PS has been a phenomenal success. Simply consider as
eamples its use in car navigation systems or walking
around city streets with the help of a smart phone.
However, GPS is unavailable inside buildings, in urban canyons,
underground, and underwater. Developing complementary
location and tracking technologies for these environments
would unleash the use of such capabilities in many applications
in the military, public safety, and commercial arenas. Within
residences and nursing homes, for example, there is an increas-
ing need for indoor geolocation systems to track people
with special needs, the elderly, and children to relieve the
need for around-the-clock visual monitoring. Other applica-
tions include systems to assist the visually impaired, locate
instrumentation and other equipment in hospitals, and
track specific items in warehouses. In first responder/public
safety and military applications, indoor geolocation systems
are needed to monitor inmates in prisons, locate miners trapped
in mines, and track/guide first responders and soldiers
inside buildings. Given the growing interest in sensor networks
and radio frequency identification (RFID) technologies,
one can also envision wider-ranging applications such as
locating unwanted chemical, biological, or radioactive
materials using sensor networks, and tracking specific items
such as controlled pharmaceuticals in their containers using
RFID tags.

Localization solutions may have different levels of com-
plexity depending on application requirements and operational
environment. For example, zone-level location accuracy via
smart phones might be adequate in a shopping mall to
determine a person’s location relative to a certain store
based on the strengths of the signals received from the mall
WiFi network. On the other hand, firefighters entering a
burning building cannot rely on availability of localization
aids such as RFID tags/readers or a WiFi network in the
building. Furthermore, the localization system required for this
scenario must have an accuracy range of 1 m — if a rescue
mission is to be launched — to 3 m. Also, such a system
must work from the high floors of multiistory buildings to
possibly many levels underground and rely solely on the
equipment the firefighters can bring to the scene. Under
these circumstances, a hybrid solution employing various types
of localization “sensors” and a smart data fusion algorithm
to combine the sensor outputs is the most promising
approach, but the challenge is to make the system small, robust,
reliable, simple to use, and inexpensive. Even more com-
plex would be a system for locating an intruder who breaks
into a building. This would be an example of noncooper-
ative localization, because a first responder or even an
offender roaming city streets while wearing a radio-equipped
ankle bracelet is “cooperating” by wearing equipment that
makes it possible to track his/her movements, but an intrud-
er is not. These examples suggest that there is never going
to be a silver bullet, that is, a localization and tracking solu-
tion suitable for all possible applications.

Recognizing the ever increasing importance and poten-
tial of localization and tracking, this special issue is designed
to provide a snapshot of the state of the technology in this excit-
ing area of R&D activity. The first article, by Rantakokko et al.,
is a fairly comprehensive overview of hybrid localization
solutions for first responder and military applications. It shows
how outputs of various sensors can be fused using an
(extended) Kalman filter or a particle filter to arrive at a
location solution. The next four articles deal with four dif-
cerent mechanisms that are expected to play important
roles in localization and tracking, whether standalone or as part
of a hybrid solution. The first of these is a comprehensive review
of ultra wideband (UWB) technology for time of arrival (TOA)
estimation and ranging by Soganchi et al. UWB ranging is
very precise when the two ranging nodes are in line of sight
(LOS) of each other. However, its non-LOS (NLOS) per-
formance is typically inadequate, as the distances up to
which this technique works and its precision depend on how
many walls or other obstacles are on the straight line connecting
the two nodes. The next article, by Bird and Arden, address-
es the use of inertial navigation systems for localization and
tracking. RF-only solutions are inadequate for estimating a
person’s or an object’s location with adequate precision in many
applications and environments (e.g., in large/complex build-
ings and mines) unless the structure is adequately instrumented.
While the drift problems of inertial measurement units (IMUs)
are well known, an IMU might be the only sensor capable of providing useful location information in GPS- and RF-degraded environments. The next article, by Soloviev and Dickman, addresses techniques to extend the operational range of GPS, such as within the periphery of buildings. In general, GPS is going to continue to play an important role in localization and tracking, because it is the only mechanism that provides location information outdoors all over the world. In a sense, GPS closes the loop in providing a location solution everywhere. The article by Ni et al. is on the use of RFID for localization purposes. This is an important area, because passive RFID tags are inexpensive and widely available, and could soon be routinely installed in large numbers in new buildings just the way sprinklers now are. The article briefly touches on the need for a reliable RF link to communicate the location information to another entity, such as when an incident command set up outside a building needs to know the locations of firefighters inside. This is an important issue because it applies to IMU-based solutions, and there are still many problems with radio communications inside large structures, mines, tunnels, and so on.

The article by Draganov et al. presents the concept of synthetic aperture navigation (SAN). The idea is to exploit real-time knowledge of user motion to synthetically build a large antenna aperture from a single omnidirectional antenna. This would enable the mobile user to not only estimate range to a signal source/anchor node but also estimate its direction. This can potentially reduce the number of anchor nodes needed by the localization system. The last article, by Lowell, addresses military applications of localization, tracking, and targeting. These applications heavily rely on global satellite navigation systems (GNSS), such as GPS, augmented by a variety of sensors not addressed by the earlier articles.

We expect to see a proliferation of localization and tracking solutions and location-based services over the next decade and their routine incorporation in smart mobile devices. While this Special Issue highlights the importance of localization and identifies the ongoing/remaining R&D topics, it would be worth revisiting this area in five years’ time to gauge the level of progress and go over remaining challenges.