Today, Real-Time Kinematic (RTK) networks are becoming commonplace. There is at least a small RTK network (or multiple RTK networks) in every state of the U.S., some with full statewide coverage. Internationally, many countries boast nationwide networks. All have been developed within a whirlwind decade since the introduction of the first network solutions.

One of the pioneering and now most widely utilized approaches to network RTK is Trimble’s Virtual Reference Station or “VRS™ network.” VRS has almost become the default term for network RTK in general. Sometimes VRS is even used a verb (“Let’s VRS it.”) or a noun (“What did the VRS say?”) How did VRS become so popular? In researching the evolution of VRS I found that it was a combination of being a pioneering solution, being very good, and continuing to evolve.

As an operator of one of the early U.S. RTK networks, I have been following the rapid adoption of this solution worldwide, its ongoing improvements, the detractors that became imitators, the skeptics that became vocal supporters, and the solution’s enduring utility. Many end users wonder “Where did VRS come from?” and “Who are the people responsible for VRS?” The American Surveyor was granted this first exclusive peek into the surveying “think-tank” that develops

>> By Gavin Schrock, LS
VRS. In this article we’ll examine the evolution of VRS and meet some of the players in the team responsible for its development.

VRS is generically referred to as a “non-physical reference station” solution. Not long after single-base RTK became available in the early 1990s, many people in the fields of geodesy and related sciences were seeking to overcome the inherent weaknesses of single-base RTK and the degradation of quality over increased baseline lengths. Dr. Herbert Landau credits a respected colleague, Dr. Lambert Wanninger, then of Dresden University of Technology, as the first to use the term “Virtual Reference Station” in a 1997 scientific paper. At the time there were many researchers working on concepts to utilize networks of stations to overcome said limitations of RTK, including Landau and his team.

When Paths Converge

In the fall of 2009 I visited the offices of Trimble Terrasat GmbH. They are housed in an unassuming but pleasant looking three-story building in the serene village of Hoehenkirchen, Germany, outside of Munich. Hoehenkirchen (which roughly translates to “high church”) is known to some as the “Birthplace of VRS.” There I met Landau’s team, a group of very talented but modest people, all with roots in surveying, who quietly developed not only VRS, but also other popular solutions and software. During the course of the interviews I heard many interesting stories of how the paths of the individuals converged, united, and resulted in this team; for example, the high school prodigy in China who was studying the stars, the farm girl who had an aptitude for math and a fascination for maps, and the surveying and geodesy student who was destined to lead this diverse dream team to develop VRS and other popular products.

In 1986, Landau was a research assistant at the Institute of Astronomical and Physical Geodesy of the University FAF in Munich for the celebrated Professor Günter Hein. Landau, whose roots are in more conventional surveying, was working toward his PhD in the use of GPS for Geodesy and Geodynamics, which he was awarded in 1988. He cracked a smile when speaking of long field campaigns using rods and subtense bars. After stints as a research assistant at his alma mater and as a commercial software developer, Landau looked toward the future of geodesy and moved to Munich and the new institute there.

Landau began to take satellite geodesy seriously with the advent of such systems as the TI-4100, an early dual-frequency receiver that could track four satellites for as much as four hours per day. By the end of the 1980s, the team of Hein and Landau at the institute in Munich was fielding so many requests from commercial interests for geodetic tool development that they decided to spin off a commercial venture: Terrasat GmbH.

Along with GPS solutions, Terrasat GmbH began developing post-processing software in 1990 for such clients as Spectra Precision. They also developed products such as GeoGenius, the first commercial package capable of processing multiple constellations, later to become Trimble® Total Control (TTC) Software. Landau became managing director of Terrasat GmbH in 1993 and developed their first RTK product for Spectra Precision—Geotracer-RTK—as well as reference station software like GPSBase, which was the forerunner of Trimble GPSNet™ Software.

Dr. Herbert Landau, co-founder and managing director of Trimble Terrasat, leads the carefully selected team of talented researchers, scientists, support specialists, product developers, and product testers.
The development of these successful tools for Spectra Precision gave Landau and his team the funding and “bench” to invest in the research needed to bring network RTK to fruition. In 1999 Terrasat introduced the first VRS software for both DGPS and RTK solutions, and a Virtual RINEX option for post-processing shortly thereafter. The VRS software models errors due to ionosphere, troposphere, multipath and orbits, and reduces the differential biases for DGPS and RTK positioning significantly. VRS technology was implemented early-on for the Bavarian Land Authority.

By 2001 VRS networks began springing up in Europe, Asia and the U.S. It was obvious that this new product was going to be a hit. As a part of the acquisition of Spectra Precision by Trimble, Landau’s operations became Trimble Terrasat, a move that would provide this development group the marketing, distribution and support networks needed to bring these new solutions to a wider market. But Landau and the team were not satisfied to rest on their laurels; they wanted to take this solution higher.

Internet searches for academic papers on the subject of network GNSS and other aspects of precision positioning will frequently bring up the names of Dr. Xiaoming Chen, Christian Pagels, and Dr. Ulrich Vollath. These are three of the many individuals who add their own areas of expertise to the whole team effort. Everyone I talked to at Terrasat emphasized the teamwork aspect—not the hollow slogans on posters, but the kind that comes from working in a development atmosphere requiring implicit trust in the skills of team members in their contributions to such sophisticated products. The team has been quite successful at cherry-picking just the right talent for the job.

Ulrich Vollath received a PhD in computer science from the Munich University of Technology, and has developed algorithms for Terrasat for more than a decade. An understanding of the underlying physics was also needed, so Christian Pagels, with a degree in physics from The University of Erlangen, came onboard as the Senior Development Engineer. Xiaoming Chen studied surveying and geodesy at the University of Wuhan, China, earned his PhD in 1997, and then joined a team in Singapore seeking to develop networked GPS solutions. It was not long before Chen would hear of the research going...
Dr. Xiaoming Chen has been contributing his algorithmic wizardry to the team since 2001. A math prodigy, he once used his uncle’s transit to track and compute the path of Haley’s Comet — while still in high school.

The team recently introduced VRS’Net™ Software, which puts upgraded versions of GPSNet tools and improved algorithms on a whole new platform, while also including a distributed processing environment, integration of TIM, advanced accounts tools and management interfaces. The new platform enables Trimble to offer such services as a fully-fledged utility. Trimble Terrasat is not only responsible for GNSS algorithms and RTK product development, the team is also responsible for the development and QA/QC and the new Trimble 4D Control Software for deformation monitoring, which integrates both optical total stations and GNSS.

The 40+ engineers and scientists on the team work in three main groups: development, QA, and support. Cornelia “Conny” Waldecker, had been a gifted student of math and science when she chose a career in surveying and geodesy. After attending the University of Bonn and earning the letters Dipl.-Ing. (Diploma’d engineer) Waldecker joined a division of Spectra Precision in Darmstadt, and joined the team in Munich in 2001. After many years as a front-line support specialist and then support manager, she became well known to the user community and was often referred to as “Saint Conny”—many of the most difficult support threads would include the line “We’ll send this over to Conny.” As leader of the QA group, Waldecker and her team managed rigorous tests of software and related instrumentation. Her lab looked like something out of NASA with total stations set up all over the building for testing, spinning and measuring round-the-clock, doing their silent robotic gymnastics. In January, Conny was named product manager.

Terrasat is often the final word in customer support threads on products developed and QA’d there. The support team, led by Christopher Daub, keeps a knowledge base of support questions and customer feedback. During my visit, some
of the team members from the development, QA and support teams gave me an impromptu “end user” grilling, soliciting feedback and listening to “wish list” items. They seemed to find it quite amusing that whenever I proposed improvements, Pagels would simply smile and reply, “We have already thought of that.”

It is a bit intimidating sometimes to be around so many highly intelligent people. I joked with the team that I worried that the sheer weight of their collective IQs might collapse on itself and go supernova. While highly productive, the office doesn’t have the frantic atmosphere of laboratories we see parodied in the movies. In contrast, the offices are uncluttered, with only a few things on the walls, and things are surprisingly quiet. Landau is proud of the fact that a full 15-20 percent of the work his team does could be characterized as pure research: studies that are not required to be “productized,” but more for the good of science and geodesy.

I quizzed Chen on issues like the upcoming solar max. He said he feels confident that for most real-time sessions the effects will be mitigated quite well, short of some extreme events like solar scintillation (Google it!) that will increase during the solar max, effects would be easy for the field users to recognize by watching the quality indicators in their field collection software. I asked if he was working on anything new and cool, and as I expected, he simply grinned and changed the subject.

**What’s Next?**

When asked about the future of surveying and what gee-whiz solutions we might expect in, say, 30 years, Landau spoke directly from his field surveying experiences. “We will always have trees and things blocking our sight so we are always looking for new and creative ways to solve this challenge,” he said. “Simply put, our R&D efforts are focused on helping make our users more productive regardless of the technology.” I asked if some other great as-yet-to-be-discovered scientific breakthrough would change surveying forever. He replied, “We will simply keep improving. Perhaps some non-GNSS sensors may become sufficiently cost-effective and practical to add.” He also added a caution to “not let the solutions become buried in the tools,” And of course, we should not forget “good surveying practices.” Indeed it was reassuring to find out that this team has a solid background in actual field surveying.

When asked about hobbies, Landau spoke unenthusiastically about skiing and wind surfing, but I could tell that like Chen, Waldecker, Pagels, Vollath, and the others on the team, he probably gained great satisfaction from his work. I thought about what film maker George Lucas once said, that he “gets to dream for a living.” If a job well done is a measure of happiness, then the Terrasat team certainly has a lot to be happy about.

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**Gavin Schrock** is a surveyor in Washington State where he is the administrator of the regional cooperative real-time network, the Washington State Reference Station Network. He has been in surveying and mapping for nearly 30 years and has been a regular contributor to this publication.