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## APL-C-900 Electrical Capacitance Tomography Process Imaging Research System

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The APL-C-900 series is a revolutionary system that is capable of providing cross-sectional images of fluid processes including concentration and velocity of mixtures of non-conducting fluids and solids. The table below outlines possible application areas. The first column indicates the process materials, with the continuous phase noted first. Please note that the performance of each system may vary between different fluid combinations and that no guarantees of performance can be given for such novel technology.

*Note that Atout has an active programme of product development and specifications may change at any time*  
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## APL-C-900 Electrical Capacitance Tomography Process Imaging Research System

The APL-C-900 is a high-speed twin-plane ECT system suitable for non-invasive measurements of non-conducting two-phase flows containing twin-plane ECT measurement electronics:

- Able to measure 56 independent capacitances on each 8 electrode sensor plane,
- Resolution better than 0.01 fF,
- Stability better than 0.2 fF,
- Temperature compensation built-in,
- Acquisition rate (2 planes, 56 measurements per plane) > 3000 complete frames per second,
- Full guarding on each plane - total up to 32 driven electrodes including 16 measurements channels,
- smb connectors to sensor leads,
- Ethernet connection to PC,
- 100-250V AC single phase power supply.

Process materials	APL-C-900
<b>Air/dry solids</b>	Concentration & velocity images, mass flowrate
<b>Cryogenic fluids</b>	Mass, fill level, distribution, centre of mass, and slosh forces can all be measured for cryogenic fluids such as LN2 and LH2 in tanks and storage vessels
<b>Fuel storage</b>	Mass, fill level, distribution, centre of mass, and slosh forces can all be measured for aviation and automotive fuel in Atout's <b>Smart Tanks*</b>
<b>Liquid/solid</b>	Concentration & velocity images (note that the liquid must be non-conducting)
<b>Cryogenic liquids/gas</b>	Volume fraction, velocity and flowrate of bubbles in the flow
<b>Oil/gas</b>	Concentration & velocity images
<b>Oil/water</b>	Concentration & velocity images if there is less than 30% dispersed water present
<b>Oil/gas/water</b>	Permittivity images if oil or gas are continuous and there is less than 30% dispersed water present
<b>Propellant</b>	Mass, fill level, distribution, centre of mass, and slosh forces can all be measured for liquid propellant in satellite and launcher and Atout's <b>Smart Tanks for Space*</b>
<b>Wet gas (oil or water dispersed in gas)</b>	Concentration & velocity images
<b>Wet steam</b>	Concentration & velocity images
<b>Water/oil</b>	n/a

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## APL-C-900 Base System

The APL-C-900 base system is required for all Atout ECT systems. It incorporates the power supply and ethernet communication bus and includes the control PC (laptop) and the powerful range of APL software including:

Data acquisition (real-time) software:

- multi-frequency operation 1MHz, 2.5MHz, 5 MHz square wave,
- acquire and display capacitances in fF in real-time,
- save data in .bcp format and .csv format,
- capable of undertaking calibration in rig without sensor removal,
- save and load calibration files as required.

Data analysis software:

- able to read .bcp files and display images and time series data,
- capable of calculating permittivity, concentration and density from capacitance images,
- undertake cross-correlation between user-specified zones, plot velocity in each plane,
- built-in permittivity to concentration models to include parallel, series, maxwell and extended maxwell-wagner-sillars,
- output time-series and zonal data to .csv format.

Flow rate calculation can be made using cross-correlation between zones in two planes, output in two-phase flows to include average concentration, velocity and volumetric flow rate.

PARAMETER	SPECIFICATION
Ambient temperature rating	5C to 45C
Communication	Ethernet
Power consumption	100W approx from 240AC supply

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## APL-C-900 Capacitance Measurement Unit

The APL-C-900 CMU is a completely new capacitance measurement unit for our powerful electrical capacitance tomography system. Coupled to a suitable APL sensor, and with the APL-C-900 base system, the concentration distribution of non-conducting fluid-fluid or fluid-solid flows can be derived on two planes axially separated along the pipe. Images from the two planes are cross-correlated to provide flow structure velocity images. See references [1], [2] and [3] for further technical background.

PARAMETER	SPECIFICATION
Number of electrode drives	8
Number of planes	2
Number of guard drives	2
Maximum image capture rate	2500fps
Measurement resolution	Better than 0.1fF
Measurement noise level	less than 0.03fF rms at 560 fps with 24 electrodes
Communication	Ethernet
Excitation frequency (square wave)	1 to 10 MHz
Power consumption	20W approx (depending on excitation frequency) from 24V DC supply



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## APL-S Sensor Heads

The APL-S series of sensor heads are twin-plane clamp-on sensors to fit to existing plastic pipe:

- 8 independent segments fitted around pipe allowing sensor to be separated between any electrode pair,
- two measurement planes and 3 guard electrodes per segment,
- measurement electrode length < 35mm, plane separation 60 to 70mm centre-to-centre,
- overall driven guard length (including embedded measurement planes) >200mm,
- overall sensor length < 350mm,
- smb connectors to each measurement electrode and set of guard electrodes,
- factory calibration supplied for material permittivities 1.0 to 7.5.

PARAMETER	SPECIFICATION
Pipe diameters	50 to 300mm.
Technology supported	ECT (APL-C-900)
Prototype pressure rating	0 bar nominal gauge pressure (clamp-on)
Calibration	Factory calibration of flowmeter at time of first build, occasional pipe-empty 'zero' during use.
Connection	SMB-RG174 cables

Other sensor sizes and specifications available to order, and **Smart Tank\*** systems can also be provided – see ref [4].

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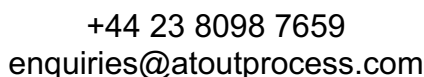


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- [1] Ross Drury, Andy Hunt, James Brusey (2018) *Identification of horizontal slug flow structures for application in selective cross-correlation metering* Flow Measurement and Instrumentation Volume 66, April 2019, Pages 141-149 DOI: 10.1016/j.flowmeasinst.2018.12.002
- [2] Hunt, A., Abdulkareem, L.A., and Azzopardi B.J., “*Measurement of Dynamic Properties of Vertical Gas-Liquid Flows*”, in Proc. 7th International Conference on Multiphase Flow **ICMF 2010**, Tampa, FL USA, May 30-June 4, 2010.
- [3] Hunt, A., “*Weighing without touching - Applying Electrical Capacitance Tomography to Mass Flowrate Measurement in Multiphase Flows*”; **Measurement and Control** **47**, pp 9-25, February 2014.
- [4] Andrew Hunt, Ross Drury and Richard foster-Turner “*Propellant Slosh Force and Mass Measurement*”, **International Journal of Aerospace Engineering**, vol. 2018, Article ID 3026872, 9 pages, 2018. <https://doi.org/10.1155/2018/3026872/>.

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