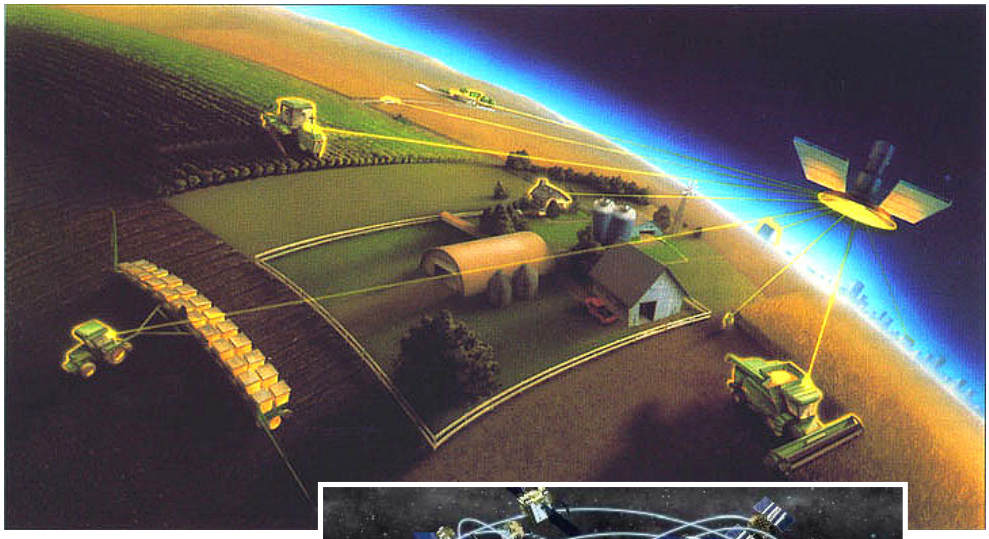
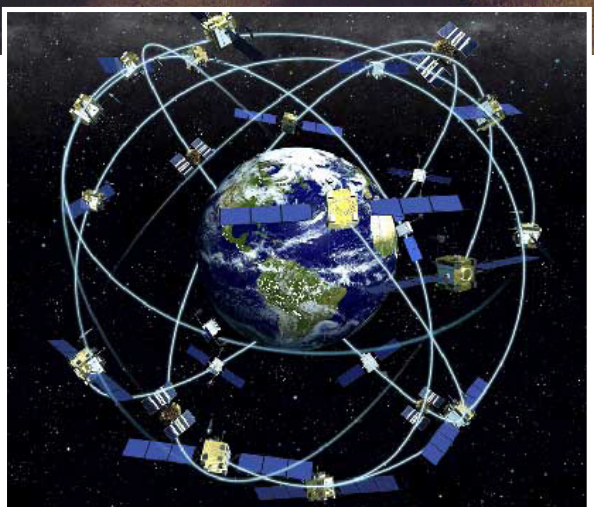
Deconstructing Precision Agriculture

Global Positioning System (GPS) and Atomic Clocks

The development and implementation of precision agriculture has been made possible by the Global Positioning System (GPS). GPS-based applications in precision agriculture are being used for farm planning, field mapping, soil sampling, tractor guidance, crop scouting, variable rate applications, and yield mapping. GPS allows farmers to work during low visibility field conditions such as rain, dust, fog, and darkness. Today, more precise application of pesticides, herbicides, and fertilizers, and better control of the dispersion of those chemicals are possible through precision agriculture, thus reducing expenses, producing a higher yield, and creating a more environmentally friendly farm.





GPS space satellite network connects farms to positioning data.

The **U.S. Department of Defense (DoD)** developed GPS, which is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains it, and makes it freely accessible to anyone with a GPS receiver.

The GPS system concept is based on *time*. The satellites carry very stable atomic clocks that are synchronized to each other and to ground clocks. Dr. Bill Philips from the **National Institute of Standards and Technology (NIST)** lead the invention of the first atomic clocks and won the 1997 Nobel Prize in Physics. **NIST** has officially launched an atomic clock that is three times as accurate as the one used today. The previous atomic clock, called NIST-F1, was launched in 1999. It was accurate to within plus or minus one second over the course of 100 million years. The newly launched atomic clock, called NIST-F2, is accurate to within plus or minus one second over 300 million years.

If the timing is off by just a thousandth of a second, that translates into almost 200 miles of error. New research at **NIST** to improve atomic clocks will keep perfect time for 5 billion years – about the whole, entire age of the earth. The aim is to create a clock that, during the entire age of the universe, would not have lost a second.

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Biographies

Dr. Raj Khosla is a Professor of Precision Agriculture at Colorado State University. In 2009, he was named the Colorado State University distinguished Monfort Professor. In 2012, he was selected as the Jefferson Science Fellow by the National Academy of Sciences and is currently working as the Senior Science Advisor in the Bureau East Asia Pacific, U.S. Department of State, Washington D.C. Prof. Khosla is the founder and Past President of the International Society of Precision Agriculture. He is also on the National Space-Based Positioning, Navigation, and Timing (PNT) Advisory Board.

Rod Wiemer is the farm manager for Fagerberg Produce in Eaton, Colorado, the third largest producer and distributor of onions in the country. Rod manages 2500 acres, including 1000 acres of drip irrigation and uses autopilot systems, with three base stations, with centimeter resolution, to know precisely where pipes are when tilling, planting and harvesting. In 2000, Fagerberg Farms were the first farm in Colorado to add GPS to their operation to place drip lines within quarter of inch accuracy on Earth.

Mark A. Harrington has served as a vice president of Trimble since 2004, and currently serves as vice president for Trimble's Agriculture, Forestry, Water and Energy Utilities and Public Safety Divisions, with responsibility for several corporate functions and geographical regions. From 2007 to 2009, Mr. Harrington served as vice president for Trimble's Survey and Mapping and GIS Divisions, and from 2004 to 2007, he served as vice president of strategy and business development

Carl J. Williams is Chief of the Quantum Measurement Division of the Physical Measurement Laboratory, NIST. He coordinates Quantum Information Science and Quantum Based Measurement program across NIST and co-chairs an interagency effort in support of these activities under the Committee of Science of the National Science and Technology Council. He is a Fellow of the American Physical Society, the American Association for the Advancement of Science, and the Washington Academy of Science. He received the Department of Commerce Silver Medal in 2003 for his leadership of the NIST Quantum Information Program, the Department of Commerce Gold Medal for science in 2008 for scientific contributions and was awarded the 2005 Arthur S. Flemming Award for Scientific Excellence in Government Service for his contributions to quantum physics.

GPS made possible by

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NIST National Institute of Standards and Technology U.S. Department of Commerce

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