsburgh the large number of assignees and USPTO classes represents a very rich opportunity for university-industry collaborations.

Some regional players stood out above the rest in terms of patenting productivity. Of Cleveland's 88 assignees 37 had more than 1 patent. The top IP producer for all regions was Cleveland based on power management company Eaton Corporation with 243 patents. Alcoa was Pittsburgh’s top IP producer with 50 patents and Mylan, Inc. topped the list in Morgantown with 6. Again, the result is a rich landscape of companies who share the same technical interests as the TrUE Alliance and represent an opportunity for collaboration, knowledge transfer, and perhaps licensing.

In Table 1 below we list the potential industry collaborators for the city of Cleveland. Table 2 is the list for Pittsburgh, and Table 3 for Morgantown. From the names of the assignees and the size of their IP holdings in the USPTO classes of the TrUE Alliance we can see that they range from small companies, perhaps startups, to very large companies. Later in this report we will discuss an economic development mechanisms that utilizes the Innovation Genotype analysis to drive collaboration and economic development in the three cities, but first, we want to address the opportunities for WVU.

Table 1: Potential TrUE Alliance Collaborators in Cleveland

Assignee	IP#	Assignee	IP#
Eaton Corporation	243	Barkudo LLC	1
PPG Industries Ohio, Inc	126	Bluebirds Technology LLC	1
THE CLEVELAND CLINIC FOUNDATION	91	Buescher Developments, LLC	1
Parker Hannifin Corporation	34	Capacity Holdings LLC	1
Lubrizol Advanced Materials, Inc.	31	Cleveland Medical Devices Inc.	1
GE Lighting Solutions, LLC	22	COBRA AERO LLC	1
The Sherwin-Williams Company	11	EMX INDUSTRIES INC.	1
Cardioinsight Technologies, Inc.	10	EXPLORYS INC.	1
Keithley Instruments, Inc.	7	Fasteners For Retail, Inc.	1
NDI Medical LLC	7	FiberCore, LLC	1
SPR Therapeutics, LLC	6	Flow Polymers, LLC	1
Checkpoint Surgical, LLC	5	FUTURI MEDIA, LLC	1
Linestream Technologies	5	Hose Master, LLC	1
ARISDYNE SYSTEMS, INC.	4	HOSPITALITY ENGAGEMENT COR	1
Great Lakes NeuroTechnologies Inc.	4	INTELECT MEDICAL, INC.	1
Orbital Research Inc.	4	Keycorp	1
ABT Holding Company	3	Leading Age Supplies LLC	1
American Greetings Corporation	3	Listener Driven Radio LLC	1
Certified Security Solutions, Inc.	3	Maradyne Corporation	1
MacroPoint LLC	3	MASCOTSECRET LLC	1
MIM Software Inc.	3	Maxx Innovations, LLC	1
Austin Powder Company	2	Mazzella Lifting Technologies, Inc.	1
Cleveland Clinic Foundation	2	MERCURY BIOMED, LLC	1
CLEVELAND HEARTLAB, INC.	2	National Biological Corporation	1
DEALER TIRE, LLC	2	NEXTECH INNOVATIONS LLC	1
Deep Brain Innovations LLC	2	Nottingham Spirk Design Associate	1
Dynamotors, Inc.	2	ORTHOPAEDIC RESEARCH LABC	1
Ferro Corporation	2	OVATION POLYMER TECHNOLOG	1
Garland Industries, Inc.	2	PMI INDUSTRIES, INC.	1
INTELLECTUAL PROPERTY HOLDINGS, L	2	POLGENIX, INC.	1
La Lumiere LLC	2	Pulmonary Apps, LLC	1
Meyer Products, LLC	2	Qualitics, Inc	1
NeuroWave Systems Inc	2	QUIXBY, LLC	1
PNEUMOSONICS, INC.	2	SECURUS MEDICAL GROUP, INC	1
Sparkbase LLC	2	StreamLink LLC	1
TLS Corp.	2	The Cleveland Clinic Foundation	1
VADXX ENERGY LLC	2	THE CLEVELAND CLINIC FOUNDA	1
9S LLC	1	The Euclid Chemical Company	1
Ab Rider L.L.C.	1	The Singleton Corporation	1
ACCESS MOBILITY, INC.	1	The Telos Alliance	1
American Mine Door Co.	1	THE TRANZONIC COMPANIES	1
ANIMAL ORALECTRICS LLC	1	VOSSLOH SIGNALING, INC.	1
Austin Star Detonator Company	1	WINSTON PRODUCTS LLC	1
Axiom Automotive Technologies, Inc.	1	ZTECH, INC.	1

Table 2 Potential TrUE Alliance Industry Collaborators in Pittsburgh

Assignee	IP#	Assignee	IP#
Alcoa Inc.	50	Alertek, LLC	1
Bayer MaterialScience LLC	33	Allegheny-Singer Research Instit	1
GiftYa LLC	13	ALLPOINT SYSTEMS, LLC	1
BodyMedia, Inc.	10	Atlantic-Alliance LLC	1
ChemImage Corporation	10	ATRP Solutions, Inc.	1
Plextronics, Inc.	9	AUGMENTECH, INC.	1
QuipIP, LLC	8	Avere Systems, Inc.	1
Calgon Carbon Corporation	7	B.E.A. Inc.	1
TeleTracking Technologies, Inc.	7	Berry Metal Company	1
The PNC Financial Services Group,	7	Biometricore, Inc.	1
Aquion Energy Inc.	6	Bridge Semiconductor Corporatic	1
Stemnion, Inc.	6	Cardeeo, Inc.	1
Covestro LLC	5	Carnegie Learning, Inc.	1
Powercast Corporation	5	Certes Networks, Inc.	1
Tiversa IP, Inc.	5	Cohera Medical, Inc.	1
CardiacAssist, Inc.	4	CombineNet, Inc.	1
Cardo Systems Inc.	4	Decision Partners, LLC	1
Emerson Process Management Pow	4	DIGITAL SITE SYSTEMS, INC.	1
Moneyhoney LCC	4	Discovery Robotics	1
NEURO KINETICS	4	DRAEGER SAFETY, INC.	1
Aethon, Inc.	3	eduDollars, LLC	1
Antique Books Inc.	3	ELIZUR Corporation	1
Cernostics, Inc.	3	Ension, Inc.	1
ClearCount Medical Solutions, Inc.	3	FALCON GENOMICS, INC.	1
CRYSTALPLEX CORPORATION	3	FASTTAC, INC.	1
Koppers Performance Chemicals Inc	3	Forest Devices, Inc.	1
Liquid X Printed Metals, Inc.	3	H. J. HEINZ COMPANY	1
NSABP Foundation, Inc.	3	HAMMEL COMPANIES, INC.	1
Precision Therapeutics, Inc.	3	HELOMICS CORPORATION	1
SHOEFITR, INC.	3	HyperActive Technologies, Inc.	1
Thorley Industries LLC	3	INSPIRAVE, LLC.	1
Access Data Corp.	2	Investedge, Inc.	1
BLUE BELT TECHNOLOGIES, INC.	2	KNOPP NEUROSCIENCES, INC	1
Branding Brand, Inc.	2	LANXESS CORPORATION	1
Cellomics, Inc.	2	MEDIA AND PROCESS TECHN	1
CHEETAH TECHNOLOGIES, L.P.	2	Mid Atlantic Capital Group	1
ChemImage Technologies LLC	2	MYMEDCOUPONS, LLC	1
ChemImage Corporation	2	NanoGriptech, Inc.	1
Giftcards.com LLC	2	NanoLambda, Inc.	1
GiftCodes.com, LLC	2	NANOPHORETICS LLC	1
Hyliion Inc.	2	Near Earth Autonomy, Inc.	1
IAM Robotics, LLC	2	OMNYX, LLC	1
INDUSTRIAL SCIENTIFIC CORPOR	2	Parametric Mechanisms, LLC	1
Invivodata, Inc.	2	Pittsburgh Corning Corporation	1
KOP-COAT, INC.	2	Poiesis Informatics, Inc.	1
MAVEN MACHINES, INC.	2	PriMunt LLC	1
Mobile Aspects, Inc.	2	Qula Inc.	1
Optimus Technologies, LLC	2	REGEAR LIFE SCIENCES, INC.	1
Penthera Partners, Inc.	2	Semantic Compaction Systems,	1
REDPATH INTEGRATED PATHOLC	2	SemanticMD, Inc.	1
RedZone Robotics, Inc.	2	ShopFish, LLC	1
Rijuven Corporation	2	Smith Brothers Agency, LP	1
Seegrid Corporation	2	Sole Power, LLC	1
TDY INDUSTRIES, LLC	2	Strata Proximity Systems, LLC	1
UPMC	2	Sungard Availability Services, LP	1
Vascor, Inc	2	Thar Geothermal LLC	1
Vocollect, Inc.	2	TRINITY INTEL MEDIA, LLC	1
Advanced Materials Corporation	1	Well Control Technologies, Inc.	1
Akustica, Inc.	1		

Table 3: Potential TrUE Alliance Collaborators in Morgantown

Assignee	IP#
MYLAN, INC.	6
Blanchette Rockefeller Neurosciences Institute	5
Protea Biosciences, Inc.	2
Advanced Technology Applications, LLC	1
Confirmix LLC	1
EYE MARKER SYSTEMS, INC.	1
INTELLIGENT SOLUTIONS, INC.	1

Economic Development Mechanisms

The Innovation Genotype™ analysis identifies at a company level opportunities for collaboration and driving economic development through innovation. Next, using CMU as an example, we will demonstrate how Innovation Genotype analysis can dive down to the individual inventors and inventions that should be the focus of those collaborations.

Collective Intelligence Clusters

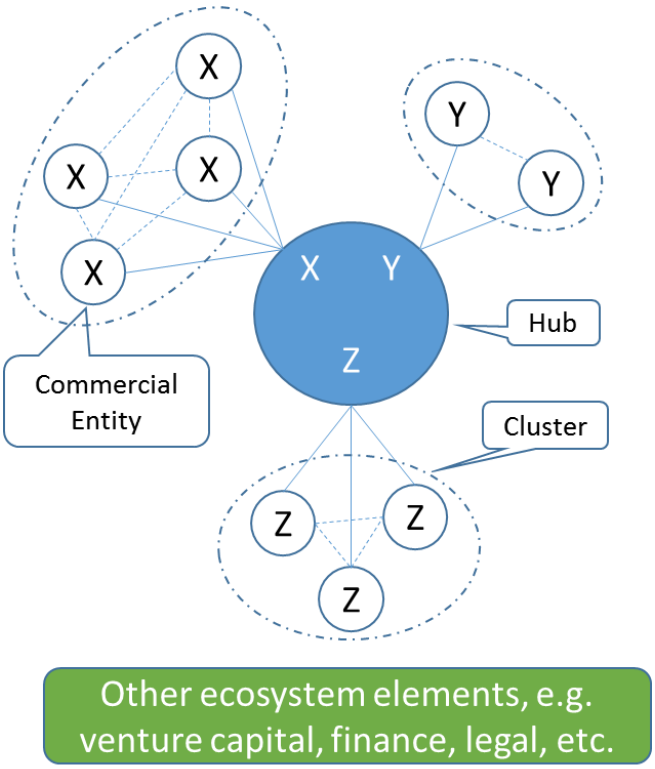
IBP has defined five mechanisms[3] that are a part of the Innovation Network Based Economic Development model which use data from the genotype analysis to drive innovation and economic development, one is Collective Intelligence Clusters (CIC). CIC are all about connecting creative people based on similarities and generating new knowledge based upon differences. The structure of the CIC mechanism is shown in Figure 5. The Hub, large blue circle, represents a "neutral" organization, for example a university, not-for-profit, or government organization that has expertise, and intellectual property in relevant technical domains X, Y, and Z. The smaller white circles represent commercial entities, large and small, who may, or may not be competitors, that also have expertise and intellectual property in one or more domains X, Y, and Z. In this case the Hub would be one of the four universities in the TrUE Alliance and the commercial entities would be the companies identified in the genotype analysis above.

Hubs facilitate dialogue between the inventors of a domain on the challenges, opportunities, and future direction of that domain. Connecting them on similarities creates a cluster (dotted lines/circles) generating a greater collective intelligence for the region and driving invention in that domain. While hubs facilitate dialogue they also rely on other ecosystem elements for success. These elements could be a combination of financial and venture capital communities, legal support, incubator space, accelerators, licensing of university or other intellectual property and more.

[3] A more complete discussion can be found on the National Academies of Science, Engineering and Medicine, Government-Industry-University Research Roundtable website, specifically see the 2/28/17 workshop "Thriving in the Innovation Economy through Collaborations of Government, Universities, and Industry".

In some sense this is analogous to the structure of the semiconductor industry's SEMATECH[4], but with the university or government lab taking the action to convene the commercial entities. Like SEMATECH these clusters would create knowledge and intellectual property on the common platforms that all competitors in X, Y, or Z need to compete, but that no one entity can easily fund on their own. For example, the SEMATECH consortium conducts research and development to advance chip manufacturing by jointly solving problems related to new materials, processes, and equipment for semiconductor manufacturing, which all members need to compete in the industry. In a similar fashion the TrUE Alliance seeks to pool resources among its members to become more competitive with other R&D organizations in the energy field.

Figure 4: Collective Intelligence Clusters



The CIC structure might vary in terms of formality, ranging from something akin to a community of interest to a formal legal structure such as SEMATEC. A CIC might start out as a Hub facilitated community of interest, that as trust grows, and competition demands, morphs into a more formal legal entity focused on increasing the region's competitiveness in a given domain.

The CIC may even decide to create a common pool of intellectual property to which all members have some rights, or to jointly fund basic research that has potential benefit to all members. The idea is to create the collective intelligence that will benefit the region, and result in higher competitiveness, job growth, and prosperity. A 2013 MIT study[5] emphasizes the importance of a convening function, coordination and collaboration mechanisms, and risk-reduction and risk-pooling, all of which are accomplished by the CIC.

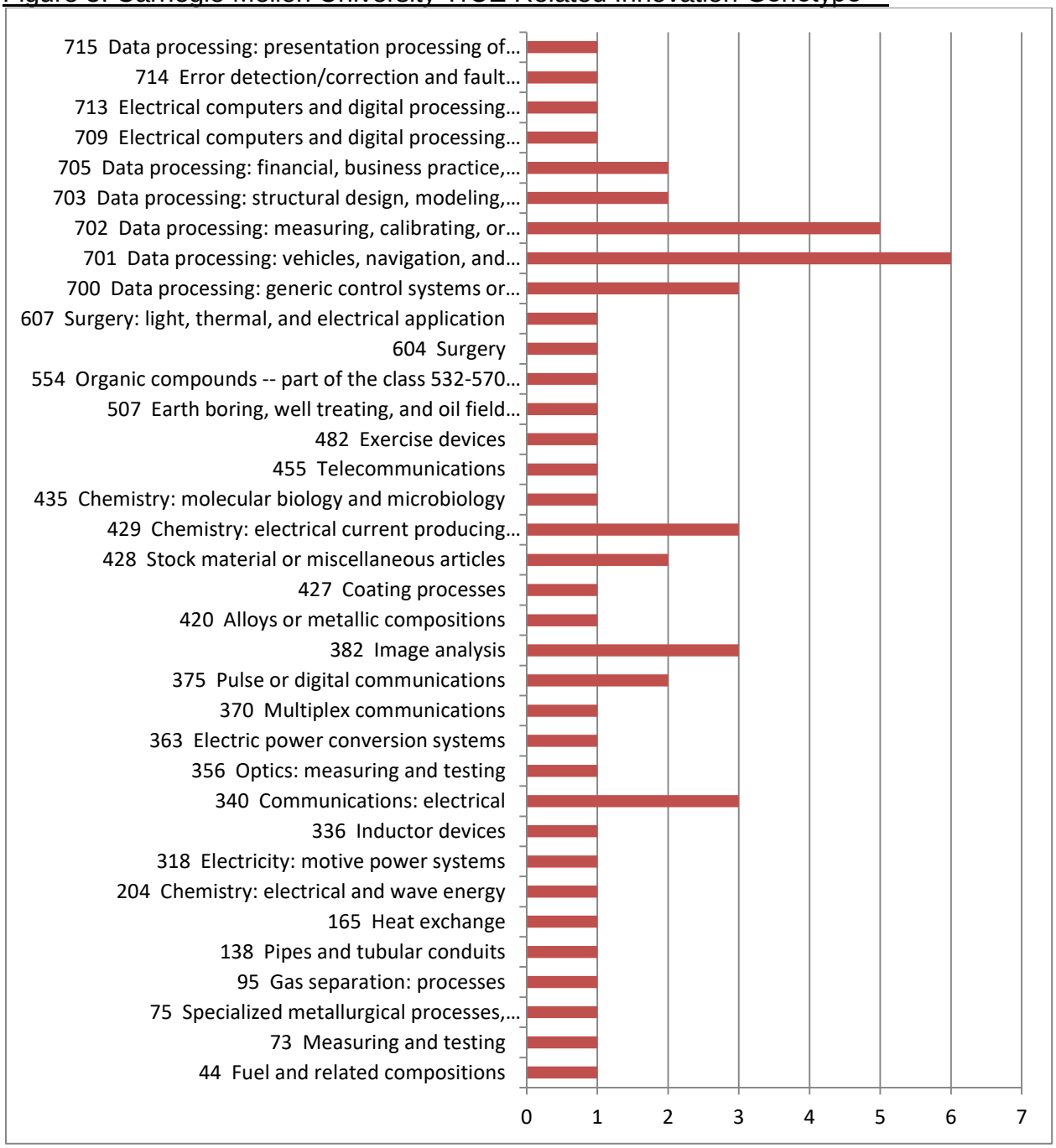
CMU – City of Pittsburgh CIC

Next we take the CIC concept and flesh it out using CMU and companies from the city of Pittsburgh. To begin we develop the TrUE related[6] Innovation Genotypes™ of CMU and the city of Pittsburgh commercial sector, and then develop the opportunities for

[4] Gary Markovits, the founder of IBP, was one of IBM's representatives to SEMATECH in its early stages.
[5] "A Preview of the MIT Production in the Innovation Economy Report", Massachusetts Institute of Technology, February 22, 2013.
[6] These are not full Innovation Genotypes of CMU or the city of Pittsburgh but rather the genotypes restricted to the USPTO classes as identified by CMU as related to the TrUE Alliance energy focus.

collaboration based upon the intersection of the two genotypes. The CMU and city of Pittsburgh genotypes are shown in Figures 5 and 6 respectively, and their intersection in Figure 7 below.

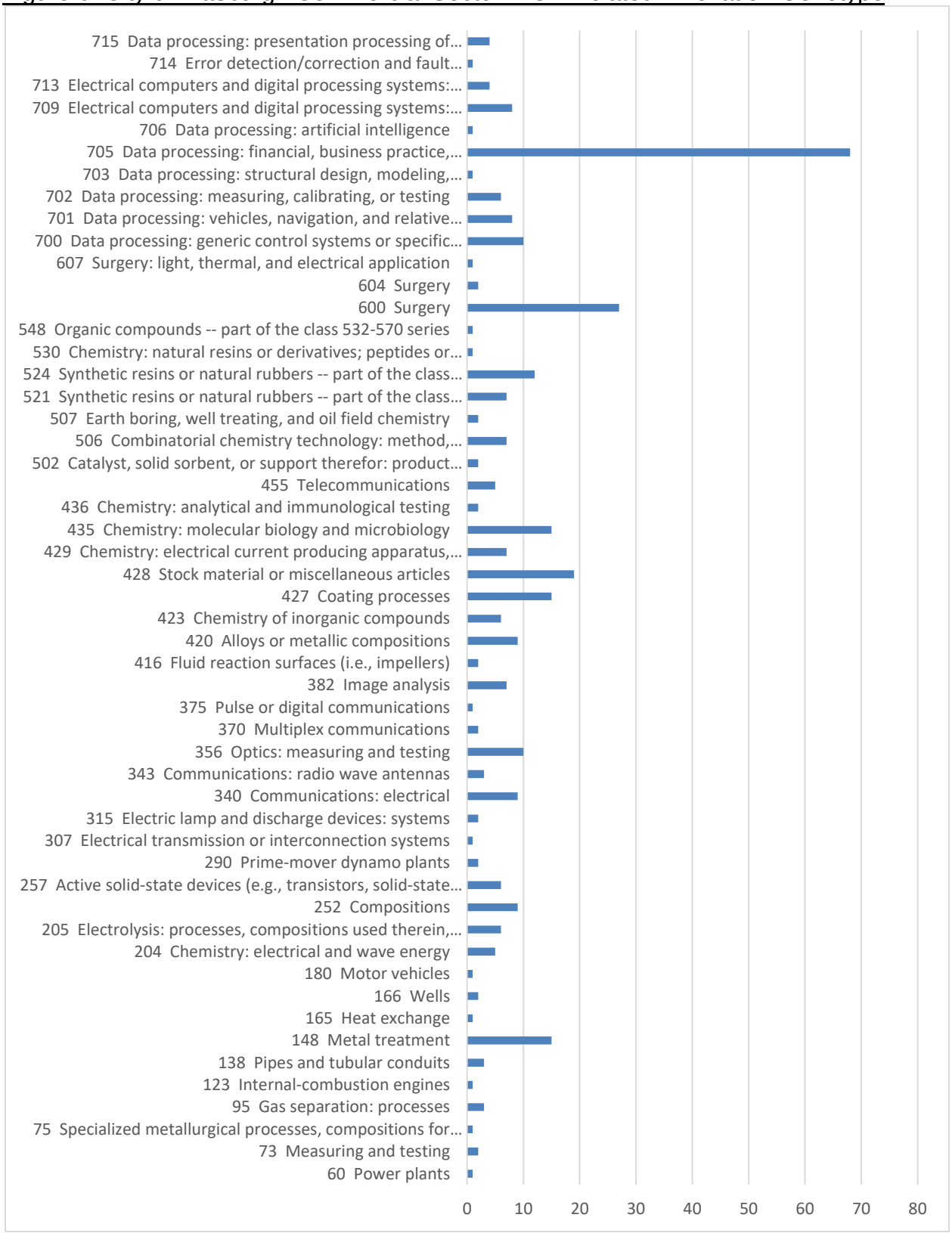
Figure 5: Carnegie Mellon University TrUE Related Innovation Genotype™



USPTO Primary Classification vs. Number of Inventions

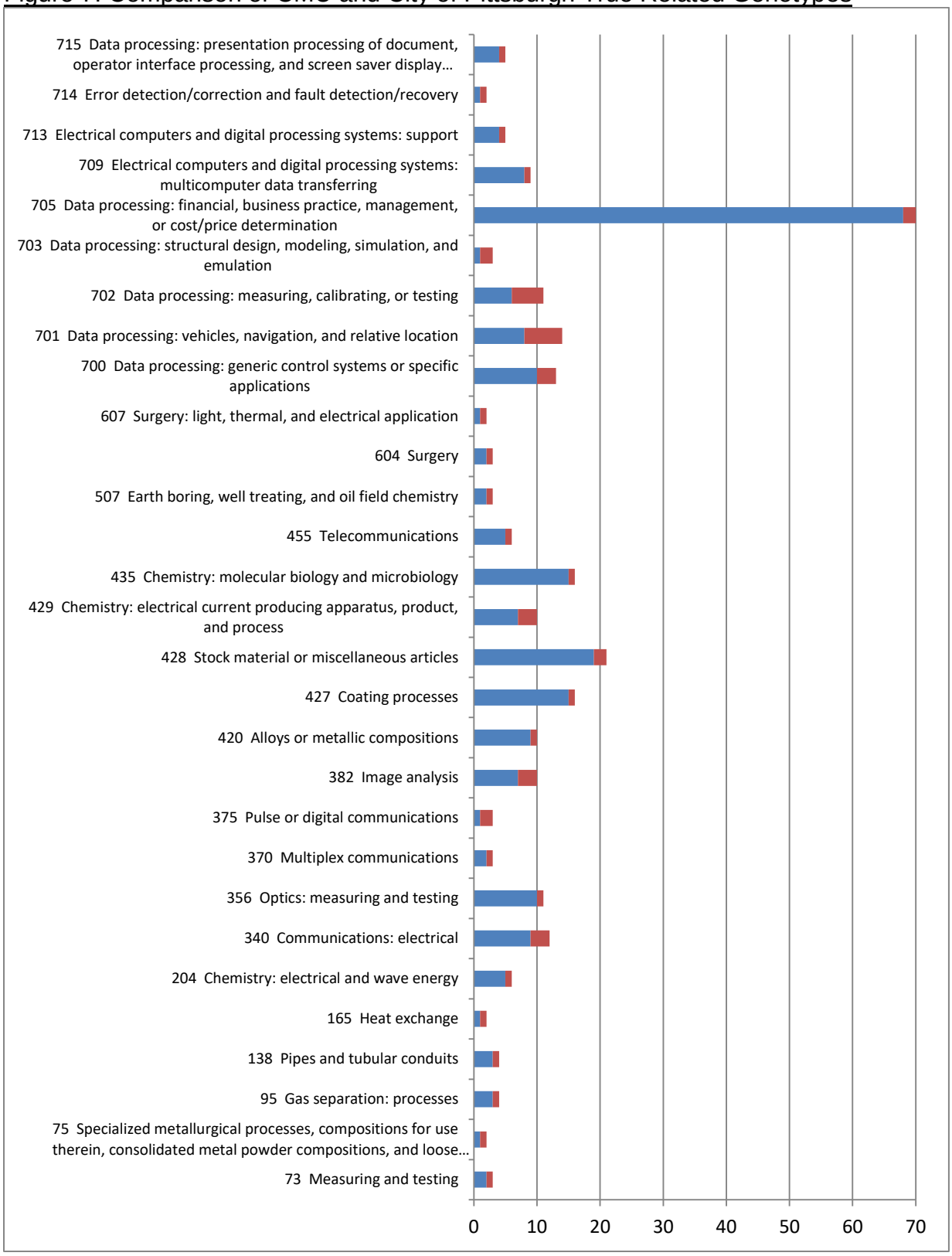
Above, CMU has 56 inventions spanning 35 USPTO classes for the period 1/1/2000 through 4/5/2017. Below, the city of Pittsburgh commercial sector produced 346 inventions in 52 USPTO classes for the period 1/1/2012 through 5/18/2017.

Figure 6: City of Pittsburgh Commercial Sector TrUE Related Innovation Genotype



USPTO Primary Classification vs. Number of Inventions

Figure 7: Comparison of CMU and City of Pittsburgh True Related Genotypes



USPTO Primary Classification vs. Number of Inventions

The CMU and city of Pittsburgh TrUE related genotypes intersect in 29 USPTO classes with CMU color coded red and the city of Pittsburgh blue. The inventions in those 29 classes were generated by 98 Pittsburgh based companies. Thus there are 98 companies and 29 domains in which to structure university-industry collaborations to drive innovation and economic development in the city of Pittsburgh.

Referring back to Figure 4 which depicts the structure of a CIC the central blue hub would be CMU and there would potentially be 29 clusters (the dotted ovals) populated by the 98 companies. In practice the actual number of clusters and companies would be smaller but this demonstrates the magnitude of the CIC opportunity for CMU in just the city of Pittsburgh.

To take the analysis further we selected the following surgery related domains from the TrUE Innovation Genotype, which are classes:

- 600 Surgery
- 604 Surgery
- 607 Surgery: light, thermal and electrical applications

While both classes 600 and 604 are titled "Surgery" they are differentiated by their respective subclasses. To understand the differences see the USPTO definition for 600 and 604.

There are fourteen Pittsburgh based companies that have invented in one or more of the three surgery related classes. These fourteen companies are potential members of the "surgery cluster" referring back to Figure 4. The fourteen companies are: Augmentech, Inc., Blue Belt Technologies, Inc., BodyMedia, Inc., CardiacAssist, Inc., Forest Devices, Inc., Maven Machines, Inc., Mobile Aspects, Inc., Neuro Kinetics, Parametric Mechanisms, LLC, Rijuven Corporation, Vascor, Inc., Calgon Carbon Corporation, Cohera Medical, Inc., and Regear Life Sciences, Inc.

CMU has two inventions from Professor Christopher Bettinger, one in class 604 and one in class 607, both relating to an ingestible electrical device. The CMU inventions are:

US20160263016 INGESTIBLE, ELECTRICAL DEVICE FOR ORAL DELIVERY OF A SUBSTANCE – Class 604
US20150088222 INGESTIBLE, ELECTRICAL DEVICE FOR STIMULATING TISSUES IN A GASTROINTESTINAL TRACT OF AN ORGANISM – Class 607

Professor Bettinger runs the Bettinger Group at CMU which is "…interested in the applying principles of polymer synthesis, materials science, and microfabrication for use in a wide range of biomedical applications including advanced medical devices, regenerative medicine, bio-interfaces, and drug delivery."

The first invention describes an electrical device that contains both "charge storage system" and a protected reservoir that contains the substance to be delivered at a given location in the gastrointestinal (GI) tract. At the appropriate time and/or in the

appropriate GI environment the electrical charge is used to release the substance from its protected reservoir.

The second invention describes an ingestible electrical device that can be tailored to expand and lodge itself in a desired location within the GI tract. Further, the device, either internally or externally powered, can deliver electrical voltages and/or currents to the GI tissue, which Bettinger claims can reduce the motility of the GI tract. The motion of the GI tract is critical to fully digesting food and absorbing nutrients. The invention claims reducing GI tract motility has the same effect as gastric bypass surgery at a much lower risk. If proven through clinical trials and approved by the FDA this invention is potentially very disruptive, and given the obesity epidemic[7] in the US, potentially very lucrative.

The next step is to explore the potential for collaboration between CMU's Bettinger Group and one or more of the fourteen companies in the surgery cluster. The first company we will examine is Body Media. Body Media is a small company of roughly 60 employees in Pittsburgh that was recently acquired by wearable products manufacturer Jawbone[8], but is still located in Pittsburgh.

Body Media has nine inventions in the surgery classes. Almost all focus on wearable devices to monitor various physiological parameters like heart rate, temperature, motion, etc. Several of them relate to systems for monitoring and managing body weight, for example:

US20130158367 SYSTEM FOR MONITORING AND MANAGING BODY WEIGHT AND OTHER PHYSIOLOGICAL CONDITIONS INCLUDING ITERATIVE AND PERSONALIZED PLANNING, INTERVENTION AND REPORTING CAPABILITY

This invention provides a nutrition and activity management system that monitors energy expenditure via a body-mounted sensing apparatus. When combined with a computer application the system provides feedback on the user's energy expenditure and food consumption in an attempt to modify behavior patterns.

One possible collaboration would be to explore combining this sensing system and the CMU ingestible electrical device for reducing the motility of the GI tract. Together they could form a more complete system to address the obesity epidemic. According to the CIC model that would involve convening Professor Bettinger's team with the Pittsburgh based Body Media inventors: Christopher Pacione, Steve Menke, Raymond Pelletier, Mark Handel, Jonathan Farringdon, Eric Hsiung, and John Stivoric. The discussion could be facilitated using IBP's Insight Driven Innovation process which teaches people how to decompose inventions into their elements and relationships and then recombine

[7] Currently 38% of US adults and 17% of teenagers are obese.
[8] The US government describes small as less than 100 employees and middle size as less than 999 employees. Jawbone has approximately 400 employees after the acquisition of Body Media. Body Media was acquired for $100 million dollars. After the acquisition Body Media remained in Pittsburgh.

elements and relationships from multiple inventions to form yet another invention. In a Navy benchmark the process was shown to save years and millions of dollars in R&D[9].

The Body Media collaboration could be mutually beneficial. The CMU technology would substantially differentiate Body Media from its competitors. And Body Media's position in the market could potentially accelerate the commercialization of CMU's technology.

As a second example consider Pittsburgh's CardiacAssist Inc., which is now doing business as TandemLife. TandemLife is another small Pittsburgh business with roughly 40 employees. Specifically, consider TandemLife's catheter invention:

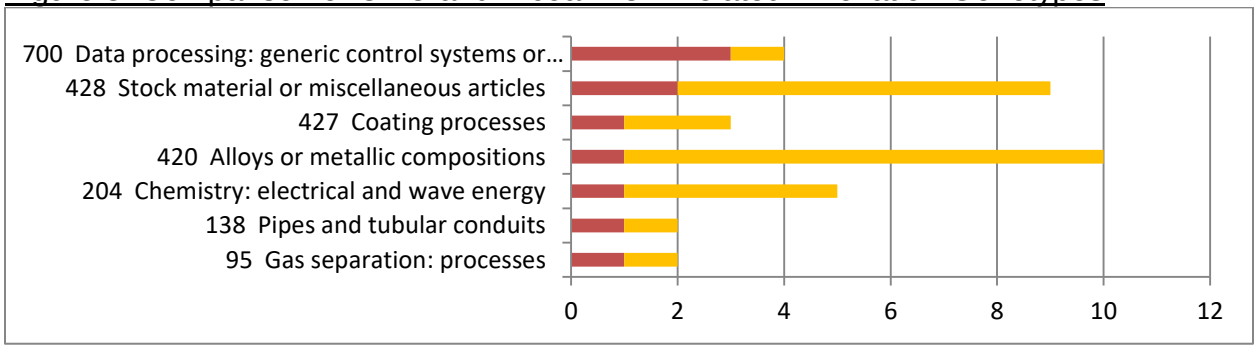
US20170014159 IMAGE-GUIDED TRANSSEPTAL PUNCTURE DEVICE

This invention describes a catheter assembly with both imaging and puncturing devices. Consider the possibility of combining this invention with CMU's electrical device but rather than ingesting it use the catheter to position and implant the device. Could the CMU device now be used to deliver electrical stimulation to specific regions of the heart? A collaboration with TandemLife could lead to further commercialization of the technologies being explored by CMU's Bettinger Group.

Again, by the CIC model the collaboration would begin by convening the CMU Bettinger team with the TandemLife inventors Jerry Stokes and John Marous of Pittsburgh.

Next we will explore the potential for collaboration between CMU and Alcoa, one of the largest companies in Pittsburgh whose genotype intersects with that of CMU as shown in the figure below.

Figure 8: Comparison of CMU and Alcoa TrUE Related Innovation Genotypes



USPTO Primary Classification vs. Number of Inventions

In Figure 8 CMU inventions are shown in red while Alcoa is in yellow. In this genotype comparison there are 10 inventions from CMU and 25 from Alcoa. With an organization the size of Alcoa, and with a sizeable overlap between the Alcoa and CMU genotypes, we would recommend using the comparative analysis to organize a discussion with Alcoa management about the challenges they are facing in the seven domains and how

[9] See "Bridging Small Worlds to Accelerate Innovation".

funding research at CMU could help Alcoa achieve its objectives. Given a set of defined challenges for each domain the next step would be to convene the appropriate CMU and Alcoa researchers to discuss potential collaborations and define specific research projects.

Pittsburgh University and Case Western Reserve Examples

The constraints of the pro bono GUIRR pilot did not allow us to do the same depth of analysis for all TrUE members as was done for CMU example. However, the same potential exists for both universities. Below we provide one example for each.

First, consider US PTO class 455 “Telecommunications”. In this class PITT has a patent for recharging devices using RF energy.

PITT US patent 8,090,414 “Recharging method and apparatus”.

INVENTION: The present invention provides apparatus and an associated method for remotely energizing power storage devices. Energization may preferably be effected through the use of RF energy from a base station, ambient energy or ultra-wide band energy. The remote station preferably has at least one antenna having an effective area greater than its physical area. The system may have an antenna and associated circuitry provided on an electronic chip such as a monolithic chip or on a printed circuit with a suitable substrate.

NEED: There remains a need for small remote power charger device and associated method that have a means for receipt of transmitted energy from the environment and energizing power storage devices on an object of interest wherein the power charger device is not dependent on inductive charging. There is also a need for a small remote power charger device and associated method having a means for receipt of transmitted energy from the environment and energizing power storage devices on an object of interest using one or more antenna(e) on a substrate. Finally, there is a need for a small remote power charger device and associated method that uses one or more antenna(e) on a substrate wherein the strength of the antenna is not dependent on magnetic induction or number of turns and area of the loop of the antenna.

A Pittsburgh company, Powercast, also has an invention related to powering devices using RF energy.

Powercast Corporation US patent application 20160205722 “SYSTEMS, METHODS AND APPARATUS FOR POWERING DEVICES USING RF ENERGY FROM A MOBILE TRANSMITTER”.

INVENTION: In some embodiments, a personal area network (PAN) includes a mobile transmitter (e.g., a mobile or cellular phone) and one or more devices (e.g., sensors) that require power to operate (e.g., collect data). The mobile transmitter can be configured to transmit a sufficient amount of power (e.g., RF energy) to the one or more devices to power the one or more local devices. In addition to transmitting power, the mobile transmitter can be configured to communicate over a wireless network (e.g., a cellular network) as its primary function.

NEED: Mobile devices, such as cellular phones, are increasingly becoming smart and capable of operating in a multitude of functions or modes. These mobile devices, however, are typically only being used to perform ancillary functions or operations, such as running software applications. The capabilities of these mobile devices are typically being underused. Thus, a need exists for a system, method and

apparatus for recharging the batteries of PAN devices or eliminating the batteries in PAN devices altogether. In both instances, RF energy can be used to provide power to PAN devices.

It is clear that the PITT and Powercast inventors have a lot in common. The CIC concept would be to convene these inventors to explore the common challenges they face and explore the potential differences, e.g. PITT's focus on the grid and Powercast's focus on personal area networks, to seek a more complete system that could produce end-to-end RF power from the grid to the personal sensors.

In the TrUE alliance CWRU's focus is energy storage. One USPTO class relevant to energy storage is 361 "Electricity: Electrical systems and devices". In that class CWRU US has patent 6,914,769 "High power capacitors from thin layers of metal powder or metal sponge particles"

INVENTION: An anode (14, 208, 410) and/or cathode (12, 212, 420) of a capacitor has a large surface area. The high surface area of the anode is provided by forming the anode from a thin, electrically conductive layer (16) formed from metal particles (18) or an electrically conductive metallic sponge (416). These materials provide a porous structure with a large surface area of high accessibility. The particles are preferably directional or non-directional sponge particles of a metal, such as titanium. The conductive layer has a dielectric film (36, 236, 414) on its surface, formed by anodizing the particle surfaces. The dielectric film has a combination of high dielectric constant and high dielectric strength. The cathode (12, 212, 420) of the capacitor is either a conventional solid material or, more preferably, has a large surface provided by forming the surface from a sponge or particles analogously to the anode. The high dielectric strengths obtainable from the capacitor allow for extreme miniaturization, making the capacitor particularly suited for integrated circuit applications.

NEED: The present invention provides a new and improved capacitor having at least one of its electrodes (anode or cathode) of high surface area which overcomes the above-referenced problems, and others.

And PPG Industries Ohio, Inc. is also interested in this domain as indicated by their US patent application 20160111227 "SUPERCAPACITOR ELECTRODES INCLUDING GRAPHENIC CARBON PARTICLES".

INVENTION: Supercapacitor electrodes comprising active charge supporting particles, graphenic carbon particles, and a binder are disclosed. The active charge supporting particles may comprise activated carbon. The graphenic carbon particles may be thermally produced. The electrodes may further comprise electrically conductive carbon.

NEED: The present invention relates to the use of graphenic carbon particles in supercapacitor electrodes.

A search of the CWRU website indicates that there is an established relationship between the university and PPG, e.g. in 2014 PPG donated to CWRU's "Women in Science and Engineering Roundtable" program. The objective of a complete analysis would be to identify all of the potential collaborations right down to the technology domains and individual researchers and build upon the established relationship.

The West Virginia University Opportunity

Generally patent productivity by geographic region scales with population. When compared to Cleveland and Pittsburgh, Morgantown WV has an order of magnitude

fewer people. This results in the substantially lower number of inventions and assignees for the area. The scarcity of local collaborators ultimately encourages organizations like WVU to look for partners over a larger region.

To tackle this challenge we modified the collaborator search strategy to include patents assigned to companies located anywhere in the U.S. that matched one or more of WVU's 20 USPTO classes. In order to keep the effort reasonable we restricted the search to the last 8 months which produced 1283 inventions from 678 assignees. The lion's share of assignees (587) had only one or two patents that matched WVU. The reaming 91 organizations had anywhere from 3 to 75 patents that aligned with WVU's energy focus in that short 8 month period. This represents a substantial opportunity for WVU. Finally, the list of potential partners can be increased by extending the time period or geographic domain or more focused by targeting a smaller set of technical domains. See Figure 9 and Table 4 below.

Figure 9: Inventions from US Companies in the 20 WVU USPTO Classes

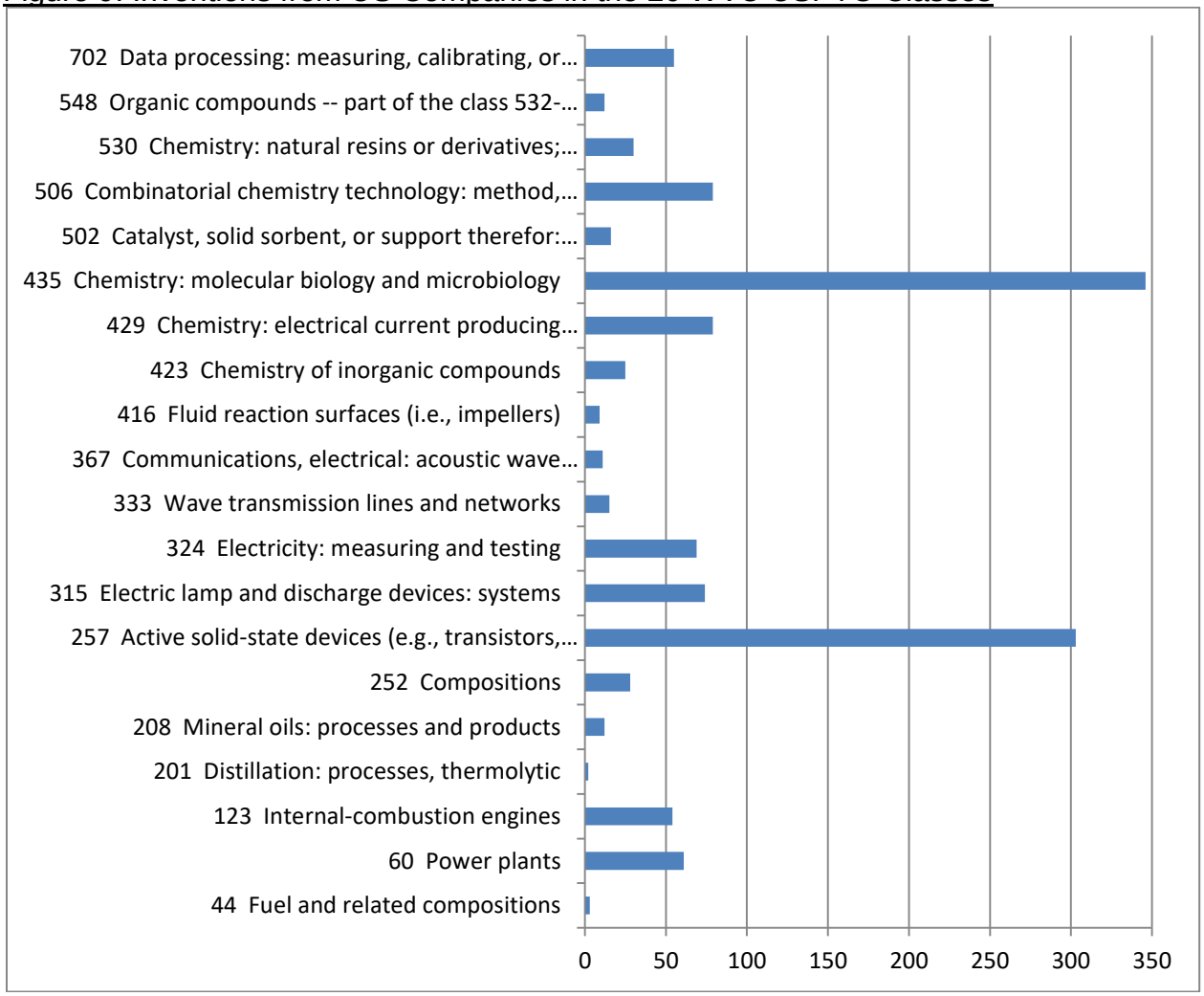


Table 4: Top Assignees Matched to WVU's Innovation Genotype™

Top Assignees Matched to WVU's Innovation Genotype			
Assignee	IP#	Assignee	IP#
INTERNATIONAL BUSINESS MACHIN	75	Lutron Electronics Co., Inc.	10
Texas Instruments Incorporated	24	Universal Display Corporation	10
Micron Technology, Inc.	23	Schlumberger Technology Corporation	9
Ford Global Technologies, LLC	22	Codexis, Inc.	8
General Electric Company	22	QUALCOMM INCORPORATED	8
Intel Corporation	17	Cummins Inc.	7
LIFE TECHNOLOGIES CORPORATIO	16	Apple Inc.	6
Invensas Corporation	15	Cree, Inc.	6
United Technologies Corporation	14	Roche Diagnostics Operations, Inc.	6
GM GLOBAL TECHNOLOGY OPERA	11	SEMICONDUCTOR COMPONENTS INDUSTF	6
Sensor Electronic Technology, Inc.	11	Applied Materials, Inc.	5

In the TrUE Alliance WVU's focus is on fossil fuel technologies and more specifically shale gas. An important USPTO class for shale gas is class 44 "Fuel and related compositions". As we noted in the genotype analysis above, there were no commercial inventions in class 44 for Cleveland, Pittsburgh or Morgantown. However, when we expanded the search to companies across the U.S. we did find potential collaborators for WVU. Below is one example.

WVU has the published patent application 20070227062 "Method of converting animal waste into a multi-phase fuel".

INVENTION: A method of creating a multi-phase fuel wherein said fuel comprises a gas, a solid, a liquid solvent phase and an aqueous phase from animal waste comprising the combination of the animal waste, a solvent, and a water/alcohol solution into a fluid mixture, placing the mixture into a closed reactor, heating said reactor between about 245° C. and 385° C. for between about 5 and 70 minutes and cooling said resulting multi-phase fuel. The animal waste may be manure, mortalities, municipal waste, or chicken litter. The preferred solvent is petroleum with the preferred petroleum being diesel fuel. The final multi-phase fuel can be separated into four separate fuels: a solid fuel, an emulsified solid in the liquid solvent phase by blending the solid, the solvent and a surfactant, an aqueous phase, and the recovered liquid solvent phase. Petroleum is the preferred solvent and the separation may be any conventional means. The mixture preferably consists of 1 part by weight animal waste, about 1.5 parts by weight diesel and between about 0.11 to about 1.86 parts by weight a water/alcohol solution. The water/alcohol solution is between about 5% to about 85% alcohol before heating. Additionally, an alkali base may be added to increase waste solubility.

NEED: There is a need for a method to reduce an ash by-product of the reaction, making the heating of the reaction more uniform, increasing the solubility of the waste, and the using of all solid and liquid by-products as a fuel.

As we might expect there were several potential collaborators in the energy centric state of Texas. One such potential collaborator is KiOR, Inc. from Pasadena, TX, with US patent application 20130000183 "CATALYST FOR THERMOCATALYTIC CONVERSION OF BIOMASS TO LIQUID FUELS AND CHEMICALS"

INVENTION: Catalyst compositions comprising a phosphorous-promoted ZSM-5 component and a silica-containing binder, and methods for making and using same, are disclosed. More specifically, processes for making a catalyst for biomass conversion are provided. The process includes: treating a ZSM-5 zeolite

with a phosphorous-containing compound to form a phosphorous-promoted ZSM-5 component; preparing a slurry comprising the phosphorous-promoted ZSM-5 component and a silica-containing binder; and shaping the slurry into shaped bodies. Such catalysts can be used for the thermocatalytic conversion of particulate biomass to liquid products such as bio-oil, resulting in higher bio-oil yields and lower coke than conventional catalysts.

NEED: To date, a need remains for novel and improved processes and catalysts for the conversion of solid biomass materials to produce fuels and specialty chemicals. More specifically, a need exists for improved catalysts that can increase biomass conversion efficiency and increase the yield of desired conversion products.

Both WVU and KiOR are interested in converting biomass into useable fuels. WVU is focused on a method for reducing the ash by-product of the reaction, making the heating of the reaction more uniform, increasing the solubility of the waste, and the using of all solid and liquid by-products as a fuel. KiOR is focused on improved catalysts that can increase biomass conversion efficiency and increase the yield of desired conversion products. A collaboration between the WVU and KiOR inventors could produce yet another invention that might have positive attributes beyond their individual inventions and advance knowledge in the biomass conversion domain.

If WVU is willing to collaborate with companies across the U.S. the potential for innovation and/or licensing of IP is enormous.

Summary & Next Steps

The objective of the pilot was to demonstrate the potential of using IBP's Innovation Network Based Economic Development (INBED) model, and Innovation Genotype™ analysis, to identify industry partners to collaborate with the four universities in pursuing energy related innovations and economic development. Three of the universities wanted to focus on the tristate region, which was further constrained to the cities of Cleveland, Pittsburgh, and Morgantown. West Virginia University wanted to look for collaboration partners across the U.S.

The pilot began by defining the energy related Innovation Genotype of the four universities. This is essentially the collection of energy related technical domains of interest expressed as a collection of 69 US Patent & Trademark Office primary classifications. With this IBP conducted a series of searches and analyses that resulted in:

- Identifying 212 companies from the three cities that had one or more inventions in the 69 USPTO classes that defined the energy alliance Innovation Genotype

- Of these 212 potential collaborators 88 were from Cleveland, 117 from Pittsburgh, and 7 from Morgantown.

- The companies ranged in size from Fortune 500 companies to startups.

The INBED process goes beyond simply identifying potential collaborators at the university-company level, it identifies the technical domains and individual researchers that should be convened to collaborate. Further, using a process developed by IBP it analyzes the inventions from both the university and industry partners to identify combinatorial opportunities to generate more inventions.

To demonstrate the process the pilot focused on Carnegie Mellon and the city of Pittsburgh. For each we generated their energy related Innovation Genotypes, and examined the intersection between them to identify potential collaborations between Carnegie Mellon and Pittsburgh companies. Finally, we examined several companies in a technical domain, identifying the researchers and synergies between their inventions. The results were:

- For the periods examined Carnegie Mellon had 56 inventions spanning 35 energy related technical domains, and the city of Pittsburgh had 346 inventions spanning 52 energy related domains.

- There were 29 energy related domains in common between Carnegie Mellon and Pittsburgh companies.

- To examine the opportunities for collaboration with SMEs we selected the "surgery" domain and found 14 Pittsburgh companies that were potential collaborators.

- Carnegie Mellon had 2 inventions in the surgery domain related to ingestible electronic devices. The 14 Pittsburgh companies had 30 inventions in the surgery domain.

- We selected two SMEs, Body Media and CardiacAssist and in both cases were able to identify synergies between their inventions and Carnegie Mellon's ingestible electrical device invention.

- Identified the specific industry and Carnegie Mellon inventors to convene and explore the synergies.

Carnegie Mellon is also interested in collaborating with large Pittsburgh based companies, to that end we selected Alcoa and examined the intersection of Carnegie Mellon's genotype with that of Alcoa. The result was:

- Overlap between Carnegie Mellon and Alcoa in 7 energy related domains

- 10 inventions from Carnegie Mellon and 25 from Alcoa

- The Innovation Genotype analysis can serve as a guide to developing additional energy related collaborations between Carnegie Mellon and Alcoa

The same potential exists for Case Western Reserve and Pittsburgh University for collaboration with tri-city companies. Because a full analysis for every university was beyond the scope of this pro bono pilot we selected and explored one example each for Case Western and Pittsburgh University.

- Potential collaboration between Case Western Reserve and PPG Industries of Cleveland in high power super capacitors

- Potential collaboration between Pittsburgh University and Powercast of Pittsburgh powering and charging devices using RF energy

Finally, for West Virginia University we searched the last eight months of inventions from US companies in the 20 technical domains of the West Virginia University energy related genotype. The result was:

- 1,283 inventions in the 20 technical domains from US companies

- 678 companies as potential collaborators for University of West Virginia

- A range of companies from Fortune 500 to startups

- Explored the domain of converting waste into multi-phase fuel and found a synergy between University of West Virginia and KiOR of Texas.

The initial pilot has demonstrated how the use of Innovation Genotype™ analysis can identify opportunities for collaboration, innovation and licensing between universities and industry. A next possible step would be to explore conducting a more robust study that would identify and detail a significant number of potential collaborations and then pursue their realization using the Innovation Network Based Economic Development model.

Sincerely,

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