Mobile Localization Experiment
Using The Global Observer
Prototype in Camp Roberts, USA

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Next Trial

From studies, Trial 1 and 2 in CAPANINA:
- Smart antenna techniques including tracking terminals for HAPs
- Spectral sharing techniques
- Station-keeping information for the handoff and antenna stabilization algorithms
- Etc.

An experiment was scheduled as Trial 3:
Mobile localization using Pathfinder-Plus
- Smart antenna test to confirm footprints and spectral sharing for HAPs
- CAPANINA’s optical payload using Pathfinder-Plus
- A 8-element array antenna for the radio localization have been developed

Radio Localization by Array Antenna at High Altitude Platform (HAP) System

Applications:
- Smart antenna (antenna beamforming)
- Emergency calls detection
- Distress
- Monitoring system for radio waves (unlicensed radio waves)
- Etc.

Location (angle ) estimation with a high degree of accuracy is expected because of:
- Line-of-sights condition
- Less effects of multi-pass signal
- Wide antenna aperture

A promising application of HAP systems!!

Alpine accident!!

Distress Beacon
Large Aperture Array Sensor
Onboard the Platform

Technical issues
- Realtime, remote calibration of the position of sensor elements
- Sensors with wide angle directivity

Detection accuracy to be less than several meters

Antenna Calibration and AOA Estimation for Localization

- Airships and solar-powered airplanes have flexible structures in common
- Flexible structure causes fluctuation of the antenna element position
  - Results in a severe degradation of Angle-of-Arrival estimation (AOA) of signals
  - Severe degradation of position estimation
- A realtime compensation scheme of the fluctuation is needed
- Inherent phase and amplitude characteristic differences between antenna elements should be also calibrated
AV’s High-Altitude Long Endurance (HALE) Global Observer UAV System

- Missions: Communications Relay & Remote Sensing
- Features: High-Altitude, Long-Endurance platform (all latitude capability)
- Endurance / Range: Over 1 week / global
- Payload: Up to 1,000 lbs, 6+ kW
- Operating Altitude: 65,000 feet
- Availability: Within 2 years

Global Observer Prototype
Specs & Performance

- Gross Take-off weight: 81.6kg
- Maximum payload weight: 22.7kg with minimum battery for a 30-minute flight
- Maximum battery configuration: 2.75 hours
- Maximum power: 1kW=900 watts for level flight + 100 watts for payload
- Wing span: 50 feet
- Wing Thickness: 3 inches
- Main payload bay: 21 inches dia. X 30 inches long
- Flight speed: 14 m/sec
- Flight altitude: 300m AGL nominal / 1,000 m AGL maximum
Experimental Description for Mobile Localization Test

- Array antenna system for mobile localization has been developed
- Experiment using small UAV
  - Aims of the experiment
    - To prepare the future test using Global Observer UAV with wide antenna aperture
    - To confirm antenna calibration technique for element fluctuation in the position
    - Reference stations are used for antenna calibration and eliminate the change of platform attitude
    - To evaluate the performance of radio localization by using 1-D array antenna
  - Place and Date
    - Camp Roberts, CA, USA: http://www.calguard.ca.gov/cpRbts/
    - November 8-15, 2006

Mobile Localization Experiment Using A UAV (Global Observer Prototype)

- RF frequency range: 1477-1501 MHz
- Min. receiving power: -36 dBm
- Max receiving power: -26.8 dBm
- Signal bandwidth: 100 kHz
- Max altitude: 1000 m
- Service area: 1 km in radius
- Estimation interval: Less than 50 msec
- Receiving antenna: 6 elements linear array antenna
- Element spacing: Unequal distribution
- Input polarization: Circularly polarized wave
- Array Sensors
- Up to 1 km
- Reference Point Stations
- Mobile Terminal
- 1 km
Proposed Realtime Calibration Scheme

The phase displacement, $\delta_{\phi}$, of a signal arriving in the direction $\phi$

$\delta_1 = \delta_{\phi} + \phi$
$\delta_2 = \delta_{\phi} + \phi$
$\delta_3 = \delta_{\phi} + \phi$
$\delta_4 = \delta_{\phi} + \phi$

$\delta_0 = (e_1, d_1) = e_{\phi}^1 \cdot d_1, \delta_2 = (e_2, d_2) = e_{\phi}^2 \cdot d_2,$
$\delta_3 = (e_3, d_3) = e_{\phi}^3 \cdot d_3, \delta_4 = (e_4, d_4) = e_{\phi}^4 \cdot d_4$

The phase displacement parameters:

$\delta_0 = e_{\phi}^1 \cdot d_1 + e_{\phi}^2 \cdot d_2 + e_{\phi}^3 \cdot d_3 + e_{\phi}^4 \cdot d_4$ 

$\delta_0 = e_{\phi}^1 \cdot d_1 + e_{\phi}^2 \cdot d_2 + e_{\phi}^3 \cdot d_3 + e_{\phi}^4 \cdot d_4$

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$\delta_0 = e_{\phi}^1 \cdot d_1 + e_{\phi}^2 \cdot d_2 + e_{\phi}^3 \cdot d_3 + e_{\phi}^4 \cdot d_4$

Angles of Arrival (AOA) Estimation

Vector-Matrix expression

$F' = X', E' = \left[ \begin{array}{c} e_{\phi}^1 \\ e_{\phi}^2 \\ e_{\phi}^3 \\ e_{\phi}^4 \end{array} \right]$  \hspace{1cm}  $d' = \left[ \begin{array}{c} d_1 \\ d_2 \\ d_3 \\ d_4 \end{array} \right]$ \hspace{1cm} $F'' = e_{\phi}^1 \cdot (E')^{-1} \hspace{1cm} F'_0 = e_{\phi}^0 \cdot d'$

$A = \left[ \begin{array}{cccc} \exp(\|\delta_{\phi}^0(1)\|) & \exp(\|\delta_{\phi}^0(2)\|) & \cdots & \exp(\|\delta_{\phi}^0(n)\|) \end{array} \right]$

Antenna Directivity Problem

8 sensor antennas will be installed under the inner wing sections & fuselage

Concept of AOA smart antenna requires equal sensitivity to all radio signals in plane orthogonal to direction of travel across a 90 degree arc
Requirements for Receiving Array Antenna Elements

Microstrip antenna is attractive due to low profile but…
Proposed calibration method cannot deal with antenna directivity
Antenna element with flat antenna directivity is needed

Antenna Design Example
“Modified Helix Antenna”

Modified helix antenna
Radiation pattern of helix antenna; from simulation software FEKO™
**Antenna Element Position for the UAV**

<table>
<thead>
<tr>
<th>Plan</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<td>1.3</td>
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</tr>
</tbody>
</table>

Unit: meter

**And Now**

The Global Observer Prototype with our equipment is ready to take off.
Conclusions

The experiment will be conducted in Camp Roberts, CA U.S.A in November

Mobile localization experiment using the Global Observer Prototype

- To prepare the future test using Global Observer UAV with wide antenna aperture
- To confirm antenna calibration technique for element fluctuation in the position
  - Reference stations are used for antenna calibration and eliminate the change of platform attitude
- To evaluate the performance of radio localization by using 1-D array antenna

And Future