



# Project North Star Primer

*April 2003*



## Revision History

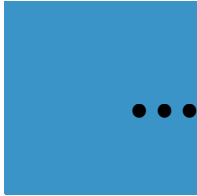
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Concluding comments	30
Paintwork	31
Hidden details	32
Major restoration steps	33
Cockpit detailing	34
Electrical wiring	36
Engines	37
Tyres	39

## Bibliography41





## About the PNS Primer



This chapter introduces the Project North Star Primer, provides a brief overview of the document, and a list of related documents and links.

## Overview

The *Project North Star Primer* has a twofold purpose: to provide a summary of the project's origin and organization, and to serve as an introduction to both the philosophy and the processes involved in restoring a museum aeroplane – the Canadair North Star, registration 17515.

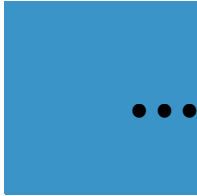
Much of the Primer's content is based upon, or comes directly from a book called *Restoring Museum Aircraft* [Mikesh] by Robert Mikesh, who is the former Senior Curator for Aeronautics at the National Air and Space Museum (NASM) of the Smithsonian Institution in Washington DC. For over 21 years Mr. Mikesh managed the restoration of the world's largest collection of historic aircraft and is one of the most highly qualified and experienced experts in the field of aeroplane restoration. Mr. Mikesh has kindly given us permission to use his book to prepare this Primer.

## Related documents and links

This section contains links and pointers to project-related information that you might find useful, or interesting, or both, and that might inspire you to further research.

- The Canadair North Star [Milberry] — Larry Milberry's book, probably the definitive history of the aeroplane.
- [Project North Star](http://www.projectnorthstar.ca/northstar1-st.htm) (http://www.projectnorthstar.ca/northstar1-st.htm) — Latest information for volunteers and up-to-date PNS progress.
- [Canada Aviation Museum](http://www.aviation.nmstc.ca/) (http://www.aviation.nmstc.ca/) — The home of the last remaining North Star.
- [Canadian Conservation Institute](http://www.cci-icc.gc.ca/) (http://www.cci-icc.gc.ca/) — A wealth of conservation information.
- [Royal Canadian Air Force](http://www.rcaf.com/) (http://www.rcaf.com/) — Learn about the history of the RCAF.
- [426 "Thunderbird" Squadron Association](http://www.entrenet.com/426/) (http://www.entrenet.com/426/) — An unofficial history of the squadron in which 17515 served.
- Canadair history Web site — Historical information about [Canadair](http://home.ca.inter.net/~rapickler/index.html) (http://home.ca.inter.net/~rapickler/index.html), and about the [North Star](http://home.ca.inter.net/~rapickler/nstar.html) (http://home.ca.inter.net/~rapickler/nstar.html).
- [Bombardier Web site](http://www.bombardier.com/index.jsp?id=3_0&lang=en&file=/en/3_0/3_0_1_5_2_1.html) (http://www.bombardier.com/index.jsp?id=3\_0&lang=en&file=/en/3\_0/3\_0\_1\_5\_2\_1.html) — Bombardier's history page.
- The North Star and the Argonaut — The North Star served in [Trans-Canada Air Lines](http://www.aircanada.ca/about-us/our-fleet/au303r.html) (http://www.aircanada.ca/about-us/our-fleet/au303r.html), and as the Argonaut in the British Overseas Airways Corporation (BOAC).





## **Project North Star organization**

This chapter discusses the origins and goals of Project North and introduces the members of the Steering Committee.

## Origins and goals

Project North Star (PNS) grew out of the efforts of Colonel Tim Timmins and General Adamson to create the means to bring back to its former glory, the Canada Aviation Museum's (CAM) Canadiar North Star. In November 2001, Robert Holmgren, PNS co-coordinator, expanded the scope of the project by submitting a proposal to the Museum to restore not just the North Star, but also six other aircraft that are now parked outside the Museum and open to the elements:

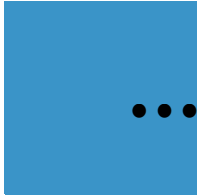
- Vickers 757 Viscount
- Canadair CP-107 Argus 2
- Lockheed Jetstar 6
- Bristol Beaufighter X
- Douglas Dakota IV
- De Havilland Canada Dash 7

Project North Star was so named by Robert for two reasons: first, the Canadair North Star will be the first aircraft restored, and second, the successful completion of the North Star's restoration will set the standard for the remainder of the work, and guide the project as its namesake Polaris, the North Star, guides celestial navigators.

In his opening remarks at the first general meeting of Project North Star on 26th February, 2003, Robert Holmgren stated the Project's primary goal — "The task that we are about to start, the restoration of the former RCAF Canadair North Star, is a sizable one, but nothing we cannot manage. Today we start what some people say can't be done, and we will complete it to the full satisfaction of the Museum Corporation."







## The North Star — history

This chapter presents notes about the history of the Canadair North Star — the company that built it, the Royal Canadian Air Force Squadron that flew it, and the aeroplane that became the last example of its type.

## Canadair

In November 1944, a group led by Benjamin W. Franklin, took over the management of the Cartierville plant in Montreal from Canadian Vickers, their former employers. Franklin's new company, Canadair Limited, had contracted with the Canadian government to assume the aircraft design and manufacturing activities previously undertaken by Canadian Vickers. Before becoming part of Bombardier Inc. in 1986, Canadair produced over 4000 aircraft, including the North Star. See the [Canadair history](#) Web site for more information about the history of one of Canada's best known aviation companies.

The same year that Canadair took over the Cartierville plant, 1944, the Canadian government obtained a license to build an aeroplane using components of the Douglas DC-4 and DC-6 aircraft. Much of the engineering design work was carried out at the Trans-Canada Air Lines (TCA) facilities at Winnipeg and Montreal (Dorval), and at Canadair's Cartierville plant.

The new airliner, officially designated DC-4M in its pressurized civilian configuration, and C-54GM in its unpressurized RCAF version, was christened *North Star* by Ben Franklin after considering other names including *Polaris*. Although it looked very much like the Douglas DC-4 and DC-6, the North Star's four Merlin engines made it easily distinguishable from its American cousins.

Throughout 1945 Canadair prepared for the North Star's production and in 1946 the first aeroplane, a C-54GM with civilian registration CF-TEN-X, was completed. On the 15th of July, 1946, CF-TEN-X took it's first flight at Cartierville — a short twenty-five minutes in the hands of Canadair test pilot Al Lilly. Larry Milberry includes an account of that first flight in *The Canadair North Star* [Milberry] by Clayton Glenn, who was on the first flight because he was an expert on the North Star's propeller control unit. Glenn says that just after takeoff the landing gear was raised and the "cockpit filled with smoke and the smell of burning rubber". Bob Brush, a Douglas test pilot, was also in the cockpit and explained that the smoke and smell came from the "nose wheel spinning against the up brake".



The North Stars of 426 Squadron played a very valuable part in the Korean War between 1950 and 1952, transporting supplies and troops to Japan in support of United Nations operations. In July 1950, a few days after the start of the war, 426 Squadron was detached to McChord Air Force



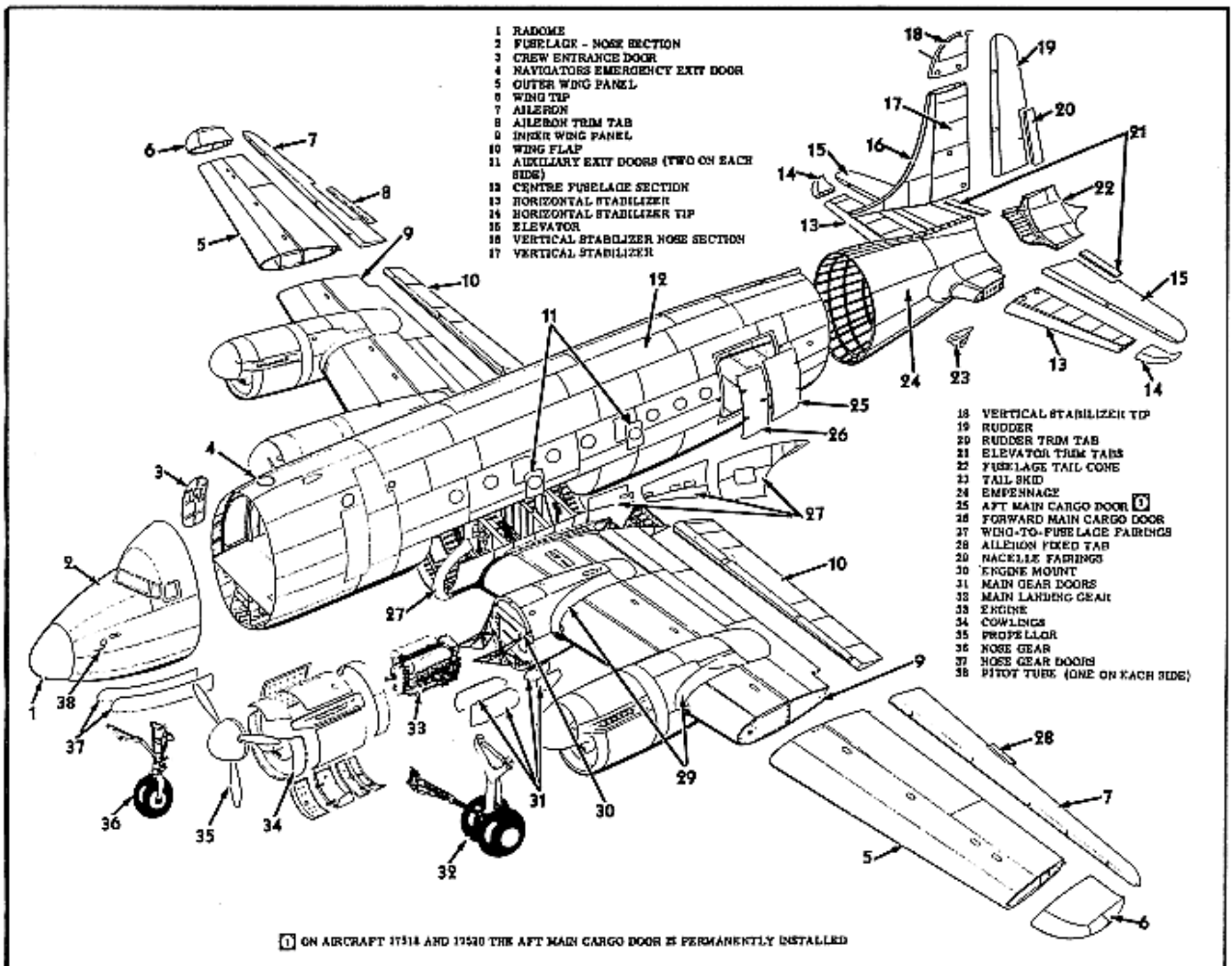
Base in Washington State where it came under the operational control of the US Military Air Transport Service (MATS). A typical Korean Air Lift route for North Star 17515, and the other 426 Squadron aeroplanes was a physically and mentally demanding fifty hour round trip flight from McChord to Japan and back with stops at Elmendorf (Alaska), Shemya (the Aleutian Islands), Handed and Misawa (Japan).

RACF North Stars flew all over the world in roles as diverse as medical and casualty evacuations, Royal tours and VIP transport, and in support of United Nations air lift operations. They were seen in the Arctic, the Middle East and Europe, the Congo and Japan, and they continued in service until 1965. By then, The RCAF had begun flying the new Canadair Yukons and Cosmopolitans, and the Lockheed C-130 Hercules.

On 8th. December, 1965, North Star 17515 took part in the RCAF North Star stand-down ceremony at Trenton, after which it was flown to Mountainview. In 1966, 17515 came to the Canada Aviation Museum [Milberry].



## C-54GM exploded view



C-54GM exploded view, legend

1. Radome	20. Rudder trim tab
2. Fuselage — nose section	21. Elevator trim tabs
3. Crew entrance door	22. Fuselage tail cone
4. Navigator's emergency exit door	23. Tail skid



## Basic specifications

*Canadair C-54GM basic specifications*

Wing span	117' 6"	Operating weight empty	44 000 lbs
Length	94' 9.5"	Max. gross takeoff weight	76 500 lbs <sup>a</sup>
Height	17' 7" (top of fuselage) 27' 6.3" (tip of tail)	Max. Landing weight	67 000 lbs
Fuselage height	11' 6"	Main cabin length	46' 6"
Fuselage width	10' 6"	Cabin floor width	8' 8"
Stabilizer span	39' 5"	Cabin height	7'

a. 78 000 lbs for passenger version with modified nose gear





## Introduction

Early in *Restoring Museum Aircraft*, Mikesh asks the question of how far a restoration project should go in taking a museum artifact and preparing it for display. He quotes a Restoration and Policy statement drawn up as long ago as 1969, but reiterates its applicability to today's museum restoration projects. No two restoration projects are the same, but as we begin the work of restoring the North Star, the advice given in that policy statement is worth considering. The statement says in part, "During the restoration process extreme care should be taken to preserve, intact, existing fabric and other materials. In making the specimen 'like new' we can destroy the research value of the specimen. ... The general tendency for laymen to 'restore' vintage aircraft to like-new condition should be resisted at all costs. ... we should expend the time and energy necessary to preserve the original materials and details."

Although restoration and conservation can be the same thing, restoration is generally more extensive and more intrusive than conservation.



As the technology of preservation, conservation is the scientific investigation of materials, the environment, and those things responsible for the deterioration of cultural resources.

## The PNS volunteer as a restoration technician

Mikesh declares that love for aeroplanes is an essential characteristic of a restoration technician. There's little doubt that the PNS volunteers have already demonstrated their possession of this trait simply by volunteering their time to this worthy endeavour.

As well as being keenly interested in aviation and in its history, restoration technicians must be mechanically competent. PNS volunteers, whether working directly with the aeroplane or supporting those who are, will be taking on the role and doing the work of restoration technicians. Flight line aircraft are not museum aircraft and technicians working on flight line aircraft have different priorities and different skills than those who care for museum artifacts. Flight line mechanics ensure that the aircraft they service and repair are safe and serviceable for their operational life span. As we perform our work, on the other hand, we should bear in mind that our goal is the preservation of the aircraft for an indefinite period of time.

In many instances, restoring aircraft components, perhaps by replacing worn or damaged parts, is easier and quicker to accomplish than preserving those parts. But preserving them ensures that interesting historical aspects are retained. For instance, Mikesh uses the example of cleaning and polishing a cockpit canopy, yellowed with age, rather than replacing it with a modern replica. More time is involved, perhaps specialized techniques are required, but the preservation of the original ensures that an example of perhaps a different canopy forming technique than would have been used today is not lost. Another interesting example from Mikesh's book is graffiti found during the restoration of a Japanese aircraft from World War II. The NASM staff preserved this discovery, which evokes the sentiments of the people who built that particular aeroplane. What "little surprises" will we find in the North Star?

## Skills and techniques

By putting into practice the techniques associated with the principles of conservation, preservation, and restoration, technicians use a wide variety of skills and processes. The following list mentions just a few of these.

- Mechanical aptitude
- Knowledge of chemistry — as it relates to the interaction of materials used to construct and operate aircraft
- Attention to detail — especially in the recording of work performed (photographic and written records)
- Knowledge of corrosion control
- Knowledge of cleaning techniques and materials
- Skill in the application of preservatives (coatings of various sorts)
- Skill in the application of inhibitors, to stop and prevent rust

Individually and collectively, the PNS volunteers bring to this project these and other skills, as well as an abundance of experience.

To accomplish our goal successfully, we must abide by the work control procedures the PNS team establishes so that restoration and preservation work is properly performed and accurately documented. This will enable us to reapply the techniques we've learned to future similar situations — no 'reinventing the wheel' — or to trace steps taken to repeat work if something goes wrong.

We will need to consult and rely upon the expertise of the Museum's curatorial staff and qualified fellow volunteers to determine the appropriate course of action in many cases. It takes a trained eye to evaluate the condition of aircraft components and parts, to determine whether a part should be stabilized in its present condition, treated in some way to restore it, or whether it is in such poor condition that it should be replaced. What chemical treatments should we use in a particular situation? What associated safety precautions should we be aware of? How should we apply the technique? Do we need to apply the technique to a test piece before we use it on the aircraft? The Museum's curator is the ultimate authority and is responsible for making these decisions.

## Restoration decisions

As we make our restoration plans, we need to ask questions that provide us with a better understanding of the aircraft we are working on. These questions will allow us to evaluate the needs and aims of the Museum and to make decisions that we hope will provide an interesting and informative display at the end of the project.

- Do we understand the full history and significance of the aircraft, is it adequately documented, and how should this history affect the restoration plan?
- What maintenance considerations must we take now and during restoration to protect the aeroplane after restoration?
- Will restoration enhance or degrade the aircraft's historical or technological significance, or those of its component parts?

For example, we should consider carefully what might be lost before removing markings commemorating an event, or repairing damage caused by some significant occurrence in the aircraft's history. The Museum's North Star experienced some interesting events during its service career — it lost a dinghy from its port wing during turbulence in 1950, it was struck by lightning in flight in 1953, and it took part in the RCAF's stand-down ceremony in 1965 [Milberry].

- Will the aircraft be the primary example of an exhibit, or will it be a supporting element in a group of aircraft?
- What time period is the aircraft to represent?
- Do the aeroplane's original markings allow the Museum to explain or interpret an aspect of its mission that would otherwise not be possible?
- In what way does the aircraft add educational value and strengthen the Museum's collection?

## Categories and levels of restoration

This section discusses two concepts regarding the classification of museum aircraft: categorization of artefacts according to their historical importance or significance, and classification of artefacts according to their state of repair and preservation.

### Artifact classification

Mikesh describes three categories under which museum aircraft can be classified. Such classifications establish guidelines by which to manage the aircraft. CAM might use the same or similar categories to classify its collection.

- Category I

Aircraft that are historically significant by virtue of having taken part in an historical event (for example, the Wright Flyer, or the Spirit of St. Louis).



Aircraft in this category are usually restored to represent the event for which they are most famous.

- Category II

Aircraft that are technically significant in some way (for example, special prototypes, or the Bell X1).

Aircraft in this category are restored to represent their technological significance.

- Category III

Aircraft that are not significant in their own right, but that represent a type of historically significant aircraft.

Examples of military aircraft, restored to represent their most widely known operational role, fall into this category.

#### **Note**

*Some aircraft can be classified as belonging to both Category I and Category II. The [Gossamer Condor](#) and the [Rutan Voyager](#) qualify in this regard.*

If CAM uses this classification system, the North Star is probably a category III aircraft, which when restored, will be representative of the type that saw long and proud service in the RCAF.

## Levels of exhibit and preservation condition

In addition to the three categories described earlier, another classification system is useful when planning restoration needs. The four **Levels of Aircraft Condition**, originally used at the [Henry Ford Museum & Greenfield Village in Dearborn](#), Michigan, describe both an aircraft's condition for exhibit and the stability in preservation of its structure. When an aircraft has been assessed and assigned one of these levels, the degree to which it requires restoration is easier to understand. The four levels described here apply to the aircraft and its engine (or engines).

- Level I Condition

The aeroplane is in pristine condition and ready to be exhibited. It is not deteriorating, so it is in a stable condition because it is either new or has undergone a complete restoration that included the application of preservation processes and safeguards.

When an aeroplane is restored to this level, it is important to take great care to preserve evidence that tells the story of the aircraft's past service. To maintain an aircraft in this condition requires a stable environment, the removal of liquids and lubricants, the protective coating of interior systems and surfaces, and even the slight pressurization of some systems with nitrogen (which supports neither combustion nor living organisms, mold and so on).

- Level II Condition

Aircraft at this level have the "in recent use, well cared-for" look. Such aircraft are also ready to be exhibited after being cleaned, having markings renewed or changed, and having some preservation work carried out.

Again, these aircraft should be in a stable condition with all their scratches, dents, and patches preserved to document its service history. Visitors to the exhibit should be able to differentiate Level II Condition aircraft, showing the signs of a well-maintained career, from signs of neglect.

- Level III condition

This level denotes aircraft whose condition has deteriorated and become unstable. Without a treatment that involves restoration and preservation, such aircraft are not ready to be exhibited.

Because of their unstable condition, Level III aircraft are fragile, brittle, and probably incomplete. Qualified museum conservation staff have to examine the aircraft to determine how far a restoration of such aircraft should be taken.

- Level IV condition

Level IV aircraft are derelict and virtually destroyed. Preserving them in their present condition might be possible and the Canada Aviation Museum has an excellent example of this approach in the Curtis HS 2L flying boat, G-CAAC.

The Museum's North Star fits in the Level III Condition classification and the extent of the work we will have to do on the aeroplane will be determined once a thorough examination by conservation staff has been done.



Summary of previous restorations, preservation treatments, and/or storage conditions.

## **Current condition and configuration**

Description of current aircraft state.

## **Final appearance configuration**

Description of the aircraft at the end of the project.

## **Individual component description**

Fuselage.

Cockpit.

Wings.

Undercarriage.

Empennage.

Engines.

Colour scheme and markings.

## **Concluding comments**

Any other comments that might further the purpose of the guidelines and the project.



## Hidden details

*Restoring Museum Aircraft* [Mikesh] describes a number of instances where restoration technicians have come across hidden details during a restoration project. Although hidden, such finds are not always unexpected and the Curatorial Guidelines for our project might contain advice about what sort of things to look out for. For example, Mikesh tells of the restoration of a World War II Japanese fighter aeroplane that had a patch applied to the skin of the vertical stabilizer. The documented restoration history of the aircraft showed that the patch was not part of the restoration, as later observers might have concluded, but a field repair during the aircraft's combat service.

We are unlikely, of course, to find bullet holes in the North Star, but Larry Milberry notes in *The Canadair North Star* that 17515 experienced two unusual incidents in its flying career (see [“Restoration decisions” on page 25](#)). The airframe might still show evidence of one or both of these events that should be preserved.

Having the curator and experienced conservation staff close at hand to provide guidance about this kind of thing is, perhaps, a good reason not to consider moving the North Star from the Museum for the restoration work, even if that were a feasible proposition.

Those who will be working on the aircraft should be aware of the importance of the possibility of uncovering little details of the aeroplane's history, and of documenting the discoveries carefully in writing and visually, where appropriate.

## Major restoration steps

There are three major steps in the restoration of an all-metal aeroplane like the North Star:

- Cleaning — to prepare the aeroplane for the restoration technicians
- Chemical treatment — to remove corrosion and inhibit further deterioration
- Protection — to shield the airframe from outside elements

The first two of these steps, cleaning and chemical treatment are an extremely important part of the restoration process. This is probably the single most important difference between genuine aircraft preservation for museum longevity and lesser restoration projects that only remove visible corrosion and paint over active deterioration.

### **Warning**

*Appropriate safety precautions must be taken when working with any chemical cleaning and preserving solutions.*

Even normally closed and unseen sections of the aeroplane (inside the wings, for example) should be thoroughly cleaned and protected. Dust and other foreign matter on metal surfaces might seem harmless, but over time can be the catalyst for corrosion and chemical change. Without detecting and arresting inside-surface corrosion in an all-metal airframe, and without applying an inhibitor against further deterioration, the airframe will eventually resemble an old car — a nice exterior finish, but with metal eaten away from within.

## Cockpit detailing

Cockpits are a reflection of the state of aviation technology at the time an aeroplane was in service, so it is important that they should receive special attention during the restoration. If a cockpit does not reflect the condition level of the aeroplane when it was operational, it should be brought up to that level.

Sometimes the time and money available for a restoration project dictates that the best that can be done with a cockpit is to clean it thoroughly and ensure that any corrosion has been properly treated.

Difficult curatorial decisions, for which there is no one right answer, might have to be made regarding the cockpit of the North Star.

During the aeroplane's lifetime, was its instrumentation changed or modified? 17515 was in service for nearly twenty years, a time period that undoubtedly saw many advances in navigational equipment and aircraft instrumentation. The North Star's technical manuals and the RCAF service records for 17515 should provide the required history, but decisions about whether to use substitute instrument or to use blanks might well arise. Whenever such decisions are made, we must be careful to document them in the restoration log noting substitutions and reasons for the actions we take.

Mikesh notes that during early restorations at NASM, instruments were always dismantled, cleaned, treated with preservative, and reassembled. Then it was realized that, unless an instrument was visibly damaged, it was already a sealed and protected unit.

Instruments in good condition then, were simply cleaned and protected externally. When in doubt though, instruments should be dismantled, cleaned, and treated as necessary.

Electrical leads for cockpit instrumentation should always be connected if they are present and if the correct connections are known. Power is never applied to restored aircraft, so we have no need to make electrical connections that are not in the original system.

Cockpit placards and decals are the finer details that add authenticity to the aeroplane and we should not overlook them in the restoration process. We can purchase such items, find similar substitutes, or



## Electrical wiring

Although it might be tempting to dispose of old electrical wiring whose rubber insulation has hardened and crumbles at the touch, or whose old fabric covering is rotting and frayed, retaining the original cables, looms, and leads is desirable. We must be careful to use photographs, labels, and diagrams when removing wiring bundles and disconnecting cables, to ensure that the wiring is returned to its original location in the aeroplane.

The techniques used to clean and treat electrical wiring can be delicate and utilize chemicals that can be dangerous. Once the dirt and dust have been removed, using an air jet, for example, cables and bundles should be first be cleaned and then degreased using alcohol or trichloroethane. To preserve the insulation, techniques using glycerin and micro crystalline wax have good results. We will have to rely on the expertise of the curatorial staff for advice on how best to proceed when we reach this stage of the restoration.

### ***Warning***

*Take appropriate safety precautions when working with any chemical cleaning and preserving solutions.*

## Engines

Considering the engines of restored aircraft as just something to hold the propellers in place is no longer considered an appropriate approach to the serious restoration of museum aircraft. Major developments in piston engine technology are at an end and examples of engines such as the North Star's Merlins are becoming fewer as time goes by. We should consider that the engines of the North Star are being restored and preserved as a historical engineering document of their type.

Should the engines be considered components separate from the aeroplane, or are they part of the aircraft as a whole? Aeroplanes and aero-engines are different in their construction, materials, and technology and, perhaps, justify separate considerations.

One approach to engine restoration — the traditional approach — is to dismantle the engine completely for cleaning and corrosion control. The different metals and components of the engine have to be treated separately and appropriately and during reassembly, the engine is coated with preservative. This process results in an engine that looks like it has just come off the production line, brand new. Is this the right thing to do? Should the engines of the North Star look new, or should they look like the engines of an operational RCAF transport?

Another approach is to leave the engine in its assembled state, inspect it carefully for corrosion — internal walls too, using special equipment if possible. If no evidence of corrosion or deterioration is found, preservatives can be applied through small openings and a thorough cleaning of external surfaces made. This concept is thought to be justified because it is less invasive, saves time and money, and preserves the engine's factory-assembled condition.

Once the engines have been restored and preserved and made ready for display, engine openings, exhaust pipes and ports attract insects and other foreign materials. We should use reversible methods for blocking these openings, cork, wood, or hard foam, for example.

Although it might not be our immediate goal, we should bear in mind that the North Star's Merlins might one day run again. This objective provides a baseline for the engine restoration decisions that will have to be made. It is extremely important that the technical manuals and engineering drawings and procedures associated with the engines be saved and preserved. Without these, much of the engine's technology and specifications (clearances, tension and torque settings, and so on) might be lost.

The mechanical restoration of propellers is important, but their general appearance and detailing is one aspect of aircraft restoration that is often overlooked. Again, one of the first decisions to be made is to what level propeller restoration should be taken. Should we restore the propellers to factory-new condition or should they show evidence of use and consequent wear?

Paint, markings (yellow tips, decals, stencilled pitch data, and so on) are some of the details we should watch for and reproduce on the restored propellers. Appendix H of *Restoring Museum Aircraft* contains extensive details about propeller markings, manufacturer's trademark decals, and the like.

## Tyres

Tyres and rubber components deteriorate more quickly than many other parts on a museum aeroplane. It is often difficult to find replacements for rubber parts and we should give them special care.

Tyres are the aeroplane's most conspicuous rubber component. They are often designed and made especially for a particular aircraft and they have a limited shelf life. Every restoration project presents its own set of challenges when it comes to tyres, and every solution is unique. Mikesh discusses various types of tyres and tyre design and notes that it is sometimes necessary to find a substitute for an original wheel when a replacement tyre cannot be found. Although it is an irreversible process, and one to be avoided if possible, it might be necessary to fill original tyres with foam to maintain their shape.

The single most important preservation technique that must be applied to the tyres on an aircraft is to relieve the load on them by placing the aircraft on jack stands wherever possible. Such stands usually support the undercarriage directly and can be made to be inconspicuous so as not to detract from the display. Tyres should also be protected from direct sunlight, oil, and hydraulic fluid to maximize their life span.

Mikesh's final note on the restoration and preservation of tyres and other rubber components is to counsel us to investigate the latest advances and technologies for the preservation of rubber products.





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