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# Snake-arm robots for aircraft assembly

Compared to the automotive industry, the aerospace industry has been slow to introduce industrial robotics onto its assembly lines. Recently, however, there has been a general move towards automation in order to increase throughput and standardise processes.

The slow introduction of industrial robots into the aerospace industry is largely due to the need for high accuracy over large structures. For example, holes have to be drilled within large structures with both high absolute and relative accuracy relative to other holes and features of the aircraft assembly.

Airbus has been researching low cost, highly flexible automation for several years. However, tasks within rib bays and other low access areas found throughout aircraft structures have remained practically inaccessible to automation. Manoeuvring an industrial robot (above) through a small opening becomes an ‘eye of the needle’ problem (right): it becomes practically impossible to use a conventional robot-arm to pass through an access hole, for example, and conduct work within a wing box.

Operating within a rib bay requires some of the capabilities of industrial robots, e.g. the ability to place tools precisely, but other capabilities must be added to operate within confined spaces. In particular it is necessary to have a robot arm that does not have prominent ‘elbow’ joints. Snake-arm robots, having continuous curvature along their length, are ideal for these applications.

## Aerospace Applications

OCRobotics is working with Airbus UK and KUKA to develop aerospace robots to deliver end effector packages capable of inspection, drilling, sealing and swaging.

A snake-arm robot can be considered as an additional tool that the larger industrial robot can deliver or as an extension to the industrial robot. The image on the right shows the industrial robot providing the linear movement required for path-following with the snake-arm robot attached as a forearm at the industrial robot’s wrist.

The snake-arm is also equipped with a wrist and interface to attach different tools for tasks such as swaging, sealing and inspection inside the rib bay.

## The demonstrator

**OC**Robotics has designed a prototype (left) which can demonstrate all the required tasks inside a mock-up of a rib bay. This shows a snake-arm robot mounted on a Kuka

The demonstrator snake-arm has 10 segments, is 1800mm in length and 90mm in diameter. The hollow bore is 15mm. The complete system has 27 degrees of freedom. This gives the arm the flexibility to 'follow its nose' into the rib bay.

The snake-arm robot can follow a path into the wing-box, either by joystick control or from a pre-determined library of paths. The arm can then move in 'cartesian mode' either by joystick control or automatically using visual servoing to ensure it is correctly aligned before beginning each task. When applying sealant, a camera on the toolpiece tracks the line of the seam to ensure accurate and even application.

## Tools and applications

The purpose of a snake-arm is to introduce tools or sensors into a confined space. In order to maximise the benefit of the snake-arm's path-following capability, the diameter of the end effector's envelope must be equal to or less than the diameter of the snake-arm. The length of the end effector must be minimised, ideally to the diameter of the snake-arm or at least to less than 1.5x the diameter.

In addition to these considerations, further restrictions were placed on the design by the snake-arm robot specification and the rib bay geometry.

Three interchangeable end effectors were designed by **OC**Robotics for the demonstrator:

- **An inspection tool** (pictured above) containing several cameras with various functions
- **A swage tool** (pictured right) to swage a rivet and direct the removed section into a collection area

- **A sealant tool** (pictured right) incorporating a standard sized sealant cartridge and nozzle, with cameras to allow automatic orientation of the toolpiece to the seam.

## Other potential aerospace applications

The demonstrator was designed to complete only the specific processes that were identified by Airbus as being important in the manufacture of certain aircraft.

However, a snake-arm robot is a method of delivering any tool or sensor package into restricted access sites. As such, it is expected that these robots will be used for in-service inspection and, potentially, repair as well as production.

Snake-arm robots can be used as stand-alone systems or in cooperation with industrial robots. As a standalone system a snake-arm robot is a steerable borescope. **OC**Robotics is conducting research to reduce the diameter of a snake-arm to make it suitable for engine inspection and repair.

Other tasks that could be considered for aircraft manufacture include: deburring; drilling; extraction of foreign bodies; installation of components; insertion of wire looms; laser welding; leak detection; non destructive testing; nut-running; painting; removal of liquids, gases or particulate matter; removal of swarf; and thermal imaging.

Snake-arm robots enable different approaches to be considered. In the long term, this technology may allow aircraft designers to consider structures that cannot be built with existing manual methods.